Environmentally Sustainable Buildings

CHALLENGES AND POLICIES

OECD

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Pour des bâtiments écologiquement viables
Enjeux et politiques

Foreword

The building sector has major impacts not only on economic and social life, but also on the natural and built environment. Various building activities, such as the design, construction, use, refurbishment and demolition of buildings, directly and indirectly affect the environmental performance of the sector. There is much room for the reduction of the environmental impact of the building sector, but various barriers stand in the way. Under such circumstances, government policies are expected to play an important role in reducing the building sector's environmental impacts, yet few studies have been undertaken in this area.

Against this background, the OECD Sustainable Buildings Project was initiated in May 1998 as a four-year project with the objective of providing guidance for the design of government policies to address the environmental impacts of the building sector. Among the various environmental issues related to this sector, the reduction of CO_2 *emissions, minimisation of construction and demolition waste, and prevention of indoor air pollution were selected as priorities for the project.*

As the final output of the Sustainable Building Project, this report presents the results of this work carried out by the OECD Environment Directorate. The report is intended to help policy makers in OECD countries to improve environmental policies for the building sector.

The OECD wishes to express special thanks to the Japanese Ministry of Land, Infrastructure and Transport for its financial support for the project. This report has been prepared by Mr. Takahiko Hasegawa of the OECD Secretariat. The report is published under the responsibility of the Secretary-General of the OECD.

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Executive Summary

The OECD Sustainable Building Project was initiated in May 1998 as a four-year project with the objective of providing guidance for the design of government policies to address the environmental impacts of the building sector. Among the various environmental issues related to this sector, the reduction of CO_2 emissions, minimisation of construction and demolition waste (C&DW), and prevention of indoor air pollution were selected as priorities for the project.

As the final output of the four-year project, the Synthesis Report presents the results of four years of work done in the OECD Environment Directorate for this project. The report is intended to help policy makers in OECD countries to improve environmental policies for the building sector and stimulate further discussion on this issue in the future. The report could also be of interest to other international organisations, researchers, industry, and NGOs.

This report is divided into seven chapters.

Chapter 1: Introduction

Chapter 2: Environmental and economic impacts of the building sector

The building sector has a great impact on energy and material use, as well as on human health.

- The building sector accounts for around 25-40% of final energy consumption in OECD countries. An analysis of energy use in buildings indicates that space heating accounts for the largest proportion of energy consumption in both residential and commercial buildings.
- The construction sector accounts for between one-third and one-half of the commodity flow in selected OECD countries. Consequently, a great amount of construction and demolition waste (C&DW) is being generated in OECD countries. A breakdown of C&DW data shows that a significant proportion of this waste comes from demolished buildings.
- Indoor air quality can significantly affect human health. Indoor air levels of many pollutants may be 2.5 times – and occasionally more than 100 times – higher than outdoor levels. People usually spend as much as 90% of their time indoors.

Chapter 3: Current environmental policies for the building sector

The OECD questionnaire survey and subsequent supplemental studies have found that various types of policy instruments have been implemented to reduce the environmental impact of the building sector.

- A significant proportion of reported policy instruments for reducing CO_2 emissions from the building sector target new buildings. Building regulations have long played a central role in improving energy efficiency in most OECD countries. Although the use of information tools, such as environmental labelling, is increasing, the use of economic instruments remains limited; and government intervention for upgrading existing buildings has been modest.
- Most of the reported policy instruments for minimising C&DW are implemented at the demolition stage.* A landfill tax and regulatory instruments, such as a ban on landfill and mandatory separation, are widely used in European countries. A smaller number of countries have introduced policy instruments at downstream stages, such as an aggregate tax, certification scheme, *etc.* Few instruments were identified at upstream stages.
- The most widely used instrument for preventing indoor air pollution is the setting of target values for the concentration of pollutants. Regulations on the quality of building materials have been implemented in four European countries, and environmental labelling schemes covering the issue of indoor air quality exist in several countries.

Chapter 4: Unique characteristics of the building sector and barriers to improvement

The building sector has several unique characteristics in terms of its product, production process, and the way the product is used. These unique characteristics have created specific barriers to improving the environmental performance of buildings and building activities. For instance, although some energy efficiency investments in buildings can be paid back in a very short period of time, due to the longevity of buildings, there are some other investments which require a long time to do so. In the latter case, investment appraisal may be difficult due to uncertainty regarding factors which affect

* In this report, policy instruments for the minimisation of C&DW are classified into three categories depending on the stages where they are implemented:
- upstream stages: building design and construction for improving waste-generation-related characteristics of buildings (*e.g.* recyclability, reusablity, physical durability, *etc.*);
- demolition stages: demolition of buildings and disposal of wastes; and
- downstream stages: recycling and reuse of materials, and use of recycled materials in building design and construction.

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the benefits from the investment. Moreover, the high level of discrepancy between owners and users has caused "principal-agent" problems for improving the energy efficiency of rented buildings. Other unique characteristics that create barriers to improvement include the extended supply chain that construction requires, the spatially fixed nature of buildings and their high capital cost, and the dominance of a large number of small firms in the building sector.

Chapter 5: Policy instrument options for environmentally sustainable buildings

Policy makers in government can choose various policy instrument options, each of which has specific strengths and weaknesses. In order to make an appropriate choice, they need to take the characteristics of all these instruments into consideration. Both theoretical and empirical studies have been undertaken to evaluate the main policy instruments, and the findings have provided valuable insights into policy instrument characteristics and their implications.

Policy instruments for reducing CO_2 emissions from buildings

- While mandatory standards for building design set in building regulations are usually not economically efficient, they do appear to be the most dependable instrument for achieving a given goal of energy efficiency if they are effectively enforced. Although it is often difficult to set standards that are strict enough to have a substantial impact on a significant proportion of new buildings, there may be room for upgrading such standards and improving their effectiveness in many OECD countries.
- Capital subsidy programmes could encourage energy efficiency investment for both new and existing buildings if the proportion of free riders were sufficiently reduced. However, it is unlikely that such programmes could have a major impact on a wide range of building activities because they require tax revenue expenditures. Views on the potential impact of energy taxes on investment in energy efficiency measures, which are supported by empirical evidence, are mixed and further studies are necessary to draw any conclusion on the effectiveness of energy taxes in improving the energy efficiency of buildings. However, such taxes, as well as tradable permit schemes, are presumed to achieve the least-cost solution and provide continuous incentives to seek more cost-effective technologies.
- Empirical evidence suggests that energy audit programmes can encourage energy efficiency investment in existing buildings. Although environmental labelling schemes could theoretically play a large role in the sectors for new and existing buildings, no clear empirical evidence was found to indicate how the schemes could actually affect building design.

Policy instruments for minimising C&DW

- Empirical evidence indicates that a landfill tax can effectively reduce the final disposal of C&DW if the tax rate is set high enough. Although regulatory instruments, such as a ban on landfill, may have great potential to reduce the final disposal of C&DW, there appears to be no empirical evidence to clearly indicate their effectiveness. Some other regulatory instruments, such as mandatory reporting and demolition permission, may be effective in preventing illegal dumping which is often regarded as the main negative side effect of a landfill tax.
- At downstream stages, virgin material taxes may have great potential to promote recycling with modest administrative cost, although there is no supporting empirical evidence. Reliable certification schemes for recycled materials, coupled with specifications that assume the use of recycled materials, may encourage the use of recycled materials in the building sector.
- At upstream stages, there appears to be no instrument – except for greener public purchasing policies – that could effectively improve the performance of buildings with regard to waste generation.

Policy instruments for preventing indoor air pollution

- Empirical evidence indicates that regulations on the quality of building materials could effectively improve indoor air quality with modest administrative cost.
- Although it is theoretically presumed that environmental labelling schemes could improve building performance only indirectly through changing the behaviour of buyers, empirical evidence suggests that the schemes directly encourage manufacturers to produce materials that are better for health. The establishment of target value for the concentration of pollutants may be a good starting point for making stakeholders aware of the problem, and for helping with the implementation of other instruments.

General policy instruments

- Introducing a greener public purchasing strategy for construction procurement has great potential to improve the environmental performance of the building sector. This instrument may be particularly important in areas where no other policy instruments are feasible.
- Since the construction industry does not have much capacity to undertake research and development and is slow to adopt new technologies, it is important for government to provide support for environmental R&D and the diffusion of relevant technologies in a close partnership with the construction industry.
- Despite some of the industry's unique characteristics and the difficulties they pose for voluntary instruments, such instruments may work

effectively if they target areas where participating firms could benefit economically from improving the environmental performance of their activities.

Chapter 6: Designing and implementing policies for environmentally sustainable buildings

In light of the unique characteristics of the building sector, it is important to establish a national strategy for improving the environmental performance of the sector. Such a strategy should be specifically aimed at the building sector, providing guidance that fully reflects the sector's needs, and it should help policy makers implement appropriate environmental policies.

- In order to achieve the most with limited resources, policy makers need to make appropriate choices with regard to the policy instrument and its target. There is great potential for improving the effectiveness and efficiency of policy instruments by targeting a36
- specific category of buildings. Similarly, appropriately choosing the point of intervention improves not only the effectiveness of policy instruments but also their economic efficiency, and reduces administrative cost.
- Proper co-ordination of policy instruments is required at two levels. First, different kinds of policy instruments for the same environmental objective should be co-ordinated so that they can create greater synergy for improving the environmental performance of the building sector. Second, since environmental impacts of the sector are interrelated, policy instruments for reaching different environmental objectives could potentially conflict. In order to avoid such conflicts, basic principles for policy co-ordination need to be established.
- The establishment of a framework to monitor the environmental performance of the building sector would not only enable governments to set out quantified policy targets, but also provide policy makers with the information they need to use policy instruments in the most effective way. Collecting data on the environmental performance of the building sector, above all site-based data, is usually time-consuming and costly; however, this problem could be overcome by making the best use of a policy framework for environmental labelling schemes.

Chapter 7: Conclusions: policy recommendations

On the basis of discussions in the previous chapters, the following general policy recommendations have been made:

General policy framework

- Establish a national strategy for improving the environmental performance of the building sector.

- Establish a framework to regularly monitor the environmental performance of the building sector.
- Develop a close partnership between government and industry for the support of R&D and technology diffusion.
- Introduce a greener public purchasing strategy for construction procurement.
- Minimise administrative cost by eliminating the duplication of administrative processes.
- Undertake more *ex-post* evaluation of policy instruments by means of a close international co-operation.

Policy instruments for reducing CO_2 emissions from buildings

- Appropriately co-ordinate regulatory instruments and non-regulatory instruments.
- Improve the environmental effectiveness and economic efficiency of building regulation.
- Develop a synergy by combining economic instruments and information tools.
- Place more emphasis on energy efficiency improvement in existing buildings.
- Undertake extensive analysis on the cost-effectiveness of energy efficiency measures.

Policy instruments for minimising C&DW

- Create a synergy for minimising C&DW by co-ordinating policy instruments across the stages of the life-cycle of buildings.
- Reduce the final disposal of C&DW with a combination of economic and regulatory instruments.
- Establish a sustainable material flows within the building sector by promoting the use of recycled building materials in building construction.
- Encourage pro-active response from contractors to reduce construction waste.
- Continue to explore possible measures for improving the waste-generation-related performance of buildings.

Policy instruments for preventing indoor air pollution

- Improve the quality of building materials by implementing instruments that target building materials manufacturers.
- Avoid providing misleading information to consumers.
- Undertake more studies on the causal mechanisms of indoor air pollution.
- Establish a framework to identify newly emerging indoor health problems.

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Environmentally Sustainable Buildings
Challenges and Policies

Chapter 1

Introduction

The building sector has major impacts not only on economic and social life, but also on the natural and built environment. Various building activities, such as the design, construction, use, refurbishment and demolition of buildings, directly and indirectly affect the environmental performance of the sector. It is apparent that there is much room for improvement and for reducing the environmental impact of the building sector, but various barriers stand in the way and these may be difficult to overcome solely through market mechanisms. Under such circumstances, government policies are expected to play an important role in reducing the building sector's environmental impacts, yet few studies have been undertaken in this area.

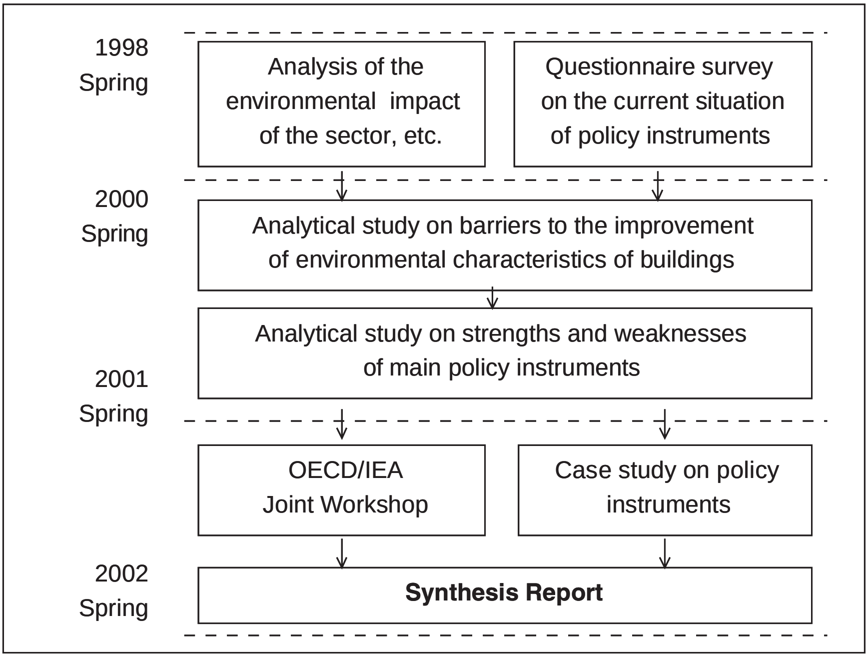
Against this background, the OECD Sustainable Buildings Project was initiated in May 1998 as a four-year project. Its objective was to provide guidance for the design of government policies to address the environmental impacts of the building sector. Buildings and building activities are linked to a wide variety of environmental issues. Among these, the following three – which provide an instructive cross-section for policy design for this area – were selected as priorities of the project:[1]

- reduction of CO_2 emissions;[2]
- minimisation of construction and demolition waste (C&DW);[3] and
- prevention of indoor air pollution.[4]

The four-year work programme of the project can be divided into several different parts (Figure 1). After analysing the significance of the environmental impact of the building sector and the current situation of policy instruments in OECD countries, the programme sought to examine both the theoretical and empirical aspects of policy design for discussion. While two analytical studies were conducted with the aim of establishing a theoretical framework on which to base discussion of the design of environmental policies, case studies of policy instruments were also conducted to obtain empirical evidence indicating the degree of effectiveness and efficiency of the instruments. These two aspects of the issue were also discussed by a number of policy makers and experts at the OECD/IEA Joint Workshop that was held in June 2001.

The information provided in this report is the result of four years of work done in the OECD Environment Directorate for the Sustainable Building Project. The report is intended to help policy makers in OECD countries to

Figure 1. **Work programme of the Sustainable Building Project**



improve environmental policies for the building sector and stimulate further discussion on this issue in the future. The report could also be of interest to other international organisations, researchers, industry, and NGOs.

Structure of the Synthesis Report

The Synthesis Report contains seven chapters. The objectives and structure of the report are explained in the introduction (Chapter 1). Chapter 2 provides data on the significance of the environmental and economic impacts of the building sector. The data indicate that the sector has a significant influence on energy and material use, as well as on human health, and highlight the importance of designing effective policies for this sector. This chapter also discusses the scope for improving the environmental performance of buildings and building activities, which could contribute to reducing the sector's environmental impact.

Chapter 3 describes the current situation of government policies to reduce the environmental impact of the building sector. In 1998, the OECD Secretariat conducted a questionnaire survey on the current situation of environmental policies for the building sector in OECD countries, and 20 countries have responded. The collected information has been supplemented and updated by information from literature and communication with policy makers in these countries. The chapter summarises the results of the survey and analyses the trends of policy design in this area.[5]

Chapter 4 examines the characteristics of the building sector and main barriers to improving the sector's environmental performance. The building sector has several unique characteristics in terms of its product, production process, and the way the product is used. These unique characteristics have created specific barriers to improving the environmental performance of buildings and building activities. The first step in designing effective and efficient policies may be to better understand the nature of the barriers that government policies have to address. This chapter provides an analytical framework for developing discussion on the design of environmental policies for the building sector. The framework is based on the main findings from the analytical study that was done to identify the unique characteristics of the building sector and the main barriers to improving its environmental performance, and to understand how these are related.

Chapter 5 analyses policy instrument options for improving the environmental performance of the building sector. Policy makers in government can choose various policy instrument options, each of which has specific strengths and weaknesses. In order to make an appropriate choice, they need to take the characteristics of all these instruments into consideration. An analytical study – examining how theoretical arguments regarding the design of environmental policies for other sectors can be applied to the building sector – was conducted to assess the strengths and weaknesses of the main policy instruments.[6] In addition, case studies on policy instruments were conducted to find empirical evidence that could indicate the degree of their effectiveness, *etc*. This chapter presents the main findings from both the theoretical and empirical studies, as well as draw links and identify contradictions between the two studies.

Chapter 6 examines several important issues related to designing and implementing environmental policies for the building sector. Section 6.1 discusses ways to set out a national strategy to improve the environmental performance of the building sector, which subsequently should greatly affect how policies are designed and implemented. When designing environmental policies for the building sector, it is very important to appropriately choose the target of policies in terms of type of building and point of intervention. Section 6.2 discusses how the choice of targets can affect the effectiveness of policies as well how policy makers should set policy targets. Section 6.3 examines the issue of policy co-ordination. Policy makers

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can create effective and efficient policy packages by properly co-ordinating policy instruments. This section discusses how policy co-ordination affects the effectiveness, *etc.* of policy packages at two levels: co-ordination of different types of instruments for the same environmental objective on one hand, and co-ordination of instruments for different environmental objectives on the other. Section 6.4 discusses how governments should monitor the environmental performance of buildings and make use of the results from the monitoring.

Finally, on the basis of discussions in the previous chapters, the concluding chapter (Chapter 7) presents key policy recommendations for OECD countries for designing and implementing environmental policies for the building sector.

Notes

1. Other environmental issues related to the building sector, such as water use, land use, spatial pattern of building stock and preservation of bio-diversity, have not been examined in this project, and were left for future study.
2. This project focuses on issues related to the energy performance of buildings.
3. This project focuses on the quantitative aspect of the issue.
4. This project focuses on the problems caused by the emission of pollutant sources, mainly formaldehyde, from building materials and products.
5. Detailed information on the results of the survey are included in the Annex.
6. The chapter will place its emphasis on three main policy instruments (regulatory instruments, economic instruments and information tools), though other general instruments, such as greener public purchasing, support for R&D activities and technology diffusion and voluntary instruments, will also be discussed.

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Chapter 2

Environmental and Economic Impacts of the Building Sector

The building sector has long been a main economic base in OECD countries. The construction industry[1] accounts for around 5-15% of GDP, and 45-55% of gross fixed capital formation. The industry also provides 5-10% of total employment (Table 1). The impact of the sector is not limited to the economic sphere. The sector also has a great impact on energy and material use, as well as on human health. Improving the environmental performance of buildings and building activities could contribute to reducing the sector's environmental impact.

Table 1. **Contribution of the construction industry to GDP, gross fixed capital formation and employment**

	GDP	Gross fixed capital formation	Employment
EU (1999)	9.7%	47.6%	7.5%
Japan(2000)	13.7%	53.4%	9.9%
USA (2000)	4.7%	45.7%	5.0%

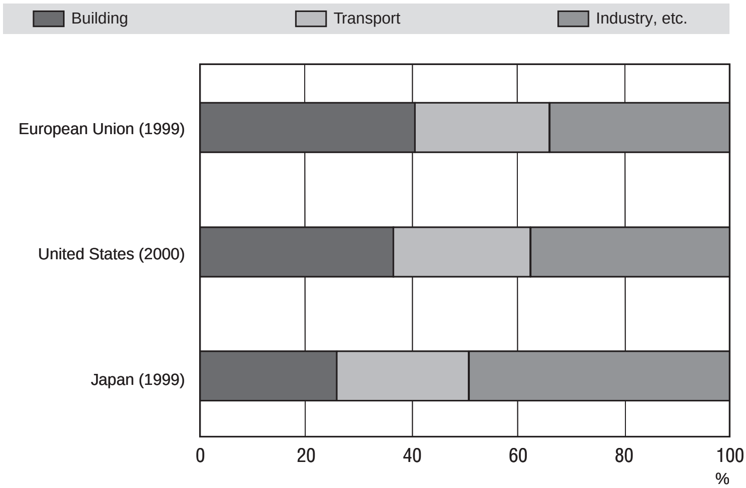
Source: European Commission, 2001; US Department of Commerce, 2001; US Department of Labor, 2001; and Japanese Ministry of Land, Infrastructure and Transport, 2001.

2.1. Energy use and CO_2 emissions

A great amount of energy is consumed in the operation of buildings. The building sector accounts for around 25-40% of final energy consumption in OECD countries (Figure 2). Energy consumption in the building sector has long been on the increase, and it is predicted that this trend will continue in OECD countries. (OECD, 2001a). Figures 3 and 4 show that both the sector's energy consumption and the sector's share of total energy consumption have been increasing in the US and Japan.[2] The share of the sector's energy consumption has increased from 30% in 1960 to 34% in 1980 and 36% in 2000 in the US. Similarly, in Japan the share has increased from 13% in 1970 to 26% in 1999.

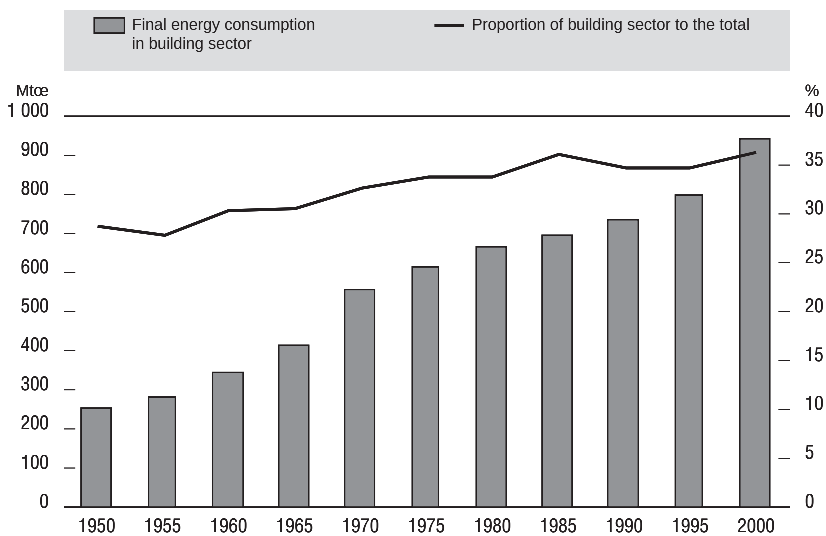
Figures 5 and 6 show the percentage of final energy consumption by end use in both commercial and residential buildings in the US and EU. They indicate that space heating accounts for the largest share of final energy consumption in both categories of buildings. In Australia, heating, ventilation and cooling account for around 43% of energy consumed in commercial buildings (Langston, 1997).

Figure 2. **Final energy consumption by sectors**



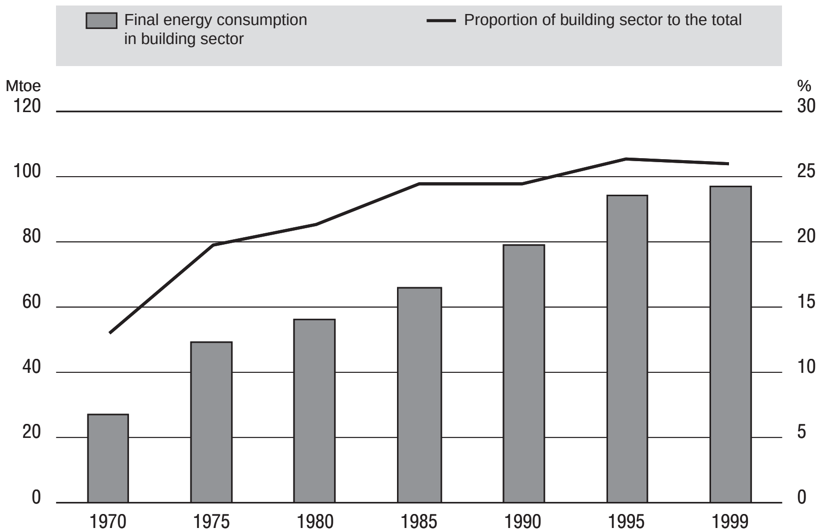
Note: Energy use by the building sector here is for the operation of buildings only. Energy use for manufacturing and transporting building materials, *etc.* is not included.
Source: European Commission, 2001b; US Department of Energy, 2001; and Japanese Resource and Energy Agency, 2000.

Figure 3. **Energy consumption in the building sector and its proportion to the total, US**



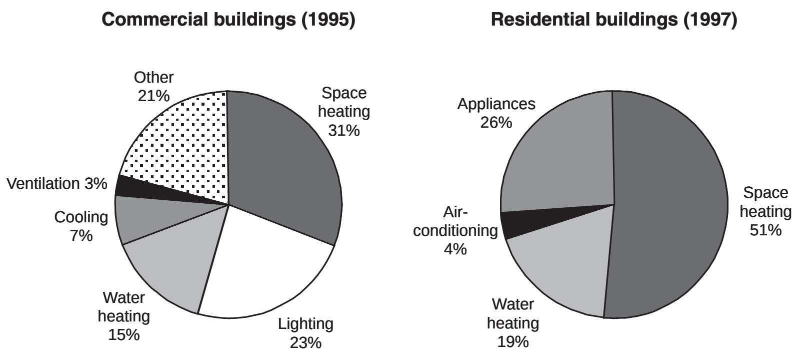
Source: US Department of Energy, 2001.

Figure 4. **Energy consumption in the building sector and its proportion to the total, Japan**



Source: Japanese Resource and Energy Agency, 2000.

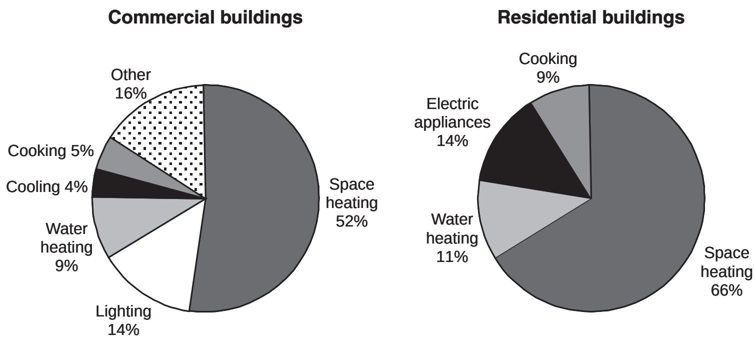
Figure 5. **Breakdown of final energy consumption by end use, US**



Source: US Energy Information Administration, 1998, 1999.

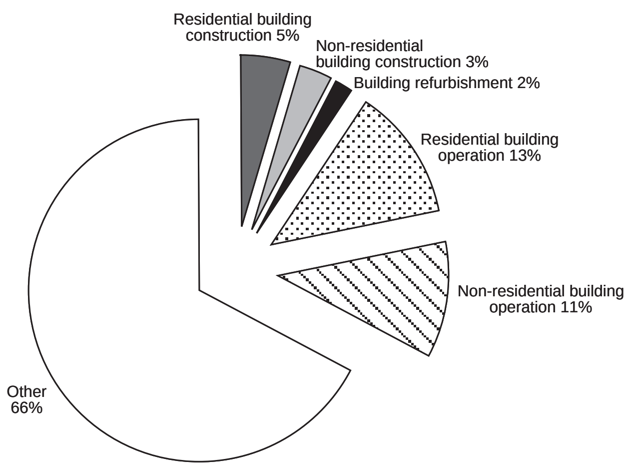
The impact of the building sector on energy use is not limited to energy used for the operation of buildings. A considerable amount of energy is also used in construction activities, including the manufacturing and transportation of building materials. In Japan, it was estimated that construction activities, including refurbishment work, account for about 10%

Figure 6. **Breakdown of final energy consumption by end use, EU (1997)**



Source: European Commission, 2001b.

Figure 7. **Breakdown of CO_2 emissions, Japan (1995)**

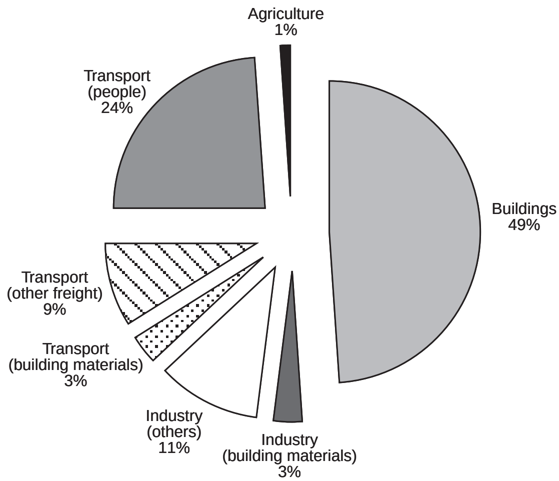


Source: Oka, 2000.

of total CO_2 emissions (Figure 7). Another analysis in the UK indicates that the transportation and manufacturing of building materials each account for 3% of final energy consumption (Figure 8).

Since the biggest share of energy use in the building sector is attributable to the operation of buildings, it is crucial to improve the energy efficiency of buildings. This generally means reducing the quantity of energy[3] required to

Figure 8. **Breakdown of final energy consumption by sectors, UK (1996)**



Source: Howard (2000).

satisfy certain needs that owners and users have in terms of internal environment and services. Various design elements affect energy efficiency, from very basic elements (*i.e.* the orientation and shape of the building structure which influence the heat gained from daylight), to detailed elements (*i.e.* the method of sealing joints between building components). There are four basic principles in the design of an energy efficient building. The first is to ensure that the orientation and location of the building on the site maximises passive solar potential. The second is to minimise the energy demand for operation by optimising the design of building envelopes. The third is to maximise the use of renewable energy technologies and sources. The fourth is to install energy efficient equipment for residual energy demands.[4]

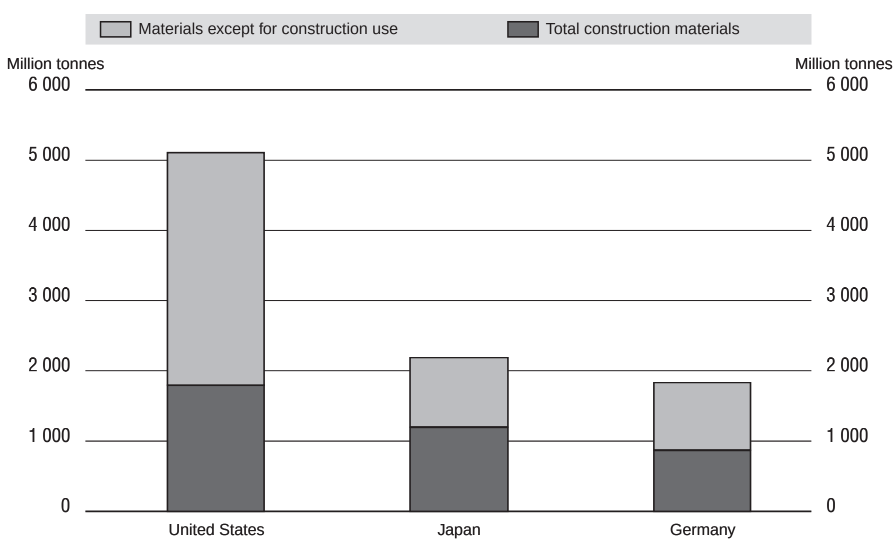
As the energy efficiency of buildings progresses, attention has increasingly been directed toward energy use at the construction stage – including manufacturing of building materials. The energy consumed directly and indirectly during the process of producing goods and services is generally referred to as embodied energy. In the context of building construction, this refers to the total energy consumed in the processing of materials, manufacturing of building materials and components to be assembled on site, the transportation of building materials to the site, and their assembly on site.[5] If designers and contractors were to choose building materials with less embodied energy, and building material manufacturers were to use less energy in production processes, then energy consumption in construction processes could be reduced.[6]

2.2. Waste generation

Buildings, which by their nature shape a large volume of space to satisfy the needs of their users, inevitably require a large amount of materials for their construction. Material flow analyses for Germany, Japan and the United States show that the construction sector accounts for between one-third and one-half of commodity flows when expressed in terms of weight (Figure 9). Various kinds of materials are used for different building components, such as structural parts, outer-walls, roofs, windows, fittings, interiors, pipes, and equipment.

Consequently, building activities generate a considerable amount of C&DW in OECD countries. In the European Union, C&DW is estimated to be roughly 180 million tonnes per year,[7] constituting the largest waste stream in quantitative terms (European Commission, 2000). In Japan, C&DW amounted to 7.9 million tonnes in 1999, representing about 19% of total industrial waste by weight (Japanese Ministry of Environment, 2001). Of the roughly 14 million tonnes of

Figure 9. **Total commodity flow in selected OECD countries, 1991**



Source: World Resource Institute, 1997.

waste that is landfilled in Australia each year, 44% (by weight) is attributed to the construction industry (Langston, 1997). In the US, estimates for this waste stream have typically ranged from 10% to 30% of municipal solid waste[8] (Fishbein, 1998), but the most recent, one official survey estimates C&D to constitute nearly 40% of municipal solid waste (US Environmental Protection Agency, 1998).

There are three sources of C&DW. The first is material removed from buildings when they are demolished. The second is material removed from buildings when they are refurbished. The third is the waste generated at construction sites, such as surplus materials and packaging. In general, the first two categories (demolition waste), accounts for a significant proportion of C&DW. For instance, in the US, building demolition accounted for 48% of total building-related C&DW in 1996, and renovation for 44%, but only 8% of C&DW was generated at construction sites (US Environmental Protection Agency, 1998).

As a large proportion of building materials are used in the structural parts of buildings, most demolition waste is in the form of concrete and bricks, as shown in the breakdown of C&DW in Japan and Denmark (Tables 2 and 3).

Table 2. **Breakdown of construction and demolition waste (C&DW) in the building sector[1] by weight (Japan, 1994)**

	Proportion to the total
Concrete	75%
Concrete + Asphalt	4%
Lumber	3%
Mixed waste	7%
Soil	11%
Total	100%

1. Limited to building-related C&DW.
Source: Japanese Ministry of Social Affairs, 1997.

Table 3. **Breakdown of construction and demolition waste (C&DW) in the construction sector by weight (Denmark, 1999)**

	Proportion to the total
Concrete	24%
Asphalt	19%
Soil and stone	15%
Non-combustible	4%
Tile	3%
Other	35%
Total	100%

Source: Danish Environmental Protection Agency.

It is important to note that a sharp increase in C&DW is predicted for this century. It is estimated that demolition waste generated in the European Union will increase from 160 Mt in 1995 to 330 Mt in 2010 and 500 Mt in 2060 (Cairns *et al.*, 1998). Similarly, building-related demolition waste in Japan is estimated to increase from 12 Mt in 1995 to 42 Mt in 2010 and 56 Mt in 2025 (Research Group for Environment Friendly Building Technology, 1995).

Reducing the amount of materials incorporated into products is often considered to be at the top of the list of measures for waste minimisation. However, in the case of buildings, it is not easy to achieve reductions in material weight or volume. A building is by nature produced to shape a large space for a certain use – so it inevitably incorporates a large amount of materials. In addition, basic performances of buildings are often linked to the quantity of materials, where thicker load-bearing walls and floors generally mean a higher level of structural strength, sound proofing, physical durability, or energy efficiency, given that other conditions being unchanged.

As it is difficult to reduce the quantity of materials used for buildings, promoting the reuse and recycling of building materials and components could be emphasised for waste minimisation in this sector. The recycling rate of C&DW varies between countries. Within the EU, 25% of C&DW is recycled, with the recycling rate of EU countries ranging from less than 5% to 90% (European Commission, 2000). In Japan the recycling rate for building-related C&DW was 26% in 2000 (Japanese Ministry of Land, Infrastructure and Transport, 2001b). In the US, the reported recycling rate in five states ranged from 37% to 77% (US Environmental Protection Agency, 1998).

Another method to minimise C&DW is lengthening the service-life of buildings. The quantity of C&DW from demolished buildings per year could be halved if the average service-life of buildings were doubled. Three important factors affect the service-life of buildings. The first is their physical durability, which usually refers to the length of time that structural parts of buildings are expected to keep their basic physical performances[9] under presumed conditions.[10] The second is the proper maintenance of buildings. The third concerns the functions of buildings and their adaptability to new needs. Regardless of their physical condition, the service-life of buildings cannot be extended if they do not satisfy the needs of potential buyers and tenants. In this sense buildings will be used for longer period of time only if they can be adapted to other or new needs.

With regard to waste generated at construction sites, there are various ways to reduce this waste. For instance, better site management could reduce the quantity of surplus materials, and the packaging of materials could also be reduced.

2.3. Indoor air environment

Health problems resulting from indoor air pollution have become one of the most acute environmental problems related to building activities. Relatively high levels of pollutants, arising from building materials and components (*i.e.* finishes, paints, and backing materials), can pose various health problems, such as irritation of the eyes, nose and throat, headaches and dizziness. Studies of human exposure to air pollutants conducted by the US Environmental Protection Agency indicate that indoor air levels of many pollutants may be 2.5 times – and occasionally more than 100 times – higher than outdoor levels. These high levels of indoor air pollutants are of particular concern because it is estimated that most people spend as much as 90% of their time indoors (US Environmental Protection Agency, 1995). Similarly, a survey conducted in 7 European countries found that people spend 88% of their time indoors (Cochet, 2001).

Efforts to increase energy efficiency and reduce greenhouse gas emissions, coupled with the lack of adequate ventilation, have sometimes exacerbated the indoor air problem by making buildings more air-tight. The air-tightness of buildings, however, varies from country to country, depending on such factors as regional differences in building methods and whether or not (and when) measures for upgrading air-tightness were introduced. This means that indoor air pollution has become an issue in different countries at different times. While Northern European countries became aware of "sick building" issues in the late 1970s or early 1980s, other countries did not perceive this to be a problem until very recently.

Many factors affect the concentration of pollutants inside buildings. In the case of pollutants related to building materials like formaldehyde, the main determinants of concentration are usually the quantity of pollutants contained in building materials, temperature, humidity and fresh air ventilation. In general there are two approaches to lowering concentration levels. It is widely argued that the most effective approach is to eliminate or reduce the pollutant sources inside buildings. Nonetheless, increasing the exchange of indoor air with outdoor fresh air can also mitigate indoor pollution problems.[11]

Notes

1. The construction industry deals not only with buildings but also with infrastructures. Buildings usually account for a significant proportion of the economic output of industry in OECD countries.
2. There are some exceptions to this trend. For instance, the total energy consumption in the building sector in Germany decreased by 20% between 1997 and 2000.
3. This usually does not include renewable energy.

4. It is important to note that management and maintenance practices can also affect the energy consumption in buildings.
5. It is important to note that although the amount of energy embodied in one building is usually much smaller than that of the energy consumed for the operation of the building, the former is consumed before the construction work is completed while the latter is consumed during very long period of time. Therefore the significance of the embodied energy is not so small as it looks when the short-term goals are to be achieved.
6. Energy consumption during construction processes can also be reduced, in the long run, by lengthening the service lives of buildings.
7. Earth and excavated road materials are not included.
8. C&DW are usually not included in municipal wastes.
9. This refers mainly to structural strength.
10. In terms of local climate, condition of maintenance, *etc.*
11. This particular example points to building pollution mitigation challenges whereby increasing ventilation may increase energy consumption for space heating and cooling.

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Chapter 3

Current Situation of Environmental Policies for the Building Sector

Various types of policy tools have been implemented to reduce the impact that the building sector has on the environment in OECD countries. In order to analyse the trend of policy design in this area, a questionnaire survey on the current situation of environmental policies for the building sector was conducted by the Secretariat of the OECD, and 20 countries responded. The collected information has been supplemented and updated by information from literature and communication with policy makers in these countries (OECD, 2001b). Among various kinds of policy instruments, the survey focused on three kinds of principal policy instruments: regulatory instruments, economic instruments and information tools. This chapter summarises the survey results and provides an overview of current environmental policies for the building sector.[1] Detailed information on the results of the survey is included in the Annex.

3.1. Policy instruments for reducing CO_2 emissions from new buildings

A significant proportion of reported instruments for reducing CO_2 emissions from the building sector target new buildings.

3.1.1. Energy efficiency improvement

Most of the policy instruments that have been implemented with an aim to reduce CO_2 emissions from new buildings are related to energy efficiency improvement. They are expected to reduce the energy used for the operation of buildings, which accounts for a significant proportion of energy use in the building sector. Although building regulation has played a central role in the improvement of energy efficiency, other, non-regulatory policy instruments are increasingly being implemented.

Regulatory instruments

Mandatory standards for building design. Building regulation was first introduced to impose minimum standards (*i.e.* for structural strength and fire prevention) to protect occupants from life-threatening problems. However, after the oil shocks in the 1970s, most OECD countries extended the coverage of building regulation to include the energy efficiency of buildings. As a result, all the countries that responded to the survey, except for Japan, now have energy efficiency standards in their building regulation, although what the regulation covers varies between countries.

Economic instruments

Economic instruments, which are being increasingly used in other industrial sectors, have not been fully explored in the building sector. One of the reasons may be that governments have relied heavily on regulatory instruments.

Subsidy programmes and tax exemption schemes. Subsidy programmes and tax exemption schemes have reportedly been introduced in nine countries. One example is the Commercial Incentive Program in Canada which offers a financial incentive to incorporate energy efficiency features into new commercial buildings.[2] Another example is a German subsidy programme which subsidise the cost for installing highly efficient heating equipment in, or improving thermal insulation of new owner-occupied dwellings. It is important to note that some large-scale subsidy programmes have also been used to promote the use of solar energy and are aimed at lowering the production cost of building components like photovoltaics. Six countries reported using tax exemption schemes; in the Netherlands, for example, firms that invest in "green projects", including buildings, are eligible for tax deductions.

Premium loan schemes. There are six countries where premium loan schemes are reportedly used in the building sector. The Japan Housing Loan Corporation, which is a public institution that finances about 600 000 housing units per year, grants lower interest rate loans to those who build or buy houses that meet the recommended government energy efficiency standards.[3] In the US, a number of premium loan schemes have been implemented across the country and many of them are supported by federal housing loan institutions. In Germany, the government is providing low-interest loans to those who buy or construct dwellings with a much higher energy efficiency level than required by building regulation.

Energy taxes and tradable permit schemes. Energy taxes could be one of the measures used to improve the energy efficiency of both new and existing buildings. Energy used in buildings is taxed in some way in OECD countries. Although, in many cases, the primary objective of these taxes is to raise financial revenue. there are five countries that have implemented environmentally related tax[4] that covers energy use in the building sector, mainly for environmental objectives. As for tradable permit schemes, the survey indicates that no country has so far implemented such a scheme in the building sector.

Information tools

Policy makers have been paying increasing attention to information tools as a means to reduce energy use in the building sector. Many countries have recently introduced new environmental labelling schemes for buildings, which can be classified into three categories (Box 1).

Box 1. **Three types of environmental labelling schemes for buildings**

1. Mandatory Energy Labelling

- Labelling is obligatory.
- Scope of assessment is limited to energy efficiency.
- Mainly applied for dwellings.

2. Voluntary Environmental Labelling

- Labelling is voluntary.
- Scope of assessment covers main environmental characteristics (*e.g.* energy efficiency, use of recycled materials, indoor air quality).
- A large number of performance items are indicated.
- Mainly applied for commercial buildings.

3. Voluntary Comprehensive Labelling

- Labelling is voluntary.
- Scope of assessment covers not only environmental attributes but also others.
- A small number of performance items are indicated.
- Mainly applied for dwellings.

Mandatory energy labelling for buildings. The first category is mandatory energy labelling, which is an obligatory labelling scheme to provide information on the energy efficiency of buildings to potential buyers. This type of labelling has been introduced in six European countries. For instance, in the UK, as of the beginning of 2001, all new dwellings are required to carry an energy label to provide prospective buyers with information on each home's energy efficiency.

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Voluntary environmental labelling for buildings. The second category, voluntary environmental labelling, may be the most common form of environmental labelling. This type of scheme is used on a voluntary basis, and the assessment criteria are not limited to energy efficiency and cover a wide variety of environmental attributes of buildings. Many schemes in this category have been developed across countries and seven of the schemes were reportedly established with a commitment from government. One of the best known examples is the Building Research Establishment Environmental Assessment Method (BREEAM) in the UK where various environmental aspects of buildings, such as energy efficiency, indoor air quality and use of recyclable materials, are assessed.[5]

Voluntary comprehensive labelling for buildings. The third type of labelling scheme, voluntary comprehensive labelling, has been introduced only in four countries. Under this scheme, the information that is provided for potential buyers is not limited to environmental characteristics, such as energy efficiency, but to other basic characteristics as well. Under the Qualitel scheme in France, seven performance parameters, including energy efficiency, are rated and a label is issued to houses which receive a rating greater than "3" for all performance parameters.[6] A similar scheme, the Housing Performance Indication Scheme, was implemented in Japan in 2001.

Environmental labelling for building materials and products. While labelling schemes for buildings are intended mainly to provide reliable information to clients, labelling for building materials and products aims to help designers by providing information on the environmental characteristics of building materials and products. Environmental labelling schemes for building materials and products mainly deal with issues of waste minimisation and indoor air quality that often affect the choice of materials. One of the few reported examples dealing strictly with energy efficiency is the Energy Star Products Scheme in the US which grants a special label for products that meet specific energy efficiency standards, including heating/cooling appliances, lighting, insulation and windows.

Other information tools. Other measures implemented in ten countries aimed at building designers include recommended standards or guidelines. For instance, the Swiss Federal Office of Energy has established E2000 Eco-building standards to promote the design of energy efficient buildings. Life-cycle assessment of environmental impact is important in building design, and as a result many software applications for life-cycle assessment of buildings have been developed – some with government support.

3.1.2. *Reduction of embodied energy*[7]

Few policies have been implemented for the purpose of reducing the energy used in construction processes, including manufacturing and transportation of building materials. In the UK, the Building Research Establishment is setting up an information database on the environmental impacts of building materials – including embodied energy. A similar project is being implemented in Australia, and the embodied energy of buildings will be rated in a labelling scheme of Greece. Besides these, no policy instruments have been reported for the reduction of embodied energy. Even environmental labelling schemes to assess environmental impacts of buildings in detail in many cases do not cover embodied energy.

3.2. Policy instruments for reducing CO_2 emissions from existing buildings

Government intervention for upgrading existing buildings has been modest compared to intervention for new buildings, although various policy instruments have been introduced in recent years aimed at existing buildings.

Regulatory instruments

Mandatory standards for building design. Traditionally, building regulations are limited to new construction, with an exception being the major refurbishment of existing buildings. This is the case with the energy efficiency standards of the regulation. An exception is a number of communities and states in the US that have implemented residential energy conservation ordinances (RECOs). RECOs are regulatory instruments that require owners of buildings to implement specific low-cost energy conservation measures at the time their building is sold or renovated.[8]

Obligation for utilities companies. Another regulatory approach is to obligate utilities companies to contribute to improving the energy efficiency of their customers' assets. Under the Utilities Act, the UK government is scheduled to set the Energy Efficiency Commitment obligation, which will be imposed on electricity and gas suppliers from 2002 to promote the energy efficiency of domestic consumers, with a special focus on low-income consumers.

Economic instruments

Capital subsidy programmes. A small number of countries reported having capital subsidy programmes for existing buildings, and two kinds of approaches were identified. First, both the UK and US have large-scale programmes aimed at low-income households. In the US, for example, about

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two-thirds of 200 000 single-family units and 20 000 multi-family units weatherised annually are treated under the Weatherization Assistance Program (DeCicco *et al.*, 1994) Second, the Dutch government reported implementing capital subsidy programmes for dwellings, the Energy Premium Scheme, but this do not take the income level of occupants into consideration.[9]

Premium loan schemes. The premium loan scheme is being used for improving the energy efficiency of existing buildings in four countries. For instance, in corporation with local financial institutions, many state and local governments are providing low-interest, fixed-rate loans in the US. Since 1996, the German government has implemented premium loan schemes which aim to encourage improving heating equipment and building envelopes of existing buildings.[10]

Information tools

Mandatory energy labelling for buildings. The survey indicates that three countries have implemented mandatory labelling for existing buildings that are put on the market. In Denmark, small buildings must be assessed according to prescribed criteria when they are sold, and large buildings must be assessed once a year. In France, under regulation introduced in 1996, standardised cost estimates of energy consumption must be presented for all buildings that are sold or rented. A mandatory scheme in Germany covers existing buildings when they are under major renovation.

Voluntary labelling for buildings. There are a few voluntary labelling schemes covering existing buildings. For instance, the German government recently introduced a voluntary labelling scheme for existing buildings. However none is reportedly being widely used for existing buildings.

Energy audit programmes. Five countries reportedly have implemented energy audit programmes that provide owners of buildings with technical assistance for upgrading the energy efficiency of buildings. For instance, the Energy Performance Advice programme in the Netherlands conducts building audits and gives recommendations on energy efficient measures, and the government provides the necessary computer programme as well as financial support.

3.3. Policy instruments for the minimisation of C&DW

Most of the reported policy instruments target C&DW in general or demolition waste; only three specifically target construction waste.

Since policy instruments for the minimisation of C&DW can be implemented at various stages in the life-cycle of buildings, this section examines at which stages the various policy instruments are best implemented:

- upstream stages: building design and construction for improving the waste-generation-related characteristics of buildings (*e.g.* recyclability, reusability, physical durability, etc.);
- demolition stages: demolition of buildings and disposal of wastes; and
- downstream stages: recycling and reuse of materials, and use of recycled materials in building design and construction.

3.3.1. Upstream stages

The waste-generation-related performances of buildings (such as the recyclability of the building materials and physical durability of buildings[11]) are mostly fixed at the design stage, yet there are few policy instruments aimed at improving these performances at this stage. Few countries have reported introducing regulatory or economic instruments in this area. Japan has introduced a premium loan programme for dwellings with a high level of physical durability.[12]

3.3.2. Demolition stage

Most of the reported policy instruments for minimising C&DW are implemented at the demolition stage.

Regulatory instruments

Since the mid-1990s, some European countries and Japan have implemented regulatory instruments with an aim to reduce the final disposal of wastes. In the European countries, most of these instruments were introduced after a landfill tax had been implemented for some time. Japan may be the first country that has introduced a major regulatory policy instrument (mandatory separation and mandatory delivery) without combining it with a landfill tax.[13]

Ban on landfill. In five European countries there is a total ban on landfilling a certain category of C&DW. The scope of the ban varies between countries (see Box 2), but the main objective is to prevent recyclable/reusable materials from being be disposed in landfill sites.

Mandatory separation and mandatory delivery of waste to processing facilities. Mandatory on-site separation of C&DW is one of the most common instruments for the minimisation of C&DW. In seven European countries and

Box 2. **Construction and demolition waste banned from landfill sites**[1]

Belgium (Flanders region) (From 1998)

Unsorted wastes

Denmark (from 1997)

Combustible wastes

Germany (from 2001)

Unsorted wastes

The Netherlands (from 1997)

Recyclable/reusable wastes (masonry and concrete rubble, metals, untreated wood, paper and cardboard, *etc.*)

Sweden (from 2002)

Combustible wastes

1. Hazardous wastes are regulated separately.

Japan there is a requirement to separate some C&DW materials from other materials on demolition sites. In Japan, demolition contractors are obligated not only to separate wood, concrete and asphalt on construction sites but also to deliver them to processing facilities. Three other countries also reported implementing such regulation.

Mandatory reporting and demolition permission. In four countries, it is required to submit the document describing how demolition waste will be treated to authorities, before demolishing buildings. For instance, in Sweden, a waste management plan must accompany the notification of demolition of buildings that is submitted to authorities, and it must explain what the destination of the waste will be. In four European countries, before starting demolition works, owners of buildings are required to obtain permission (demolition permission) from authorities by submitting similar reports.

Licensing system. Six countries reported that some demolition and disposal activities can be carried out only by those who have obtained licences from authorities. There is a licensing system for demolition contractors in Japan, Sweden and Germany. Some other countries have implemented a licensing system for facilities that process C&DW.

Economic instruments

Landfill tax. Landfill taxes are widely used in European countries. In total ten countries reported having introduced such a tax. The UK, Czech Republic, Italy and France – all of which have not implemented any of the main regulatory instruments discussed above – rely heavily on this instrument for minimising C&DW. Other countries, like Denmark[14] and the Netherlands, have implemented a landfill tax as part of their policy packages that also include main regulatory instruments. The landfill tax rate greatly differs between countries. For instance, while the rate for inert-waste is £2/tonne (about 3.2 euro/tonne) in the UK, in Denmark it is about 50 euro/tonne.

Information tools

Waste information exchange schemes. The only information tool reported for minimising C&DW at the demolition stage are a waste information exchange scheme and guidelines for the management of C&DW. In the UK, an Internet-based waste information exchange scheme has been established, and the Flemish waste agency in Belgium is operating a similar system.

3.3.3. Downstream stages

Regulatory instruments

The survey could identify only a few regulatory instruments applied for minimising C&DW at this stage of the life-cycle of buildings.[15] For instance, there is the Building Materials Decree that was introduced in 1999 in the Netherlands. The decree imposes a standard for the maximum amount of hazardous chemicals contained in materials, that could potentially damage surface water or soil.[16] It is expected that the decree will help to alleviate fears that recycled materials may leach hazardous chemical.

Economic instruments

Three kinds of economic instruments were identified, but they are used by a limited number of countries.

Virgin material tax. The use of a virgin material tax on building materials is limited to four European countries. In Denmark, an aggregate tax is levied on the quarrying of gravel. Finland also levies a control fee on gravel abstraction, and Sweden levies an excavation charge (OECD, 2001c). In the UK, a tax on virgin sand, gravel and rock (Aggregate Levy) is planned for 2002.

Premium loans. The only reported policy instrument that provides an economic incentive to use recycled materials is a premium loan scheme in Japan. The Japan Housing Loan Corporation has initiated a premium loan programme for dwellings that incorporate a certain amount of recycled materials.

Capital subsidy for processing plants. Only two countries reported providing financial support for facilities that process C&DW. The UK has been subsidising the purchase of crashing plants, and the Walloon government of Belgium is investing in recycling companies dealing with C&DW.

Information tools

Besides pilot projects and other general programmes for minimising C&DW, a few types of information tools were found, although they are used in a limited number of countries. Guidelines for dealing with demolition wastes are issued in three countries. For instance, regional authorities in Germany have issued guidance and information on how to increase the recovery of materials and reduce landfilling. Recommended standards regarding the use of recycled materials have been established in Germany and the Netherlands. In the Flanders region in Belgium, a voluntary certification scheme[17] for recycled aggregates has been developed. The certification is conducted on the basis of technical specification provided by authorities. In four countries, environmental labelling schemes for buildings include the use of recycled materials in their assessment criteria, and in six countries, labelling schemes for building materials and products cover the use of recycled materials.

3.4. Policy instruments for preventing indoor air pollution

Regulatory instruments

Regulation on ventilation. Minimum standards for air exchange through ventilation have traditionally been included in building regulations with the aim to keep indoor air fit for human health, and some countries have introduced new provisions to address the problem of indoor air pollution related to building-materials.

Regulation on the quality of building materials. Six countries reported using regulation to control the quality of building materials and products, in terms of the amount of pollutant source contained in the materials. In Denmark, engineered wood products can be used in buildings only when they have passed a control system approved by the government. In Germany, it is prohibited to sell engineered wood products that do not satisfy predetermined standards.

Economic instruments

No economic instruments were found in the survey that specifically address indoor air pollution, with the exception of a premium loan scheme and a capital subsidy programme in Norway.[18]

Information tools

Target values and guidelines. Various information tools were identified through the survey. The most widely used instrument in this area may be setting maximum target levels for the concentration of pollutants in rooms. Based on these targets, guidelines or other forms of information for dealing with this issue have been provided for both suppliers and consumers. Thirteen countries reported having set such target values or guidelines. For instance, the Swiss Federal Office of Public Health has established a checklist for a "first qualitative estimate" of indoor air pollution in existing buildings. In the US, a national educational programme for consumers and a technical assistance programme on indoor air quality management for building owners and managers have been introduced.

Environmental labelling schemes. Six countries have implemented environmental labelling schemes for buildings that have assessment criteria related to indoor air pollution. In seven countries, environmental labelling schemes for building materials and products are reported to have criteria on the quantity of pollutant sources contained in building materials and products.

Notes

1. Since there is a big difference in improving the energy efficiency of new and existing buildings, instruments for these sub-sectors will be discussed separately.
2. Although the subsidy is given to those who invest in building construction, the CBIP is not intended to cover a part of the capital cost, but to cover the extra cost of designing an energy efficient building.
3. The Japan Housing Loan Corporation provided premium loans for about 180 000 energy efficient homes in 2000.
4. Energy related taxes are defined as any compulsory, unrequited payment to general government levied on tax-bases deemed to be of particular environmental relevance.
5. Other examples in this category include ESCALE in France, EcoEffect in Sweden, LEED in the US, MINERGIE quality label in Switzerland, Green Home Scheme in New Zealand and the EcoProfile in Norway.
6. This scheme was applied to nearly 40% of newly built apartments in France in 2000.
7. The discussion in this sub-section can be applied to measures for reducing the energy used for refurbishing existing buildings.
8. RECOs usually target dwellings, but in some cases they also cover commercial buildings.
9. The Dutch government has also implemented a capital subsidy program, called TELI, which is targeting low-income households.
10. Federal states in Germany have also implemented premium loan schemes targeting low-income households.

11. The physical durability of buildings usually refers to the length of time that structural parts of buildings are expected to keep their basic physical performances, typically structural strength.
12. Germany, Korea and Japan have laws with a general recommendation to use more recyclable and recycled materials.
13. Japan's regulation on the management of C&DW has taken effect from the beginning of 2002.
14. In Denmark, an incineration tax has also been implemented.
15. A new Japanese law requires contractors to make efforts to use as much recycled materials as possible.
16. Under the decree, owners of buildings are required to confirm that only materials certified as meeting this standard are used in their buildings.
17. In this report, the "certification" of building materials is defined as an instrument to ensure the general performances of building materials such as strength, while "environmental labelling schemes" of building materials and products focus on their environmental performance.
18. For instance, up to 65% of the cost of implementing measures to address the radon concentration could be subsidised with a maximum of 20 000 krone (about € 53) in Norway, if the high level of radon concentration is identified.

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Chapter 4

Unique Characteristics of the Building Sector and Barriers to Improvement

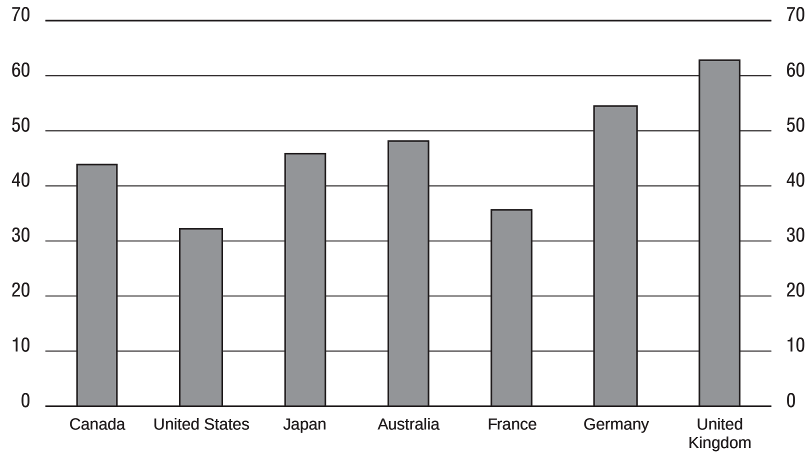
The building sector has several unique characteristics in terms of its product, production process, and the way the product is used. These unique characteristics have created specific barriers to improving the environmental performance of buildings and building activities. The first step in designing effective and efficient policies may be to better understand the nature of the barriers that government policies must address. This chapter provides an analytical framework for developing discussion on the design of environmental policies for the building sector. It identifies the unique characteristics of the building sector and the main barriers to improving the environmental performance of buildings, and shows how these are related.

4.1. Long-lived nature of products

Buildings are one of the most long-lived products across economic sectors. While the length of the service lives of buildings varies according to many factors, including location, materials, construction methods, and the way buildings are used and maintained, they usually last for several decades (Figure 10). The long-lived nature of buildings automatically results in a low turnover rate of the building stock and significantly affects the choice of policy instruments for the building sector. Table 4 shows the ratio of annual housing starts to housing stock in some OECD countries. The ratios appear to be well below those of other durable products. As indicated in Table 5, the equivalent ratios for automobile stocks[1] are much higher than for housing stock. Due to the low turnover rate, technical innovation cannot be easily incorporated into much of the existing building stock and, as a result, obsolete technologies have long been locked into existing buildings. The analysis of building shell conservation features in the US clearly indicates that older buildings tend to incorporate fewer energy efficiency measures (Figure 11). One of the biggest challenges is to upgrade the energy efficiency of existing buildings, which obviously would have a great impact on total energy use in the building sector.

Improving the energy efficiency of products usually means extra capital costs, but these are often recovered by a reduction in energy cost when using the products. Buildings are no exception. Life-cycle cost assessments often indicate that the extra capital cost of making energy improvements can be more than recovered from energy savings during the long service lives of buildings. However, consumers generally reject the efficiency option if their investment is not paid for through energy savings within a short time. Several

Figure 10. **Estimated average service lives of buildings and constructions in selected OECD countries[1] (years)**



1. Average service life is calculated using a delayed linear retirement pattern, in which the average service life is equal to the sum of the parts of the initial investment scrapped multiplied by the class average of their age over the total potential life of the investment. Dwellings are not included.

Source: OECD, *Industrial Sectorial Database* (1998 version).

Table 4. **Housing starts/housing stock ratios in selected OECD countries**

	Housing starts (A) 000s	Housing stock (B) 000s	(A/B)
Australia	107 (1998)	7 012 (1997)	1.7%
Canada	150 (1999)	11 768 (1999)	1.3%
France	286 (1995)	27 807 (1995)	1.0%
Germany	473 (1999)	37 984 (1999)	1.2%
Japan	1 215 (1999)	43 922 (1997)	2.8%
UK	199 (1995)	24 442 (1995)	0.8%
US	1 667 (1999)[1]	115 253 (1999)	1.4%

1. Privately owned housing only.

Sources: Australian Bureau of Statistics (2000a, 2000b); Canada Mortgage and Housing Corporation (2000); Statistics Canada (2000); European Commission (1998); Japanese Ministry of Construction (1999); US Census Bureau (2000b, 2000c), German Federal Ministry of Transport, Building and Housing.

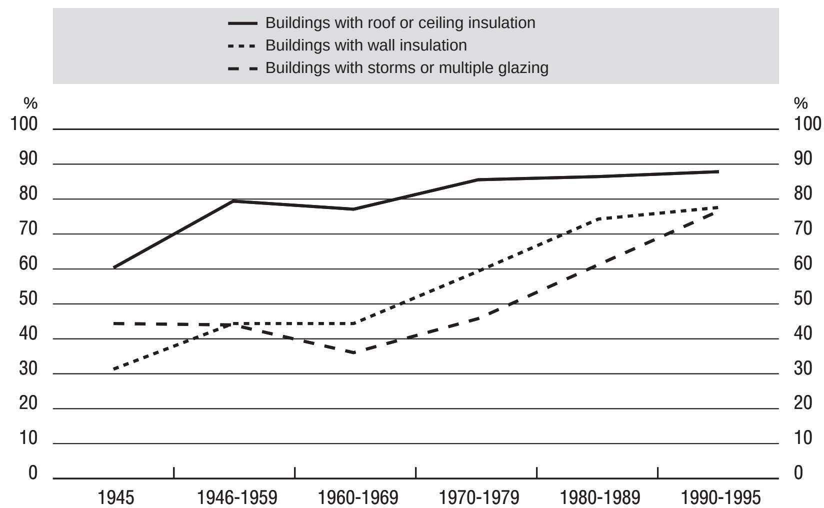
estimations suggest that discount rates for energy efficiency investment in housing insulation are at least 10%, and sometimes above 30% (Brill *et al.*, 1999). Consequently, there has been an "energy efficiency gap" between the most energy-efficient technologies available at some point in time and those that are actually in use (Jaffe *et al.*, 1999).[2]

Table 5. **New automobile registration/registered automobile stock ratios in selected OECD countries**

	New automobile registration (A) 000s	Registered automobile stock (B) 000s	(A/B)
Japan	5 861 (1995)	65 015 (1999)	9.0%
UK	2 486 (1995)	22 824 (1999)	10.9%
US	17 424 (1995)[1]	194 063 (1999)	9.0%

1. Total sales of new automobiles.
Sources: International Road Federation and the Automobile Manufacturers Federation of Japan.

Figure 11. **Building Shell Conservation Features in the US (by year)**



Source: US Energy Information Administration, 1998

Various explanations have been given for this "efficiency gap". They include the lack of information on the demand side, lack of expertise on the supply side, and principal-agent problems.[3] Moreover, although some energy efficiency investments in buildings can pay for themselves in a very short period of time, due to the longevity of buildings, there are some other investments which require a longer time to be paid back. In the latter case, investment appraisal may be difficult due to uncertainty regarding factors which affect the benefits from the investment, thus discouraging the extra investment. When making irreversible investments that can be delayed, this uncertainty can lead to an investment hurdle rate that is higher than the discount rate used by analysts who ignore this uncertainty (Jaffe *et al.*, 1999).

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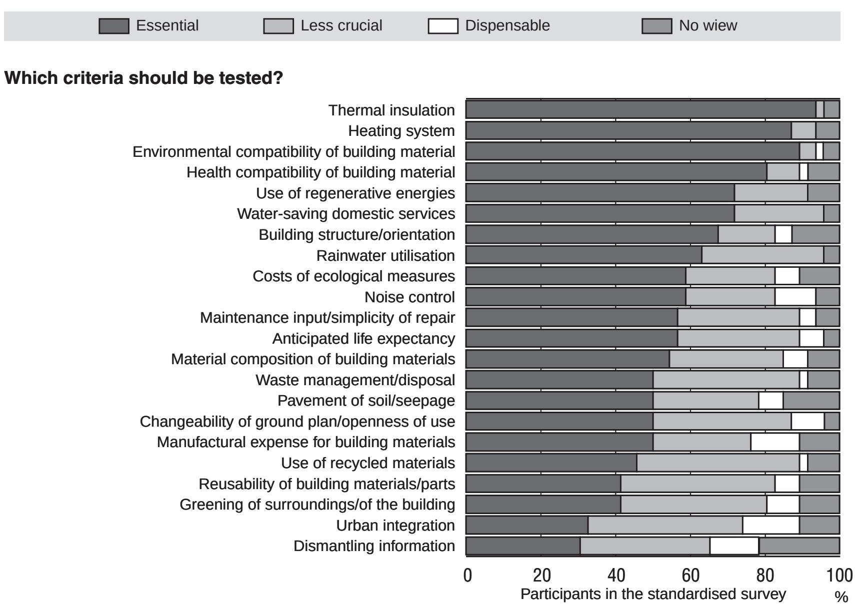
Narrowing down this efficiency gap is obviously quite important for achieving reductions in CO_2 emissions from the building sector.

The longevity of buildings also greatly affects the management of demolition waste. Long service lives imply that the demolition stage, where the demolition waste is generated, is far from the designing stage in the time scale. Consequently, for designers, contractors or their clients, the demolition of buildings is perceived as just something that will be done some time far in the future by someone else. Under such circumstances, it is not surprising that buyers tend to have little concern for the reusability and recyclability of buildings that they are going to buy.[4]

Figure 12 shows the results of a survey conducted in Germany on how stakeholders perceive the design of prospective environmental labelling schemes for buildings.[5] The results clearly indicate that stakeholders are more interested in environmental characteristics and features of buildings associated with direct economic benefits than in those that have little rapport with such benefits. While "thermal insulation" and "heating system" are regarded as "essential" criteria by more than 80% of respondents, most criteria

Figure 12. **Stakeholders' perception of environmental labelling schemes for buildings in Germany**



Source: Blum *et al.*, 1999.

related to waste management, such as "reusability of building materials" and "dismantling information", are perceived as having the least importance.

A similar trend can be identified in a postal survey asking 300 estate agents in the UK to gauge whether certain features of housing were valued very highly, moderately, or not at all by perspective purchasers. While "energy efficient space heating" was highly valued by 26% and moderately by 48% of the respondents, "environmentally friendly building materials" was considered of no importance by 80% (Rydin, 1992). The results of both surveys suggest that information tools such as environmental labelling schemes may be more effective for improving energy efficiency than for waste minimisation.

4.2. Extended supply chain

The lifecycle of products in the building sector is very extended and generally divided into the following stages:

- design and construction;
- use and refurbishment;
- demolition; and
- use of recycled/reused materials.

During each stage, different actors in the construction industry intervene which can have an impact not only on the buildings themselves, but also on the surrounding environment. For instance, the assembling of building materials and products is usually conducted on building sites by contractors. However, as buildings are composed of a wide variety of materials and building activities are supported by a number of different services, various industries are committed indirectly to the building sector. There are many actors involved at the demolition stage and use of recycled/reused materials stages as well. Demolition work on-site is usually conducted by specialised demolition contractors. Demolition wastes are conveyed to a landfill site, incineration site or processing facilities for recycling. Processed materials are then passed on to building material manufacturers who supply contractors with their products.

For policy makers, the complexity of the supply chain of the building sector means that many choices are possible at each point of intervention. Targeting the right points of intervention and the careful co-ordination of policy instruments are essential for implementing an effective and efficient policy package.

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4.3. Discrepancy between owners and users

A considerable proportion of buildings, whether residential or commercial, are currently rented to individuals and firms. As Table 6 shows, in selected OECD countries at least 30% of the housing stock is currently occupied by tenants. Commercial buildings also show a high rental rate. Compared to other main durable products, buildings probably show the highest level of discrepancy between owners and users.[6]

The owner/user discrepancy has caused "principal-agent" problems for improving the energy efficiency of rented buildings.[7] It is usually tenants who pay energy bills and benefit from improved energy efficiency, but this is generally not reflected in the rent level.[8] As a result, when landlords are taking decisions concerning the design of buildings, they have inadequate incentive to make an extra investment for energy efficiency. Data from the UK in 1986 demonstrate a low level of energy efficiency among rental dwellings compared with those that are owner occupied. While 31% of owner-occupied dwellings were in the top efficiency quartile, only 8% of dwellings with private tenants indicate a similar performance (Bell *et al.*, 1996). For policy makers, rented buildings may require a different approach than owner-occupied buildings.

Table 6. **Households by tenure in selected OECD countries**

	Owned	Rented
Australia (1997)	70%	30%
Canada (1999)	64%	36%
France (1995)	60%	40%
Germany (1993)	42%	58%
Japan (1997)	62%	38%
UK (1994)	67%	33%
US (1999)	67%	33%

Sources: Australian Bureau of Statistics (2000b); Statistics Canada (2000); European Commission (1998); Japanese Ministry of General Affairs (1998); US Census Bureau (2000c).

4.4. Spatially fixed nature of products and production processes, and heterogeneity of buildings

The building sector is distinguished by the physical nature of its production process and its products. A large proportion of the work involved in building a structure takes place at the site where the product will be used. Even if most building components are produced in factories, most of them are still assembled on-site and need site preparation and foundations. Although other industrial production processes are site-based and also subject to the vagaries of nature – particularly those which involve a physical transformation of land, like agriculture, forestry and mineral extraction – few combine a spatial fixity of production and product such as occurs in construction (Ball, 1989).

Most buildings are designed and constructed in the "custom-made" manner – that is, individual buildings are designed to satisfy specific requirements of clients in light of the specific conditions of the site, such as its area and shape, flexibility of the ground, climate of the area, surrounding environment, including the situation of neighbouring buildings, and infrastructures. This is largely due to the spatially fixed nature of the products and production processes in the building sector, as well as the considerable power of buyers to incorporate their preferences into the design of buildings. The unique nature of the building sector has led to the low level of standardisation in the design and production of buildings and the failure to exploit the economies of scale resulting from limited repetition (Finkel, 1997).[9]

The low level of standardisation – or, in other words, the high level of flexibility – in the design of buildings can be illustrated by comparing the number of different kinds of components used for housing with those used for automobiles. Toyota, one of the largest automobile manufacturers, also supplies prefabricated housing in Japan.[10] Toyota's most popular car model consists of about 1 800 kinds of components that are assembled at their factories (*e.g.* side-view mirror) and about 3 700 (twice as many) alternatives for these components (*e.g.* standard side-view mirror, wide side-view mirror, *etc.*). The number of alternatives is largely due to the need for automobiles to satisfy different regulations in different countries. On the other hand, the most popular model of prefabricated housing is comprised of 1 900 kinds of components (*e.g.* window frames), but around ten times as many (some 19 000) alternatives for these components (*e.g.* wooden window frame, aluminium window frame *etc.*) are available. This allows for considerable flexibility in design (Table 7).[11]

Table 7. **Average total number of options per kinds of components for one unit of automobile and housing**

	Number of kinds of components used in one unit[1] (A)	Total number of alternatives for all components (B)	Average total number of alternatives per kinds of components (B/A)
Automobile	1 800	3 700	2
Housing	1 900	19 000	10

1. The number of kinds of components assembled in factories for producing the models that had the largest sales in 1999 (excluding small units for connecting components such as bolts and nuts).
Source: Toyota Ltd.

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For prospective buyers who are looking at what is on the market, it is not easy to understand the level of performance of poorly standardised products like buildings, especially when this concerns invisible performance such as energy efficiency. A "standardised" model of product manufactured under standardised quality control methods can undergo laboratory tests that provide results, but this is not feasible for actual buildings. Consequently, prospective buyers tend to lack information on the quality of buildings unless they conduct costly assessments.

The custom designed nature of buildings also has a large impact on administrative cost. Implementing policy instruments in this sector often requires authorities to check whether the design of a certain building meets prescribed standards. Due to the large heterogeneity in building design, site-by-site inspections are usually required which effectively pushes up administrative cost.

4.5. High capital cost

Buildings are products that require a significant amount of capital expenditure to construct or purchase. One reason for the high capital cost is that buildings are fixed to land whose supply is basically limited and the purchase of buildings usually includes that of the land. For instance, consumers usually buy housing that costs several times as much as their annual household income (Table 8).

As a result of such high capital costs, buyers of housing tend to have fewer opportunities to participate in the building market than in markets for cheaper products, preventing consumers from "learning by buying". In other words, consumers often have limited opportunities to obtain valuable information through past transactions in the building market. The results of a

Table 8. **Housing price/household income ratio in selected OECD countries**

Country	Year	Average price of new housing (A)	Average household annual income (B)	(A/B)
Germany	1996	533 695	95 169	5.61
Japan	1998	44 059 000	8 079 000	5.45
UK	1998	83 900	22 358	3.75
US	1998	152 500	46 737	3.26

Notes: House price and household incomes are indicated in each country's currency at the time of survey. The definitions of average house price and average household income are as follows: Average housing price: Average estimated cost of construction (Germany); average price of new detached housing financed by the Japan Housing Loan Corporation (Japan); median price of new housing financed by housing societies (UK); median price of new detached housing (US). Average household income: Average household income (Germany); average household income (Japan); average income of households financed by housing societies (UK); median household income (US).
Source: Japanese Ministry of Construction, 2000.

survey conducted by the Japan Housing Loan Corporation indicate that out of 3 800 consumers who had bought housing sometime during the last five years, 60% of them felt that they did not have sufficient information on the quality of the housing at the time of transaction (Japan Housing Loan Corporation, 1999). In a situation where environmentally friendly measures are not commonly integrated into building design, it is likely to be very difficult for buyers – as well as for those who are supposed to advise them – to obtain precise information on the cost of integrating environmentally friendly measures. In a survey, quantity surveyors (cost consultants) in the UK indicated that more energy efficient and environmentally friendly buildings require an increase in capital cost by 5-15%, although the additional cost should not be more than 1%, even if the building design has many environmentally friendly features (Bartlett *et al.*, 2000). Thus the lack of precise and reliable information on the demand side associated with high capital cost is one of the main barriers to improving the environmental characteristics of buildings.

4.6. Dominance by a large number of small firms

The construction industry is characterised by the dominance of a large number of small-scale builders. The proportion of firms in this sector employing fewer than 10 persons was 81% in the US (US Census Bureau, 2000a), 93% in EU countries (European Commission, 1993) and 75% in Japan (Japanese Management and Co-ordination Agency, 1996). The average number of employees in construction firms in some OECD countries is no more than 9 (Table 9).

The dominance of small-scale firms can be largely explained by the poorly standardised production process in the building sector that makes it difficult to exploit economies of scale. Small firms generally do not have specialised staff for research and development and are slow to adapt to new technologies. According to a survey of 12 000 housing contractors in Japan, the

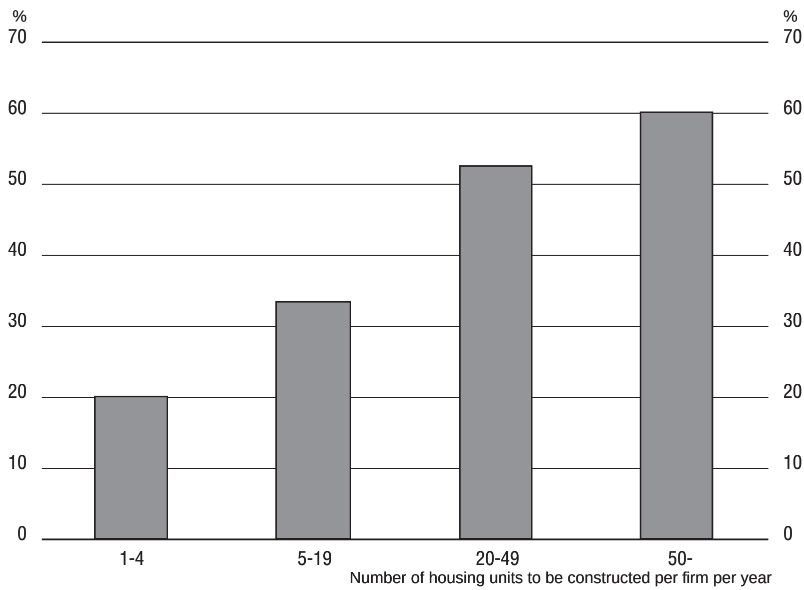
Table 9. **Average number of employees per firm in the construction industry**

Country	Year	Number of employees 000s	Number of firms 000s	Average number of employees per firm
Australia	1996	484	194	2.5
Japan	1999	5 090	612	8.3
UK	1999	959	166	5.8
US	1997	5 665	656	8.6

Sources: Australia Bureau of Statistics, 1999; Japanese Ministry of General Affairs, 1999; UK Department of Environment, Transport and the Regions, 2000a; US Department of Commerce, 2000.

size of firms – in terms of the number of housing units they build per year – is closely related to the introduction of new energy efficient technologies. While 60% of contractors supplying more than 50 units per year responded that they were prepared to supply highly energy efficient housing, only 20% of those supplying fewer than 5 units per year answered that they were prepared to supply such housing (see Figure 13). It appears that government support for the dissemination of technical information among small-scale firms is particularly important in the building sector.

Figure 13. **Percentages of contractors prepared to supply highly energy efficient housing in Japan**



Source: Organisation for Housing Warranty, 1996.

Notes

1. Automobiles and buildings are two examples of the few products that have relatively long service lives, and that are used by a great number of individual consumers and firms.
2. It is also argued that potential energy saving is often overestimated, and there is a large difference between anticipated performances and actual performances (Jaffe *et al.*, 1999, Metcalf *et al.*, 1997, Cole, 1998).
3. Principal agent problems are discussed in Section 4.3.

4. The lack of concern is also attributive to the fact that the environmental cost of generating waste is not fully internalised in the decisions by those in the supply chain.
5. A total of around 160 association/institutions of designers, owners, tenants and estate agents were contacted, and 46 responded.
6. Another example of durable goods characterised by the owner/user discrepancy may be automobiles. However, the proportion of automobiles for leasing and rental is not as large as for housing. For instance, automobiles for rental and leasing account for 3% in Japan (1996) and 9% in the UK (1999), and 4% of automobiles are leased in the US (1994, excluding those for rental) (Sources: Japanese Car Leasing Association, Japanese Car Rental Association, and the British Vehicle Rental and Leasing Association).
7. Principal-agent problems can arise when energy efficiency decisions are made by parties other than those who pay the bills (Jaffe *et al.*, 1994*a*).
8. Landlords commonly do not provide information on the energy efficiency of their buildings for prospective tenants.
9. This does not apply to manufacturing of building materials and components.
10. Toyota supplied about 3 300 units of prefabricated housing in 1999.
11. It is important to note that housing is not exported like automobiles, and that it is prefabricated and thus much more standardised in design and production process than other housing.

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Chapter 5

Policy Instrument Options for Environmentally Sustainable Buildings

Policy makers in government have various policy instrument options to choose from, each of which has specific strengths and weaknesses. They need to take the characteristics of all of these instruments into consideration when they are trying to choose the most appropriate instrument. In order to provide insight for making such a policy choice, the OECD Secretariat has undertaken two kinds of studies. One is an analytical study on the characteristics of the main policy instruments that can be used for the building sector (OECD, 2001d). On the basis of a review of the relevant literature, the study assesses the strengths and weaknesses of the main policy instruments, and examines how theoretical arguments regarding the design of environmental policies in other sectors can be applied to the building sector. The other study, which is based on case studies of policy instruments implemented in several OECD countries, aims to find empirical evidence that could indicate how effective these policy instruments have been (OECD, 2001e). This chapter presents the main findings from both the theoretical and empirical studies, as well as draw links and identify contradictions between the two studies. After describing the evaluation criteria used in both studies in Section 5.1, results of the studies will be presented according to policy objectives in Sections 5.2-5.5. Since the studies focus on three principal policy instruments – regulatory instruments, economic instruments and information tools – discussions in these sections will focus on these three instruments. Characteristics of other policy instruments (*i.e.* greener public purchasing, support for R&D and technology diffusion, and voluntary instruments) will be discussed in Section 5.6. This will be followed by some conclusions on the characteristics of policy instruments (Section 5.7).

5.1. Criteria for the evaluation of instruments

In the following sections, the strengths and weaknesses of policy instruments will be discussed according to the following four criteria:

Environmental effectiveness

Environmental effectiveness relates to the environmental impact and performance of the instrument studied, *i.e.* how much the instrument contributes to the achievement of the policy objective (if defined), or to reductions in emissions (if no specific policy objective is defined).

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Economic efficiency

Economic efficiency refers to the extent to which a policy instrument has enabled a least-cost achievement of an environmental objective. The cost may be described as the direct economic cost – incurred by both businesses and households/individuals – of bringing about the changes in behaviour to minimise environmental impacts that the policy is aiming to achieve.

Incentives for innovation

Incentives for innovation refer to how much a policy instrument stimulates innovation and diffusion of more cost-effective technologies. In general this depends on whether policies can provide polluters with lasting incentives to reduce their adverse impacts on the environment.

Administrative costs

These refer to the administrative cost burden imposed on the public authorities responsible for applying the policy instrument. They also include the administrative burden of environmental policies borne by the private sector.

In addition to these four criteria by which environmental policy instruments are usually evaluated, other criteria – such as acceptability, distributive effects and necessity of tax revenues, *etc.* – will be used when relevant in the following sections.

5.2. Policy instruments for reducing CO_2 emissions from new buildings

It is widely argued that a large reduction in CO_2 emissions from the building sector could be achieved solely by diffusing available energy efficiency technologies. For instance, in the EU, it is estimated that an energy saving potential of about 22% exists in the energy consumption for space and water heating, air-conditioning and lighting[1] (European Commission, 2001b). However, as discussed in Section 4.1, those who invest in building construction tend to significantly discount the future benefit of energy efficiency improvement, and pay much more attention to the minimisation of capital cost. As a result, there is a great gap between the most energy efficient technologies available and those that are actually being used. The main issue of policy design in this area may be how to explore the great energy saving potential of the building sector by narrowing the energy efficiency gap.

OECD countries have introduced various policy instruments for this purpose. The main policy instruments for reducing CO_2 emissions from the building sector are shown in Table 10. Those indicated in the second column target new buildings, and will be discussed in this section.[2] As discussed in

Table 10. **Main policy instruments for reducing CO_2 emissions from the building sector**

Policy instruments	New buildings	Existing buildings
Regulatory instruments	• Technology-based standards for the design of buildings • Performance-based standards for the design of buildings	• Technology-based standards for the design of buildings • Performance-based standards for the design of buildings • Imposition of obligation on utilities companies
Economic instruments	• Energy taxes • Taxes imposed on investors • Tradable permit schemes • Capital subsidy programmes • Tax credit schemes • Premium loan schemes	• Energy taxes • Tradable permit schemes • Capital subsidy programmes • Tax credit schemes • Premium loan schemes
Information tools	• Mandatory labelling schemes • Voluntary labelling schemes	• Energy audit programmes • Mandatory labelling schemes • Voluntary labelling schemes

Section 3.1, most of the instruments for reducing CO_2 emissions from the building sector target new buildings in OECD countries. This concentration of policy implementation on the new building sector can be justified, to some extent, by the fact that energy performance of buildings is largely fixed at the time of new construction. Moreover, many of the energy efficiency measures can be incorporated into buildings with the least additional cost at the time of new construction.

5.2.1. Regulatory instruments

Mandatory standards for the design of building

The appropriate design of buildings is crucial for protecting occupants from structural problems, fires, *etc*. This is the main reason why the design of buildings has long been tightly regulated in OECD countries. Those who intend to construct new buildings are generally required to submit technical documents to authorities and have their plans approved before starting construction. Authorities also conduct on-site inspections during, and at the completion of, construction work.

After the oil shocks in the 1970s, building regulations were extended in many countries from traditionally regulated areas to include the energy efficiency of buildings. The energy efficiency standards usually include the maximum limit on the U-value[3] for each building component[4] or heating load under presumed conditions, as well as a maximum air exchange rate. Heating,

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cooling, ventilation and lighting equipment are also sometimes covered by the regulation.[5]

A regulatory approach to the design of buildings can be seen as the most dependable way to achieve a given goal of energy efficiency; and the effectiveness of regulatory instruments is hardly affected by market barriers. For instance, prescribed standards can be met even in the rented sector that is characterised by principal-agent problems. Nonetheless, the effectiveness of regulations is often constrained by practical obstacles. First, it is often difficult to set standards that are strict enough to produce real improvements because of stakeholder opposition. Consequently, standards are sometimes set below existing standards of practice, affecting only a limited number of buildings. Moreover, to keep in line with the diffusion of new technologies, minimum standards need to be upgraded flexibly, but such revisions are often hampered by opposition from industry as well as by time-consuming administrative procedures.

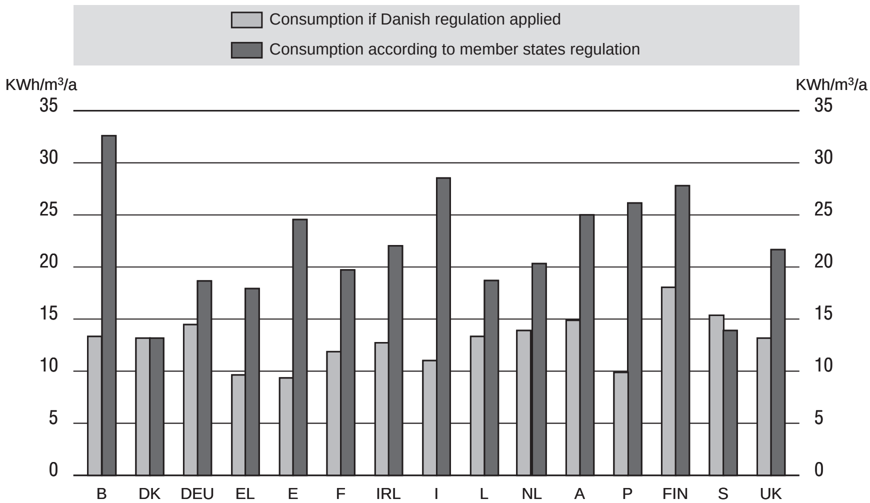
Second, there are some factors that considerably affect the energy efficiency of buildings but are not usually captured by standard monitoring and inspection processes. For instance, the air tightness of building envelopes is affected by the quality of on-site construction work and is difficult to check under the usual inspection processes. The introduction of post-construction pressurisation testing for air-leakage may solve the problem, but also increase the administrative cost. Thus, there appears to be a trade-off between the effectiveness of enforcing regulations and administrative costs.

Few empirical studies have been undertaken to examine the effectiveness of building regulation in upgrading energy efficiency and reducing energy use in buildings. In the context of the US, econometric estimates of the impacts of building regulations on diffusion of energy conservation measures suggest that building codes made no significant difference in observed building practices in the decade 1979-1988 in the US (Jaffe *et al.*, 1994b). On the other hand, *ex post* evaluation of the 1995 revisions to building regulations in the UK found that the goal of a 25% improvement in energy efficiency was successfully attained. While depending on the context of each country, the enforcement system of building regulation has a long history and has been repeatedly improved, and it can be assumed that energy efficiency standards are generally well enforced in OECD countries. Therefore the main factor which will affect the effectiveness of such regulation may be how high the standards can be set.

The analysis of thermal regulation standards in EU countries shows that there is a great difference between countries, even when climatic differences are taken into account (Figure 14). The figure also indicates that energy

Figure 14. **Comparison of energy consumption applying the model building regulation in Denmark to each EU country (climate-corrected)**

KWh/m³/a



Source: European Commission, 2001b.

consumption in most EU countries could be largely reduced by introducing Danish energy efficiency standards.[6]

One approach to significantly upgrade energy efficiency standard levels may be for governments to set and announce long-term strategies for energy efficiency improvement in the building sector. By establishing a time frame for future energy efficiency standards, stakeholders may be incited to prepare for the new standards and be more willing to accept them. For example, in 1998, the UK government announced that energy efficiency standards would be largely revised with several steps by 2005, and possible options for revisions would be made public and widely discussed among the various stakeholders.

In general, building regulations have long relied on uniform technology-based standards. In the context of other building performances such as structural strength and fire safety, it has often been pointed out that such standards should obstruct the use of new cost-effective technologies, and have effect to discourage the innovation.

Nonetheless, in recent years, OECD countries have been trying to improve the economic efficiency and increase the incentive for innovation of building regulations by introducing performance-based standards (Box 3). Introducing performance-based standards in the context of the building sector does not mean that these will replace technology-based standards. Many of the actual

Box 3. **Performance-based standards in building regulations**

Australia

A new model building code that includes performance-based standards – the Building Code of Australia – was introduced in 1996.

Canada

A model building code, including performance-based standards, is scheduled to be established by 2003.

Germany

Performance-based standards were put in force in 2002, addressing both new and existing buildings.

Japan

Performance-based standards were incorporated into building regulations in 1998.

New Zealand

A performance-based building code was introduced in 1991.

UK

An amendment to building regulations in 1991 introduced performance-based standards.

US

The draft of a model building code, that includes performance-based standards, has been proposed and will be adopted in 2002.

Source: Beller *et al.* (2001).

performances of buildings cannot be measured at a reasonable cost. Therefore, under performance-based standards, those who intend to construct buildings are required to prove that the anticipated performances of their buildings will satisfy the standards. This process often requires regulated bodies to conduct complicated calculations and laboratory tests, and to obtain certificates from approved organisations. Under such circumstances, it may be appropriate to let regulated bodies choose between technology-based standards – which do not entail large administrative costs but also do not allow for flexibility in design – or performance-based standards.

In line with this general trend in building regulation, energy efficiency standards have been repeatedly revised in OECD countries so that more flexible methods for proving compliance could be provided. For instance, under building regulations in the UK, there are three options for proving compliance with energy efficiency standards of dwellings (Box 4).

Implementation of performance-based standards may reduce the overall compliance cost to some extent by allowing regulated bodies to use more cost-effective design and technologies, but this will not improve the cost-effectiveness of allocating energy efficiency improvement between regulated bodies. More important, however, it is expected that the implementation of performance based standards will greatly increase the incentive for innovation.[7]

Few empirical studies have been undertaken on these aspects of building regulation. For instance, if there are great disparities in the marginal cost of improving energy efficiency, then energy efficiency standards would in effect impose higher compliance costs than the least-cost solution. However, the scale of these disparities has not been fully analysed, and there may not be useful empirical data to indicate to what extent building regulations are

Box 4. **Three methods for proving compliance with energy efficiency standards of dwellings in the UK**

a) Element method

- Proves that the U values of each building component are below prescribed maximum levels.

b) Target U-value method

- Allows for the flexible trade-off of U-values between elements in the building fabric – walls, windows, roofs and floors – within generous U-value maxima. The trade-off includes the heating system and solar gains from window orientation.

c) Energy-rating method

- Rates the predicted annual energy cost of a house on a scale from 1 (inefficient) to 100 (efficient), based on calculations of ventilation, heat loss, fabric heat loss, hot water consumption, internal gains, solar gains, and so on. If a rating of 80 to 85, dependent on dwelling size, is achieved, then compliance has been demonstrated. Thus a trade-off between the greatest number of sub-systems is possible.

Source: Gann *et al.*, 1998.

inefficient relative to the least-cost solutions, and to what extent the economic efficiency could be improved with the introduction of performance-based standards. Further studies on these aspects of building regulation need to be undertaken.

In general, controlling the design of buildings involves considerable costs. Due to the poor standardisation of product design and production processes in the building sector, standard quality control methods[8] that are widely used in the manufacturing sector cannot be applied to the construction industry. In addition, many building performances cannot be easily checked once construction work has been completed. Consequently, the effective enforcement of building standards requires detailed checking of design documents and on-site inspection of individual buildings by technical experts. These costs are basically incurred by prospective owners of buildings in the form of application fees to be paid to inspecting bodies.

It is also important to note that the current regulatory framework would be still be needed even if building regulations did not cover energy efficiency. This means that the enforcing energy efficiency standards does not require as much administrative cost as establishing an entire regulatory framework.[9] In many OECD countries, building inspection has traditionally been the guarded domain of local authorities, but some countries have allowed private bodies to conduct inspections so as to provide more efficient services for applicants. For example, in the UK, private bodies certified as Approved Inspectors by the Government, have been allowed to carry out building control since 1985, and there are now more than 30 of these. Through market competition, one of the approved bodies – NHBC Building Control Services Ltd – has decreased the application fee by 25% between 1985 and 2000. The UK experience suggests that in order to reduce administrative cost, it may be important to promote competition among inspecting bodies by allowing new private bodies to enter the building inspection market.[10]

5.2.2. Economic instruments

Subsidy programmes and tax credit schemes

Subsidy programmes and tax credit schemes aim to encourage potential owners of buildings to invest more in energy efficiency measures by reducing the capital cost burden. Capital subsidy programmes provide those investing in the construction of buildings with subsidies to help meet the cost of incorporating energy efficiency measures into the buildings. Similarly, tax credit schemes usually allow a part of the cost of investing in energy efficiency measures to be exempted from, for instance, income or corporation tax. Box 5 shows one example of a capital subsidy programme, the Commercial Buildings Incentive Program (CBIP) in Canada.[11]

Box 5. **Commercial Buildings Incentive Program in Canada**

- The Commercial Incentive Program in Canada offers a financial incentive to incorporate energy efficiency features into new commercial buildings.
- It has funds of approximately 6 million CAD per year.
- The target of the programme is to improve energy performance by 25% or more compared to the national model code level.
- The subsidy equals two times the annual predicted energy cost saving, up to a maximum of 60 000 CAD.
- Participants are also provided with a design support tool.
- At present, about 300 projects have been accepted into the programme.

Source: Natural Resource Canada.

Like other policy instruments, capital subsidies can have both positive and negative effects. As buyers of buildings tend to make much of capital cost and adopt high discount rates, capital subsidies could have a greater effect on investment decisions regarding energy efficiency measures than instruments which increase running costs, such as energy taxes. On the other hand, capital subsidies generally do not follow the Polluter Pays Principle.[12] Moreover, the effectiveness of the subsidy could be largely compromised if a significant proportion of total subsidies or tax credits goes to free riders, that is, to programme applicants who would have made the same energy efficiency investments even without the programme. Furthermore, introducing subsidy programmes inevitably requires tax revenues, and in a time of fiscal constraints on public spending this raises questions about the feasibility of subsidies that would have to be sizeable enough to have the desired effect (Jaffe *et al.*, 1999). As a result, it is unlikely that capital subsidy programmes or tax credit schemes could have a major impact on a wide range of building activities, though they could be effective in attaining well-focused objectives, such as the rapid diffusion of efficient technologies in a specific area.

Empirical evidence related to capital subsidies is generally consistent with these arguments. There are some empirical studies which show that the reduction of capital cost may have more impact than an increase in energy cost. Econometric estimates of the impacts of changes in energy prices and capital cost on the diffusion of energy efficiency measures in

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residential buildings suggest that capital subsidies would have greater effects than energy taxes of the same magnitude (Jaffe *et al.*, 1994*b*).[13] Hassett and Metcalf found in their study that tax credits or deductions are many times – about eight times – more effective than "equivalent" changes in energy prices (Hassett *et al.*, 1995). Also, the case study on the Commercial Building Initiative Program (CBIP) in Canada suggests that the programme has much potential to influence the decisions of investors. According to a survey of 35 projects in the CBIP, 41% of the respondents answered that the performance of buildings covered by the programme was "much better" than that of the respondents' other buildings, and 53% replied that performance was "better" (Table 11).[14]

With regard to the scale of free riders, some studies indicate that the proportion of free riders is significant. An evaluation of the capital subsidy programme for energy efficient commercial and industrial buildings in Norway indicated that the proportion of free riders is 50-70% (IEA,1997a). According to a survey conducted in 1984 in the US, 88% of the respondents who had claimed tax credits for energy efficiency measures in buildings asserted that they would have made the same expenditures without the tax credits (US Congress Office of Technology Assessment, 1992). As the scale of free riders is a very important factor in the effectiveness of capital subsidy and tax credit programme, policy makers should strive to minimise the proportion of free riders when designing such programmes. For instance, if a subsidy programme is designed so that constructing buildings with only a modest level of energy efficiency will suffice to obtain subsidies, then the proportion of free riders will be very high. In this context, it is important to regularly monitor the energy performance of newly built buildings and provide subsidies only when buildings with energy performances well above average are constructed. Finally, the case study on the CBIP found that it is unlikely

Table 11. **Results of survey on applicant's view of changes in performance**

Relative to buildings usually built by respondent, the performance of buildings enrolled in the programme is	Energy	Indoor air quality	Illumination
Much worse (1 point)	0%	0%	0%
Worse (2 points)	0%	0%	2.9%
No difference (3 points)	5.9%	28.1%	32.4%
Better (4 points)	52.9%	37.5%	52.9%
Much better (5 points)	41.2%	34.4%	11.8%
Average points	4.4	4.1	3.7

Source: Natural Resource Canada.

that the programme could be extended to cover a significant proportion of new office buildings because of fiscal constraints.

The economic efficiency and incentives for innovation that subsidy programmes or tax credit schemes generate may depend highly on the design of the programmes. These programmes can be categorised into three groups (Box 6). Type I can exploit differences in the marginal cost of improving energy efficiency between buildings and firms in order to lower the overall cost of the improvement. In addition, Type I can provide continuous incentives to look for further cost-effective ways of improving energy efficiency; however, this type of programme may entail the highest administrative cost. Conversely, Type III can be characterised as having the lowest economic efficiency, providing the least incentives for innovation and entailing the least administrative cost. There is a trade-off between economic efficiency and incentives for innovation on one side, and administrative cost on the other.

As with other types of policy instruments, few empirical studies exist on the economic efficiency and impact of capital subsidies on innovation. The case study also could not provide any empirical data to illustrate these aspects of capital subsidies.

In comparison with building regulations, it is presumed that subsidy programmes and tax credit schemes are likely to result in higher administrative costs. Type I programmes or schemes usually require relatively complicated calculations of predicted energy use, and even with the other two

Box 6. **Three types of subsidy programmes and tax credit schemes**

Type I

- To give subsidies/credits in proportion to the reduction of predicted energy use from a certain baseline figure.

Type II

- To give lump-sum subsidies/credits when prescribed performance-based standards are met.

Type III

- To give lump-sum subsidies/credits when prescribed technology-based standards are met.

Source: OECD, 2001b.

types of programmes or schemes, compliance with prescribed standards has to be checked in the same way as under building regulations. In general, subsidy programmes require more complex administrative procedures and cost burdens, and if they are conducted separately from existing regulatory frameworks, their administrative costs will be much higher than for the regulation. While the provision of tax credits is not selective and there is no actual transfer of money,[15] subsidy programmes generally do require more complex administrative processes for checking and approving applications, as well as for the actual transfer of money.

The case study on the CBIP, which is categorised as a Type I programme, found that the administrative cost directly attributed to each application is estimated to be in the range of 3 000-4 000 Canadian dollars (about US$2 000-2 500). However, the cost of adapting building energy use software for Canadian conditions, developing other design tools, and improving the standard are not included in this estimate.

Premium loan schemes

Premium loan schemes usually provide loans with lower interest rates than the market level for those investing in energy efficiency measures, and they can also upgrade the maximum limit of loans. The economic rationale for providing such advantageous loans could be that owners of buildings would be able to repay the loans with energy savings from energy efficiency measures. One example of such a scheme is the Japan Housing Loan Corporation's loan programme in Japan. According to the OECD survey, Japan is the only country that does not incorporate energy efficiency standards into building regulation. Instead, a premium loan programme has been the main instrument for improving energy efficiency of new dwellings in Japan.

The Japan Housing Loan Corporation (JHLC) is a housing finance institution that was established in 1950 by the Japanese government to improve the living standard in Japan. Since then, the JHLC has provided long-term housing loans with low and fixed interest rates for more than 18 million home buyers with financial resources that come mainly from the postal saving system. In response to growing public concern over energy supply after the oil "shocks" in the 1970s, the JHLC started to offer premiums in 1980 to those who purchased dwellings satisfying the recommended energy efficiency standards established by the Japanese government.

In line with the diffusion of energy efficiency measures and the development of new technologies, recommended standards have been revised three times. Today, premiums – in the form of lower interest rates and upgrades of the maximum loan amount – depend on the level of energy efficiency that is attained. For instance, only those satisfying the most recent

Table 12. **Premium for energy efficient dwellings under the JHLC Housing Loan**

	Interest Rates (June 1st, 2001)	Additional Loan
> 1999 standard	2.55%	2.5 million yen per unit
> 1992 standard	2.55%	1.0 million yen per unit
> 1980 standard	2.65%	——
< 1980 standard	(not eligible for JHLC loans)	

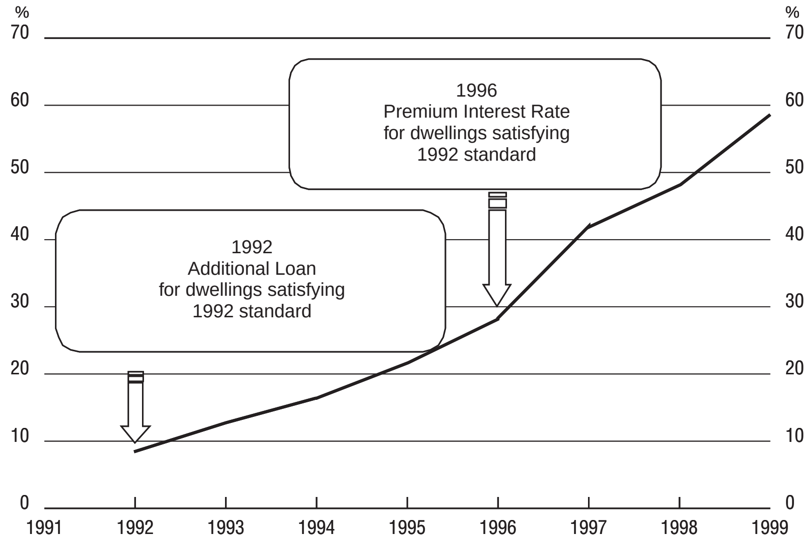
Note: The interest rate of JHLC housing loans is fixed and is usually for 35 years.
Source: Japan Housing Loan Corporation.

recommended standards are eligible for both the lowest interest rate and additional loans of up to 2.5 million yen (Table 12).

Premium loan schemes may have two potential positive effects. For those who have access to the required capital without such schemes, premium loans have the effect of reducing monthly payments; for those who do not have access to the required capital, premium loans provide it. In light of the high discount rate buyers usually adopt, it is doubtful that these schemes could have a large impact on the decisions of buyers who have access to capital. However, for buyers without capital access, premium loans may be effective in overcoming one of the market failures in this area, namely a lack of access to the capital market. In general, the capital market does not provide sufficient capital for low-income households, and premium loan schemes may work effectively if those households were targeted.

The case study on JHLC's housing loan did not provide any clear evidence regarding the effectiveness of the scheme. Since the scheme has been widely used,[16] the effectiveness of the programme may depend to a great extent on the number of free riders. While unfortunately there is no empirical study that examines the proportion of free riders with regard to housing loans, the discussions of free riders in the context of capital subsidy programmes could basically be applied to premium loan schemes. The case study here has found some empirical data that indicate the impact of the premium loan scheme on the energy efficiency of dwellings financed by the JHLC, although this cannot be considered as strong evidence to prove the effectiveness of the scheme. Figure 15 shows the proportion of JHLC-financed dwellings that satisfy the 1992 recommended standard relative to total JHLC-financed dwellings. The figure indicates that this proportion has been increasing since the premium loan scheme for this level of energy efficient dwellings was initiated in 1992. Moreover, the data also demonstrate that the increase accelerated when the most advantageous interest rate was applied in 1996.

Figure 15. **Proportion of JHLC-financed dwellings that satisfy the 1992 standard**



Source: Japan Housing Loan Corporation

Another finding from the Japanese case study is that the premium loan scheme could not encourage owners of rented housing to make energy efficiency improvements. While the premium for energy efficient housing was provided for about half of newly built owner-occupied dwellings in 1998, less than 10% of rented dwellings were covered by this programme.

With regard to economic efficiency and incentives for innovation, much of the discussion in the previous section may be relevant to premium loan schemes. The case study suggests some possible ways to improve economic efficiency and increase incentives for innovation of premium loan schemes. First, performance-based standards for the premium were provided so that designers and contractors could flexibly choose cost effective options. Furthermore, the scheme provided a greater premium for dwellings with higher energy efficiency (Table 12). Although the case study could not identify empirical evidence to show to what extent these measures have improved economic efficiency, such flexible structures should contribute to cost-effective improvement of energy efficiency and provide incentives for developing more cost-effective technologies.

Like capital subsidy programmes, it is theoretically presumed that premium loan schemes entail high administrative cost. This is because housing finance institutions need to check design documents and conduct on-site inspections to confirm that the design of dwellings applying for the premium loan scheme satisfy the standard for the premium. However, the Japanese case study shows different results. The JHLC has contracted this task out to local authorities or private firms that are independent from the house-building industry and have sufficient technical staff. The JHLC is paying 10 900 yen per unit for this task.[17] However, it is noteworthy that, even in the absence of a premium for energy efficiency measures, the JHLC would still need to check basic performances of dwellings in order to make sure that they would not incur great losses in case of repossession.[18] Thus the Japanese experience indicates that extra administrative cost for implementing premium loan schemes for energy efficient buildings should be limited if the premium for high energy efficiency is provided on the basis of existing premium loan schemes that have been implemented for other objectives.

Energy taxes

Energy taxes effectively increase the price of energy and are expected to provide energy consumers with incentives not only to reduce energy use but also to invest more in energy efficiency measures. However, due to unique characteristics of the building sector such as the trend to use high discount rates, it is not certain to what extent the energy tax could provide incentives to invest more in energy efficiency measures, especially those with long pay-back period. Moreover, in the case of such investments, investors are not likely to invest unless they believe the tax will be sustained for a long time.

Despite these arguments, empirical studies on the relationship between energy price and diffusion of energy efficient technologies show a mixed picture. According to an econometric study by Jaffe *et al.*, the effect of a 10% increase in energy prices on the diffusion of energy efficient technologies is estimated to be one-third of that of a 10% decrease in capital costs (Jaffe *et al.*, 1994b). On the other hand, there is some empirical evidence that energy prices may influence the energy efficiency of buildings to some extent. In the US, the relative prices of electricity and natural gas rose respectively by 24% and 69% between 1973 and 1993. It was estimated that without this increase in prices, energy efficiency would have been about 8% lower for room air conditioners, 16% lower for central air conditioners, and about 5% lower for gas water heaters (Newell *et al.*, 1998). In addition, regression analysis on nearly one thousand households in the US shows that energy prices affect investment in energy-saving insulation of buildings (Brill *et al.*, 1998). In the UK, it was estimated that doubling consumer energy prices would reduce space heat demand by approximately 40% by technical re-optimisation of the building thermal envelope alone. (Lowe *et al.*, 1997). As such, views on the potential impact of energy taxes on investment in energy efficiency measures, which are supported by empirical evidence, are mixed, and further studies are necessary to draw any conclusion on the effectiveness of energy taxes in improving the energy efficiency of buildings.

As the scale of the impact of energy taxes on the energy efficiency investment is uncertain, governments may have to repeatedly increase tax rates if they are to achieve a given goal of overall energy efficiency improvement. Such incremental increases of tax rates may not be so easy, because building acceptance before the introduction of higher taxes is necessary for reaping potential economic benefits of the taxes (OECD, 2001c).[19] However, it is important to note that a flexible review of the tax rate may be one of the requisites for effectively implementing an energy tax.

Among all the options for instruments to reduce CO_2 emissions from the building sector, energy taxes provide the highest flexibility for building design, and theoretically can achieve the least-cost solution if market failures are appropriately removed. Energy taxes also provide continuous incentives to seek more cost-effective technologies. Pop analysed US patent application data from 19 energy-related technology groups from 1970 to 1994, finding that the rate of energy-related patent applications were significantly and positively associated with the price of energy (Jaffe *et al.*, 1999).

Another strength of energy taxes is that they entail modest administrative costs. Unlike other policy instruments, energy taxes do not require detailed checking of design documents or on-site inspections and, since various energy taxes have already been introduced in OECD countries, the additional administrative cost should be very small. On the other hand, energy taxes generate revenues for governments that could be used for subsidy programmes. It is also important to note that energy taxes will have positive effects other than improve the energy efficiency of buildings. First, energy taxes can affect the energy embodied in building materials and products. The advantage of these taxes is that they can encourage the use of materials that embody less energy without having to measure the amount of embodied energy in individual materials. In contrast, the introduction of other instruments for reducing embodied energy requires measurement that is technically difficult and costly. In addition, energy taxes can positively affect the performance of many of the energy-using systems in a building, such as the way in which a building is operated, renovated, re-used and ultimately demolished (Lowe, 2000).[20]

Other taxes

Energy taxes may be one of the most economically efficient policy instruments and provide many incentives for innovation, if properly designed. However views on the potential impact of energy taxes on investment in energy efficiency measures, which are supported by empirical evidence, are mixed, partly because the effectiveness of energy related tax has to be assessed in the long run. Furthermore some empirical evidence indicates that investors tend to be so concerned with initial costs relative to operating costs. In many cases this is a consequence of market failure (information problems *etc.*) and these should be addressed at source.[21]

One additional approach to overcome this dilemma that has been proposed could be to impose a tax on investors or developers that is inversely proportional to the energy performance of new buildings.[22] Such a tax would, in effect, increase the capital cost burden of investing in buildings with poor energy efficiency, while the tax burden would be lessened for those who invest in energy efficiency. Since investors tend to pay disproportional attention to the minimisation of capital cost, it is presumed that this type of tax could encourage energy efficiency investment in new buildings.

According to the OECD survey, no country has implemented such a tax, and there are many issues that would have to be discussed before the tax could become a realistic option. The basic rationale for this tax is that a low level of investment in energy efficiency measures will lead to relatively greater energy use in buildings, resulting in higher external environmental cost at later stages. However, there are many factors other than the energy performance of buildings that affect actual energy use, so buildings with a poor level of energy efficiency may not necessarily consume more energy than those with a high level of energy efficiency. In this regard, the tax would not be fair measure, unless it was complemented by environmentally-motivated energy taxes.

In addition, the tax may not fairly treat those who make energy efficiency investments throughout the long service lives of buildings. When taxed new buildings are sold, it can be assumed that the relative tax burden will be reflected in part in the sales price and passed on to the initial buyers. Thus, prices for more energy-efficient buildings should be relatively more competitive than would be the case in the absence of such a differentiated tax. However, the second (and subsequent) owner(s), who have conducted energy efficiency upgrades, would not be rewarded by such a tax cut. Moreover, since applying the tax would require evaluating the energy efficiency level of new buildings, the administrative cost could be considerable.

Despite these difficulties, this type of tax could have great potential to improve the energy efficiency of new buildings, and may be worth examining as a future policy option.

Another important measure to improve the energy efficiency of buildings is removing taxes that discourage energy efficiency investments. For instance, in at least four EU countries, the Value Added Tax that is levied on energy consumption is lower than the VAT on energy conservation (EU Working Group on Sustainable Buildings, 2000). This discourages energy efficiency

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investment, and removing such counterproductive tax systems should help to improve the energy efficiency of buildings.[23]

Tradable permit schemes

There appear to be two possible approaches for using tradable permit schemes in the building sector. The first is to establish a market for permits for emitters (users or owners of buildings), as is done in other sectors. However, it is obvious that introducing this type of scheme for the building sector is not realistic due to high administrative costs. As a great number of firms and individuals emit CO_2 in a great number of buildings, it is likely that permit schemes will entail large administrative costs, perhaps exceeding the potential saving of compliance costs. The second approach would be to establish a permit market for firms that supply the fossil fuels that generate CO_2. Since these fuels are associated with a given carbon intensity, and since there are no potential means of abatement following combustion, the permits would be traded between a reasonably small number of oil, gas and electricity suppliers. It is presumed that by focusing on energy suppliers, the use of a permit trading mechanism would be much more feasible because administrative costs would be significantly reduced. An example of this approach is the UK's plan to establish the permit trading mechanism between electricity and gas suppliers under the obligation that they improve the energy efficiency of their consumers' assets.[24]

If effectively implemented,[25] permit trading schemes appear to be the most certain and cost-effective way of reducing overall CO_2 emissions from the building sector.[26] In addition, the price signal sent from the permit markets will provide appropriate incentives to seek more cost-effective ways of improving energy efficiency. As with energy taxes, the permit schemes can affect other factors determining energy use in the sector, such as the way in which buildings are operated. Furthermore, if the permit scheme is also introduced for supplying fossil fuels to the industrial sector, the scheme will have an effect on embodied energy of building materials as well.[27] However, since there is no example of a tradable permit scheme that has been implemented for the building sector, there is no empirical evidence in favour of or against these arguments.

5.2.3. *Information tools*

Environmental labelling schemes

In the context of reducing CO_2 emissions from the building sector, environmental labelling schemes provide potential buyers with information on the energy efficiency of equipment or entire buildings. Labelling equipment started earlier than labelling entire buildings. Various types of equipment in buildings, for instance lighting, have been covered by environmental labelling schemes.[28] In the US, the Energy Policy and Conservation Act requires the

Federal Trade Commission to develop and promulgate appliance energy labels for products, including air conditioners, heating equipment and water heaters (US Congress Office of Technology Assessment, 1992). In recent years, environmental labelling schemes for buildings have become a popular instrument in OECD countries, but it is important to note that assessment criteria greatly vary between schemes. In general, environmental labelling schemes related to the energy performance of buildings can be classified into three categories: mandatory energy labelling, voluntary environmental labelling and voluntary comprehensive labelling (see Box 1 in Section 3.1.1).

One example of the first category (mandatory energy labelling) is the energy rating scheme used in the UK. From the beginning of 2001, all builders of housing in the UK are obliged to visually display energy ratings of new dwellings for potential buyers and notify the building control body. These ratings are calculated using the Standardised Assessment Procedure method.[29] The introduction of the rating scheme aims to provide prospective buyers with information on the energy efficiency of new dwellings, and to encourage builders to provide dwellings that are more energy efficient.

One of the most widely used voluntary environmental labelling schemes (second category) is the Building Research Establishment Environmental Assessment Method (BREEAM), which is operated by the Building Research Establishment (BRE) in the UK. The BREEAM was first established in 1991 with the objective of providing independent and practical guidance on minimising the damaging effects of new office buildings on the global and local environment. With repeated revisions, the scheme today covers office buildings (new and existing), supermarkets, schools, and houses.[30] For each of the categories listed in Table 13, the building is assessed against performance criteria set by the BRE and awarded "credits" based on the predicted level of

Table 13. **Environmental issues covered by the assessment criteria of the BREEAM**

Issue	Description
Management	Overall policy, commissioning and procedural issues
Energy Use	Operational energy and CO_2 issues
Health and well Being	Indoor and external issues affecting health and well being
Pollution	Air and water pollution
Transport	Transport related CO_2 and location related factors
Land use	Greenfield and brownfield sites
Ecology	Ecological value of the site
Materials	Environmental implication of building materials
Water	Consumption and water efficiency

Source: Edwards *et al.*, 2001.

performance. The percentage of credits achieved under each category is then calculated and environmental weighing is applied to produce an overall score for the building. The overall score is then translated into a BREEAM rating of: pass, good, very good, or excellent.

One example of the third category (voluntary comprehensive labelling) is the Housing Performance Indication Scheme that was introduced in 2001 in Japan. The objective of the scheme is to enable consumers to compare dwellings by providing reliable information on building performance expressed in standardised criteria. Table 14 indicates the assessment criteria of the labelling scheme established by the government. It is important to note that performance criteria are not limited to environment-related ones – such as indoor air pollution, energy efficiency, and ease of maintenance – but also cover other important performances that buyers may take into consideration, such as earthquake resistance, sound insulation and fire safety.

Table 14. **Main performance criteria of the Housing Performance Indication Scheme**

Performance criteria		Ranking
Earthquake Resistance	Rank 3 Rank 2 Rank 1	– 1.5 times as strong as the building code level or more – 1.2 times as strong as the building code level or more – The building code level or more
Physical durability	Rank 3 Rank 2 Rank 1	– Can be used for three generations or more – Can be used for two generations or more – Can be used for less than two generations
Energy efficiency	Rank 1-4	In accordance with the scale of heating/cooling burden
Fire safety	Rank 1-4	In accordance with how long components can resist fire
Protection from indoor air pollution	Rank 1-4	In accordance with the quantity of estimated emissions of formaldehyde from interior finish and backing
Sound insulation of floors	Rank 1-5	In accordance with the thickness of floor slab, types of finish on floor, *etc.*
Ease of maintenance	Rank 3 Rank 2 Rank 1	– Pipes for sewage, water supply and gas can be maintained without damaging structural parts and finish – Pipes for sewage, water supply and gas can be maintained without damaging structural parts – Pipes for sewage, water supply and gas cannot be maintained without damaging structural parts
Lighting	XX%	Proportion of total area of windows which receive sunshine to the floor area of the room
Elderly-friendly	Rank 1-5	In accordance with the width of corridors, difference in levels of floor, equipment of handrails in bathrooms, entrance and staircases, steepness of staircases, *etc.*

Source: Japanese Ministry of Land, Infrastructure and Transport.

Despite major differences in how they are structured, the basic concept of labelling schemes is to change the behaviour of buyers by providing them with information on the performance of buildings. Labelling schemes generally have great potential to change buyer behaviour if:

- there is a lack of information on the demand side; and
- buyers have an incentive to buy products with higher environmental performances.

With regard to the first condition, buyers – particularly individual consumers – usually lack sufficient information on the quality and performance of buildings due to the high heterogeneity in building design and the limited opportunities that buyers have to accumulate experience through taking part in building transactions.[31] As for energy efficiency, since better energy performance results in less energy cost, buyers may have an incentive to buy products with higher energy efficiency. Theoretically, environmental labelling schemes should be effective in improving the energy efficiency of buildings.

There is some empirical evidence to suggest that conditions necessary for changing buyer behaviour in the building sector can be satisfied The results of a survey conducted by the Japan Housing Loan Corporation indicate that out of 3 800 consumers who had bought housing sometime during the last five years, 60% of them felt that they did not have sufficient information on the quality of the housing at the time of transaction (Japan Housing Loan Corporation, 1999). With regard to energy efficiency, the survey in Germany indicates that buyers show more interest in energy efficiency than in any other environmental performance of buildings (Figure 12).

Concerning the *ex post* evaluation of labelling schemes, the case study on the BREEAM found that some 25% of all new office buildings (in terms of total floor area) have been assessed under the BREEAM since its launch in 1991, and that BREEAM-assessed buildings have much higher environmental performances than typical buildings. As indicated in Table 15, the average estimated annual CO_2 emissions from 35 BREEAM-assessed office buildings are less than half of those from typical office buildings in the UK.[32]

The British experience suggests that environmental labelling schemes may have great potential to improve the energy performance of a large number of buildings with limited administrative cost on the government side. However, it is important to note that buildings designed to be highly energy efficient, even in the absence of labelling schemes, are more likely to apply to such schemes to make their good performance more visible. It is thus not clear whether the good performance was achieved because BREEAM provided designers and their clients with incentives to improve building performance, or whether the good performance would have been achieved even in the

Table 15. **Comparison of estimated annual CO_2 emissions between BREEAM assessed buildings and typical and good practice buildings in the UK**

	Estimated annual CO_2 emissions
BREEAM assessed buildings	56 kg/m^2/year
Good practice buildings	77 kg/m^2/year
Typical buildings	140 kg/m^2/year

Note: Typical building: building that has the median level of energy efficiency of UK building stock. Good practice building: building that is in the top quartile of UK building stock with regard to energy efficiency.
Source: Building Research Establishment.

absence of the BREEAM, and the buildings applied to the scheme mostly to obtain public recognition for their performance.

Although environmental labelling schemes have been drawing much attention of policy makers and experts, few *ex post* studies on their effectiveness have been undertaken. There appears to be no clear empirical evidence that labelling schemes can significantly improve the energy performance of buildings.[33] In light of the great potential of this instrument, further *ex post* studies need to be conducted. Furthermore, the results from such studies should be reflected in the design and implementation of environmental labelling schemes in the future.

One important factor that affects the effectiveness of labelling schemes is the structure of assessment criteria. In this regard, the distinction between commercial and residential buildings may be important. While buyers of the former are usually professionals and experienced, those of the latter are individuals and often inexperienced. Professional and experienced buyers usually require highly detailed information on the environmental performance of a building, but do not need information on its other basic performances. On the other hand, individuals seeking to buy housing usually not only need information on environmental performance, but also on other, invisible, basic performances of the building they are considering. As residential buyers generally do not have technical expertise, labelling should be simple enough for them to understand. It could be presumed that voluntary environmental labelling may work more effectively for the commercial building sector, and voluntary comprehensive labelling may be effective for the residential building sector. This argument is supported by the fact that voluntary environmental labelling schemes, such as the BREEAM in the UK, have been diffused mainly in the commercial building sector, while voluntary comprehensive labelling schemes, such as the Housing Performance Indication Scheme in Japan and Qualitel in France, are widely used for residential buildings.

It is also important to consider whether environmental labelling schemes should be voluntary or mandatory. Mandatory labelling can be effective in cases where those who would normally not rely on labelling take it into account because it is mandatory. However, it is sometimes argued that while labelling schemes may help those who have incentives to choose environmentally friendly products to make the right choice, they cannot create the incentives themselves. In the latter case, the introduction of a mandatory labelling scheme may result in much unnecessary administrative cost. As there is a lack of data on the effects of labelling for buildings and little empirical evidence, it is difficult to provide suggestions. An evaluation of mandatory labelling for some household appliances in the US shows that in 1986 roughly one-third of the consumers who bought clothes washers and nearly half of those who bought refrigerators – and who were aware of the product labels – claimed that the information affected their purchasing decisions (US Congress Office of Technology Assessment, 1992). This evidence may support introducing mandatory labelling schemes, but it is not certain that this evidence applies in a discussion on labelling for buildings. There is much room for further analysis on this issue.

The economic efficiency and incentives for innovation that labelling schemes can generate may depend largely on the way the performance levels of a product are indicated to consumers. A simple seal of approval is easy for consumers to understand, but this type of labelling does not help consumers make the most cost-effective choice and provides limited incentive for innovation. On the other hand, labelling schemes that indicate energy efficiency with ranks or indexes may be more efficient and provide more incentive for innovation. However, if these become too complicated for consumers to understand, then they may lose some of their effectiveness. It seems that achieving the right balance between the amount of information and its user friendliness is important in designing labelling schemes. The case studies could not find any empirical evidence to illustrate these aspects of labelling.

In many cases, the performances of buildings are assessed by third parties that issue labels or certificates. Governments are often involved in establishing assessment criteria or approving certifying bodies. Administrative costs for labelling schemes are generally higher than those for building regulations because labelling schemes often involve more detailed standards than building regulations. These costs are usually incurred by prospective building owners who pay a certification fee to certification bodies. For instance, all of the administrative costs for operating the BREEAM are covered by revenue from assessment fees paid by applicants. The typical fee for the assessment of a typical simple office building is between £2 500-3 000.[34] On receipt of the assessment fee, assessors must pay 15% of it to the

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BRE, which then uses the revenue for the maintenance and development of the BREEAM. Four to five staff members of the BRE are usually involved in this task.

The Japanese case study suggests that the administrative cost could be reduced by appropriately designing the administrative framework. In the Housing Performance Indication Scheme, the inspection system was designed so as to minimise the administrative cost. Even before the scheme was introduced, checks on building design documents and on-site inspections were being done by technical experts to meet the requirements of building regulations, JHLC's housing loan, and housing insurance schemes.[35] It would be inefficient for different experts to visit the same building site at different times to conduct on-site inspections. The total administrative cost could be greatly reduced if one expert dealt with all of these tasks. In order to promote this efficient method, the government has revised relevant laws and allowed private firms approved by the government to work for all four of these programmes and schemes.[36] Furthermore, the government has not set any limitation on the number of approved inspection bodies,[37] so that the entrance of new inspection firms could promote competition and maximise the cost-effectiveness of inspection services. The Japanese experience suggests that using the existing administrative framework and developing a competitive inspection service market could contribute to lowering administrative cost.

5.3. Policy instruments for reducing CO_2 emissions from existing buildings

As public concern over climate change increases, policy makers are paying more attention to the energy saving potential of existing buildings. While the energy efficiency of new buildings has been upgraded, a much larger number of existing buildings with a poor level of energy efficiency have been left untouched due to their long-lived nature.

In the discussion of policy design for existing buildings, it is important to note that there are several factors that are specific to existing buildings and may affect the choice of instruments:

- It is more difficult to generalise the cost-effectiveness of a certain energy efficient measure because both the costs and effectiveness of the measure are highly dependent on many specific elements of the building design.
- In general, contractors who specialise in refurbishment/retrofits of buildings are smaller than those specialised in new construction.
- It is more expensive to incorporate many of the energy efficient measures into existing buildings than into new buildings.

- It is more difficult to precisely assess invisible performances of existing buildings at a reasonable cost.
- There are no regulatory frameworks for existing buildings as there are for new buildings.
- Owners of existing buildings do not have as many contacts with technical experts as prospective owners of new buildings have with architects, contractors or developers.
- Owners always have an option "not to do anything", while prospective owners of new buildings must, in consultation with technical experts, make a decision regarding energy efficiency.
- Stakeholders do not easily accept new regulation because existing buildings were already once approved by authorities as being compliant with regulations.

In the following sections, policy instruments that were listed in Table 10 will be discussed. Many of the points that were discussed in the previous section can be applied to policy instruments for existing buildings, and in principle they will not be repeated in this section. Rather, this section will focus on how the unique features of the existing building sector may affect the choice of policy instruments.

5.3.1. Regulatory instruments

Mandatory standards for building design

In most countries, building regulations do not cover existing buildings unless when they are largely renovated or refurbished. However, some communities and states in the US that have implemented Residential Energy Conservation Ordinances (RECOs) are an exception. As shown in Box 7, RECOs require owners of buildings to implement specific low-cost energy conservation measures when their buildings, including rental property, are sold or renovated. The scope of RECOs differs between municipalities and states. Some focus on dwellings and some others cover both residential and commercial buildings. The minimum standards for RECOs are modest compared to those for new buildings. The standards are also usually very simple and specific, and typically include insulation, weather strips and caulks.

As it is difficult to incite owners of buildings to voluntarily make energy efficiency upgrades, this type of regulation (if effectively enforced) may be the most certain way of improving the energy efficiency of existing buildings. While it is administratively difficult to control the mostly invisible performance of a great number of existing buildings, RECOs have made this possible by targeting buildings to be sold in the market. It is important to note that some states and communities register the transaction only when

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Box 7. **Residential Energy Conservation Ordinances in the US**

- The sellers are usually required to contact an inspector to physically examine the home and identify those items that do not meet RECO requirements.
- The sellers are then responsible for contacting a contractor to implement required retrofit measures.
- After the required measures are implemented, an inspector typically returns for a final inspection to verify compliance and issue certificates of compliance.
- The owners are required to show proof of compliance before the deed is recorded.

Source: Suozzo *et al.* (1997).

the proof of compliance has been submitted, and this may greatly help the effective enforcement of the regulation. One advantage of RECOs is that they can affect the energy efficiency of the rental housing stock, which cannot be easily improved with other instruments due to principal-agent problems. In some communities, RECOs focus only on multi-family rental housing.

Although there are not many empirical studies that evaluate the effectiveness of RECOs, some reported successful cases demonstrate that RECOs could be a very effective instrument to improve the energy efficiency of existing buildings. In San Francisco, RECOs have resulted in the weatherisation of more than 160 000 homes and reduced average household energy consumption by more than 15%, saving the city a total of US$6 million. It is also estimated that out of 90 000 homes that were inspected by private energy auditors in the State of Wisconsin, between a third and a half of the buildings that were built prior to 1978 – and were covered by the ordinance – had been weatherised as a result of the ordinance (Suozzo *et al.,* 1997).

As RECOs always have uniform, modest, simple and specific minimum standards, theoretically they cannot attain the least-cost solution or provide incentives for innovation. However, this does not mean that RECOs are an economically inefficient instrument. When considering the diminishing returns on investment in energy efficiency measures, relatively old and not very energy efficient buildings, which are RECOs' main target, could potentially improve their energy efficiency in a very economical manner. It should also be noted that there are not many options for upgrading the low level of energy efficiency of old buildings – in particular of old residential buildings – to the minimum standard level.

Applying modest, simple and specific minimum standards may help to lower administrative cost. Although on-site inspection by technical experts is required to prove compliance, the inspection fee is not high. In San Francisco, the total inspection fee amounts to around US$168 for one- and two-family dwellings (Suozzo *et al.*, 1997). Since there is no regulatory framework for inspecting existing buildings, and this is technically more difficult than inspecting new buildings, introducing ambitious, complicated and flexible standards would result in higher administrative and compliance costs to the extent that the ordinance itself might not be accepted by stakeholders.

In many OECD countries it may not be realistic to introduce RECO-type regulation in the near future. It is generally difficult to build stakeholder acceptance for any new regulation concerning products that were once approved as complying with legislation by authorities. However, depending on the context of each country, there might be some room for extending coverage of building regulation to include the existing building sector. For instance, Germany introduced new requirements for existing buildings at the beginning of 2002. As shown in Box 8, the new requirements target three basic areas, which could have great potential for saving energy.

Under the current UK building regulation, energy efficiency standards only apply to proposed alteration work if the work affects a building's structural safety, means of escape, resistance to fire, access and facilities for the fire service, or access and facilities for disabled people. The government has proposed to extend building regulation standards to other alteration work that could affect compliance with energy efficiency standards, such as replacing windows (UK Department of the Environment, Transport and the Regions, 2000). These approaches are examples of policy options to improve

Box 8. **Energy Saving Ordinance in Germany**

- Boilers installed before October 1978 must be replaced by the end of 2006.
- Lofts that cannot be converted must be insulated by the end of 2006 to specified standards.
- Boilers and pipes in unheated rooms must be insulated to specified standards by the end of 2006.

Source: German Federal Ministry for Economics and Technology.

the energy efficiency of existing buildings, in particular of those building with a low level of energy efficiency.

Imposition of obligation on utilities companies

In the UK, under the Utilities Act, the government imposes an Energy Efficiency Commitment (EEC) obligation on electricity and gas suppliers. Companies are required to achieve targets, expressed in fuel-weighed energy benefits, by implementing programmes to promote the energy efficiency of domestic consumers. Companies are also required to focus at least 50% of their obligated energy benefits on low-income households. It is up to the suppliers to meet their targets cost-effectively; no measure or amount of money has been specified to indicate how companies should do this. The cost of EEC programmes is reflected in the gas or electricity bill, amounting to an estimated cost of no more than 90p per quarter for an average bill (UK Department for Environment, Food and Rural Affairs, 2001).

With the liberalisation of the energy supply industry, utilities companies would be in a more competitive position if they could achieve the target with less cost.[38] It is therefore presumed that utilities companies have incentives to seek the least-cost way to meet the obligation. If companies make good use of the information they obtain on the energy consumption of their customers in trying to reach their targets, this type of obligation may lead to cost-effective improvement of energy efficiency of dwellings. For instance, they may introduce support programmes which give their customers large incentives to help them meet their obligations.

More important, this type of instrument could form the basis for implementing tradable permit schemes, which may contribute to further reducing the overall cost of achieving given energy benefits.[39] Apparently it is not easy to establish a consensus for introducing this type of scheme in the energy industry, even though this instrument may have the potential to improve the energy efficiency of dwellings in a cost-effective way with little cost to government. Further studies on the effects of this instrument are required.

5.3.2. *Economic instruments*

Capital subsidy programmes and tax credit schemes

As with other policy instruments, much of the discussion regarding capital subsidy programmes and tax credit schemes for new buildings could be applied to the existing building sector. For instance, a significant proportion of subsidies for existing buildings – as is the case for new buildings – can potentially go to free riders. In the Netherlands, statistical analysis indicates that there is only a weak positive relationship between subsidies for thermal home insulation and the diffusion of thermal insulation technologies. This finding was confirmed by another study that asked subsidy programme applicants about their motivation for investing in thermal insulation. The result shows that only 11% of the respondents said that the subsidy was the primary motivation for investing in thermal insulation, and that cost savings and improved comfort were the main reasons for the investment (Kemp, 2000). As with new buildings, minimising the proportion of free riders should be a key element in the effective implementation of subsidy programmes for the existing building sector.

An important issue, which is unique to the existing building sector, is the effect of targeting subsidy programmes at low-income households. The UK and US have implemented large-scale capital subsidy programmes aimed at low-income households. The rationale for this targeting may be that low-income households tend to have little access to the capital market, and have difficulty in obtaining financial resources for energy efficiency upgrades. In addition, the targeting could also be justified by the fact that low-income households tend to live in dwellings with a low level of energy performance which, in general, can be improved in more cost-effective way than dwellings with a high level of energy performance. Moreover, a programme that focuses on low-income households may be accepted more easily politically. On the other hand, since many low-income households cannot afford to warm their homes to a satisfactory level before energy efficiency upgrades have been made, it can be assumed that a significant proportion of the energy savings potential achieved by the efficiency improvements is usually used for improving comfort rather than saving energy.

In practice, such a capital subsidy programme has been implemented with a primary aim to address the issue of "fuel poverty", which is being perceived as an important problem in the UK. There are many low-income households living in dwellings with poor energy efficiency (fuel poor households), who need to pay a considerable proportion of their income to make their homes sufficiently warm (UK Department of the Environment, Transport and the Regions, 2001). With an aim to improve the comfort of these dwellings through energy efficiency improvements, the New Home Energy Efficiency Scheme (HEES) was launched in 2000.[40] The application process of the New HEES is indicated in Box 9.

The case study on the New HEES found that the programme has contributed substantially to improving energy efficiency. In the first 9 months of implementation, the New HEES improved 89 000 dwellings. This may be partly because the entire cost for the upgrades is subsidised. It is estimated that the New HEES packages will reduce the cost of fuel used by households by between £300-600 per annum. Theoretically, the upgrades should be very cost-effective. The average amount of grant per household is estimated at some

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Box 9. **Application process to the New Home Energy Efficiency Scheme**

Step 1

- Occupants of dwellings who are interested in the HEES contact scheme managers. Scheme managers check the eligibility of the household and arrange the survey of their dwellings by telephone.

Step 2

- Surveyors (usually permanent staff of scheme managers) visit applicants' dwellings and check the current situation of energy-efficiency-related building components, and propose ways to improve efficiency.

Step 3

- If applicants agree with the proposal, scheme managers choose the contractors by competitive bid.

Step 4

- Chosen contractors contact applicants and conduct the upgrade work.

Step 5

- Contractors receive fees from scheme managers who then receive subsidies from scheme managers.

Source: UK Department of the Environment, Transport and the Region, 1999.

£600, with the estimated pay back period being 1-2 years. The case study also supports the assumption regarding the rebound effect. It is estimated that 77% of the energy saving potential achieved under the Home Energy Efficiency Schemes was used to make homes warmer (Bell *et al.*, 1996). This suggests that this type of capital subsidy programme in the short run may not produce great energy savings, though the programme could be an effective measure to reduce CO_2 emissions in the long run if sufficient financial resources are provided.

A drawback of these types of capital subsidy programmes is that, due to the principal-agent problem, they usually do not have considerable impact on rented housing where many low-income households live.[41] It is reported that the participation rates of weatherisation programmes in the multi-family rental sector have been disproportionately low in the US. The States of California and Ohio are trying to address this problem by introducing free weatherisation services for this sub-sector (DeCicco *et al*., 1994). In the case of the New HEES in the UK, the review of the previous HEES programme found that the concerns of occupants over a possible rent increase was an obstacle to diffusing the scheme in the private rental sector. Therefore, the New HEES was designed to require owners of rented dwellings to agree that they will not increase the rent for a predetermined period of time. Such special consideration may be necessary for the effective implementation of capital subsidy programmes in the rented building sector.

As has been repeatedly mentioned in this report, the cost-effectiveness of energy efficiency measures for existing buildings highly depends on the specific situation of each dwelling. Theoretically, the economic efficiency of subsidy programmes should be much improved by increasing the flexibility in the choice of measures. The results of the case study on the New HEES support this argument. Under the previous HEES programme, only one measure could in principle be implemented, but under the New HEES a wide variety of measures can be co-ordinated depending on the specific situation of dwellings. As a result of the revision, the cost effectiveness of the programme has been largely improved.[42]

When implementing capital subsidy programmes for existing buildings, technical experts need to check the eligibility of each dwelling and choose some measures from a list of options. Since there is basically no existing regulatory framework for existing buildings, experts are likely to be sent solely for the subsidy programme. As a result, the administrative costs of subsidy programmes in the existing building sector tend to be significant. The case study on the New HEES found that out of an average grant of £600 per household, as much as £130 is spent on administrative cost, mainly for inspection.

Premium loan schemes

In general, the amount of financial resources required for individual investment in energy efficiency measures for exiting buildings is smaller than that for new buildings, so private financial institutions are more likely to provide loans for investment in existing buildings without government support. Under such circumstances, premium loan schemes presumably have a more limited impact on existing buildings than on new buildings. The results of the Japanese study tend to support this argument. The Japan Housing Loan Corporation, which provides premium loans for about 180 000 new homes per year, makes only some 100 premium loans for existing housing units.

As is the case for capital subsidy programmes, premium loan schemes are not likely to work effectively for rented buildings due to principal-agent problems. However, the results of a new premium loan scheme that was introduced in Germany in 2001 shows a totally different picture. Under the scheme, all dwellings built before 1978 are eligible for a subsidy that is sufficient to reduce the interest rate of the loan by 3% if the reduction in estimated energy use is greater than a predetermined level. Contrary to expectations, a considerable proportion of the applicants for the loan are corporate landlords who possess a large number of rental units, and applications from owner-occupiers are limited. Under the scheme, 30% of the total loan was given to such corporate landlords in 2001.[43] This may be, to some extent, because upgrades of energy efficiency effectively enable corporate landlords to increase the rent in a context of relatively tight rent regulations. The German experience shows that the effects of policy instruments can be greatly influenced by contextual factors.

Energy taxes and tradable permit schemes

The advantage of energy taxes and tradable permits is that they at least can have the same effect on existing buildings as on new buildings without additional administrative cost. Unlike other policy instruments, the introduction of energy taxes and tradable permits does not require checking design documents or on-site inspection, and so the lack of an existing regulatory framework does not lead to an increase in administrative cost.

It is noteworthy that the UK government is considering introducing a permit trading mechanism for the Energy Efficiency Commitment (EEC).[44] The government has proposed that electricity and gas suppliers should be able to trade with each other the whole, or part, of their energy efficiency improvements or accredited performance towards meeting energy efficiency targets. The government also proposes that increases in household energy efficiency achieved by individual suppliers and above the level required under the EEC could potentially be sold under the UK Emission Trading Scheme that the government is planning to establish (UK Department of Environment, Food and Rural Affairs, 2001).

The UK government proposal suggests that a permit trading mechanism might be used in the building sector by establishing permit trading between energy suppliers instead of between owners of individual buildings. As this is quite a new approach in the building sector and one that may have great potential, further studies on the possibility of applying a permit trading mechanism to the building sector should be undertaken.

5.3.3. *Information tools*

Environmental labelling schemes

Environmental labelling schemes for existing buildings generally aim to provide reliable information on the energy efficiency of buildings[45] to potential buyers. The only widely used labelling scheme for existing buildings is probably the mandatory energy labelling scheme in Denmark. The Danish scheme differentiates between buildings with less than 1 500 m^2 of floor area (hereafter called "small buildings") and those with more than 1 500 m^2 (hereafter called "large buildngs"). The Energy Labelling Scheme for Small Buildings, for example, covers mostly housing.[46] Before making a sales contract, sellers of small buildings must provide buyers with energy labelling reports that follow a predetermined format and are issued by registered energy labelling consultants. The energy labelling report is composed of three parts, as showin in Box 10.[47] The first part is regarded as environmental labelling.[48]

Like potential buyers of new buildings, those of existing buildings usually have little information on the energy efficiency of buildings (both in absolute and relative terms) because energy efficiency is invisible and cannot be directly measured without costly and time consuming assessments. In addition, potential buyers of existing buildings generally do not have as many contacts with architects, contractors or developers as prospective buyers of new buildings. Under these circumstances, the availability of reliable information on energy efficiency might encourage potential buyers to choose more energy efficient options. Such a change in the behaviour of prospective buyers might also encourage owners, who are planning to sell their buildings, to upgrade energy efficiency when undertaking other refurbishment work. In the same way, labelling schemes may facilitate improving the energy efficiency of new buildings as well. Those who invest in energy efficiency measures are likely to gain from their investments, even if they sell the building before the end of its service life, because they can recoup the benefits from a higher selling price.

The impact that labelling schemes can have on energy efficiency improvement may greatly depend on how the improvement will be appreciated in the resale market. During the last 3 years, about 50 000 small buildings were assessed every year under the Danish labelling scheme. This accounts for about 60% of the annual sales of small buildings in Denmark. However, the case study on the Danish energy labelling scheme found no empirical evidence to demonstrate that the information of the first part of the energy report has actually changed the behaviour of potential buyers, or indicate how assessed buildings are appreciated in resale market. As is the case for other policy instruments, the administrative costs of labelling schemes for existing buildings are bound to be greater than similar schemes for new buildings, mainly because there are no regulatory frameworks for existing buildings. In the case of the Danish energy labelling scheme, the typical cost for issuing a report for one unit of housing is € 300-500. But like other labelling schemes, the cost here is paid by the owner as an assessment fee, and the cost burden on government should be very limited.

Energy audit programmes

Energy audit programmes provide consumers with technical assistance on opportunities for upgrading the energy efficiency of buildings. With financial support from government, these programmes provide for trained energy auditors to conduct on-site inspections of buildings, perform most of the calculations for consumers and offer recommendations for conservation measures. One example of such a programme is the second part of the energy report issued under the Danish energy labelling scheme (see Box 10). Another

Box 10. **Main components of energy labelling report**

1. Energy label

- Ranks of energy efficiency for heating (15 ranks)[1]
- Ranks of energy efficiency of electric appliances (3 ranks)[2]
- Ranks of water use efficiency (3 ranks)
- Ranks of scale of impact on CO_2 emissions (3 ranks)

2. Energy plan

- Proposal for upgrades (heating, electric appliance and water use)
- Capital cost of proposed work
- Annual energy savings expressed in quantity of fuel
- Annual energy cost savings
- Estimated lifetime of the upgrades

3. Documentation

- Present condition of walls, floors, windows, roofs, *etc.*
- Present condition of appliances, *etc.*

1. Ranks are decided according to the required quantity of energy (J) per square metre that is necessary to attain the predetermined indoor temperature.
2. Electric appliances that are sold with buildings are assessed. This does not include electric heating equipment.

Source: Danish Energy Agency.

example is the Energy Performance Advice (EPA) Programme in the Netherlands, which aims to overcome information-related barriers by providing detailed information on possible options for upgrading energy efficiency in the format of EPA reports (see Box 11). Under the programme, the government provides a computer programme as well as financial support to owners of dwellings.

Box 11. **Implementation process of the Energy Performance Advice Scheme in the Netherlands**

- Clients applying for the programme fill out forms with questions about their houses and energy consumption, and send the forms to EPA advisors.
- The advisors survey the building, collecting further data on the design of the building and behaviour of the occupants.
- Based on an analysis of the collected data with a special software tool, the advisors issue reports in a prescribed format containing the following items:
  - ❖ Energy characteristics of houses expressed in a standardised energy index (EI);
  - ❖ Various options to improve energy efficiency, with their estimated costs and benefits (*e.g.* reduction of energy consumption and payback period);
  - ❖ Outline of subsidy programmes the applications are eligible for; and
  - ❖ Estimated impacts of upgrading work on indoor air quality.
- Clients then make decisions on whether or not to implement recommended measures. They receive a lump sum subsidy of € 200 if they implement at least one of the recommended measures. In addition, if they implement the other measures as well, they are entitled to a capital subsidy that is 25% more under the Energy Premiums Programme.
- The advisors send the results of the survey to the Ministry of Housing, Spatial Planning and the Environment, which will use the data for monitoring overall energy efficiency performance in the Netherlands.

Source: NOVEM, 2001.

Energy audit programmes could be effective in improving the energy efficiency of buildings. In many cases, it is the owners of buildings who decide on whether or not to do upgrades, and how. However, since the cost-effectiveness of energy efficiency investment in existing buildings depends largely on the specific condition of each building, it is difficult for owners of buildings to evaluate the energy saving potential of their buildings. In addition, they usually do not have regular contacts with building experts. Under such circumstances, the availability of information regarding the energy saving potential of their buildings – including concrete proposals for upgrades and an analysis of the cost-effectiveness of having them done – should encourage owners to invest in energy efficiency measures.

Empirical evidence appears to support this argument. Some evaluations of energy audit programmes in the US show that energy audits have influenced decision-making of approximately 67-80% of the households participating in the programmes. An evaluation in one state shows that RCS (Residential Conservation Services) participants realised 32% of the identified potential savings for space heating compared to 12% for non-participants (IEA, 1998). The Danish case study also found some empirical evidence that energy audit programmes can encourage energy efficiency upgrades. In order to evaluate the effectiveness of such schemes, telephone surveys of owners who had purchased buildings in recent years were conducted in 2000. Three hundred owners of both small and large buildings for which energy labelling reports had been issued – as well as another 300 owners of buildings without reports – were asked questions about energy efficiency upgrades. As indicated in Table 16, 45% of owners of assessed small buildings conducted heating-related upgrades within one year, while 38% of owners of non-assessed buildings did so (Danish Energy Agency, 2001a). For large buildings, this difference increases (see Table 17). While heating-related upgrades were

Table 16. **Results of the telephone survey of owners of small buildings in Denmark**

	Owners of buildings with reports	Owners of buildings without reports
Have done heating-related upgrade work in the last year.	45%	38%
Have done electricity-related upgrade work in the last year.	27%	22%
Have done water use-related upgrade work in the last year.	21%	22%
Have not done any work.	41%	47%
Do not know.	0%	1%

Source: Danish Energy Agency, 2001a.

Table 17. **Results of the telephone survey of owners of large buildings in Denmark**

	Owners of buildings with reports	Owners of buildings without reports
Have done heating-related upgrade work in the last year.	47%	22%
Have done electricity-related upgrade work in the last year.	43%	14%
Have done water use-related upgrade work in the last year.	47%	27%
Have not done any work.	29%	56%
Do not know.	0%	2%

Source: Danish Energy Agency, 2001b.

conducted in 47% of assessed large buildings, this was done in only 22% of non-assessed large buildings (Danish Energy Agency, 2001b).

It was found that most heating-related upgrades in non-assessed buildings had been done, for instance, while replacing kitchen equipment, and most owners of these buildings did not seem to understand precisely what kind of work had been done in their buildings with regard to energy efficiency. Owners of assessed buildings, on the other hand, had a better understanding of what had been done in their buildings. This may suggest that the percentages for buildings without reports given in Tables 16 and 17 may be inaccurate and could, in fact, be lower. Moreover, the Dutch case study found that an analysis of experimental implementation of the EPA Programme between 1999 and 2000 showed that on average energy consumption at home could be reduced by 30% through the implementation of measures recommended under the EPA programme.

Compared to inspectors who check for compliance with building regulations or labelling schemes, energy auditors make more discretionary decisions depending on the situation. As a result, the economic efficiency and incentive for innovation that energy audits can generate depend highly on the expertise of the auditors. If they have limited knowledge of appropriate measures that could be implemented, they might fail to recommend the most cost-effective options. This would not only increase the overall cost for achieving a given energy efficiency goal, but also fail to provide incentives for innovations. To overcome these potential drawbacks, relevant training and education programmes, as well as strict licensing in energy auditing, may be required. Both the Danish and Dutch schemes set minimum requirements for the technical experts who provide the energy audits.

The implementation of effective and efficient energy audit programmes will entail significant administrative cost as technical experts will need to be trained and hired. A pilot energy audit programme implemented in the UK is reported to not have been cost-effective, and thus there was no follow-through with a full programme (IEA, 1998). In the Netherlands, it is reported that EPA advisors usually charge owners the same amount as a lump sum subsidy for issuing the report. Besides this cost, administrative cost will need to cover updating software tools, monitoring and evaluating the programme, which is estimated to come to some additional € 6 per dwelling.

5.4. Policy instruments for the minimisation of C&DW

5.4.1. Basic strategy for waste minimisation in the building sector

When considering policy instruments in this area, it is important to understand that policy goals need to be set for various time frames. In the short term, one of the most important issues is reducing the final disposal of C&DW which, today, is generated mainly by the demolition of older buildings. Any sort of recycling and reuse of building materials should address this issue. It is noteworthy that a significant proportion of recycled building materials is not used for buildings, but for construction projects that can use materials of lesser quality, most notably for engineering fill and road sub-base (Symonds, 1999). While it is not certain that the road sector will be able to continue using such a large amount of waste materials in the long run, it is predicted that the supply of C&DW will sharply increase in this century.[49] Therefore, even though the recycling rate of C&DW may increase substantially, current recycling practices could cause problems in the future. The use of recycled materials in other sectors may be an effective way of creating demand for recycled building materials in the short term, but their use in building construction (*e.g.* use of C&DW-derived aggregates in new concrete) needs to be promoted for the middle and long term to achieve a more self-sustaining resource flow in the building sector. As concrete, masonry and lumber usually account for a considerable proportion of C&DW, increasing the recycling of these materials within the building sector would be particularly worthwhile.

While governments need to implement policy instruments for the minimisation of C&DW generated today, it is also important to make efforts to design and construct buildings today that will generate less C&DW in the future. In some other sectors, designing for a recycling (or reuse) strategy has been successful, and it is obvious that introducing such a strategy for building design should have great potential to improve the waste-generation-related characteristics of buildings and to attain a more efficient recycling loop of building materials in the long run. On the basis of these discussions and depending on the scope of policy design, three principal policy goals for waste minimisation in the building sector can be identified (see Box 12).

Box 12. **Three principal goals in the minimisation of C&DW**[1]

Goal I (short term)

To reduce the final disposal of waste generated today. In other words, to promote reuse/recycling of waste, whether it is reused/recycled in the building sector or not.[2]

Goal II (medium term)

To increase the use of recycled materials in the building sector.

Goal III (long term)

To introduce a recycling/reuse strategy in the design process with the aim of achieving more effective ways of recycling/reusing C&DW in the building sector.

1. Reduction of hazardous waste will not be discussed in this report.
2. Reduction of the final disposal of waste also contributes to the reduction of GHG emissions.

Source: OECD, 2001b.

Table 18. **Main policy instruments for the minimisation of C&DW from the building sector**

Stages in supply chain		Options of policy instruments		
		Regulatory	Economic	Information
Upstream	Design of buildings (for recycling)	• Regulation on the design of buildings	• Subsidies for the use of recyclable materials, etc.	• Environmental labelling
Demolition	Demolition and disposal	• Ban on landfill • Mandatory separation • Mandatory delivery of waste • Mandatory reporting • Demolition permission • Licence systems • Strict regulation on landfill sites	• Landfill tax • Tradable permit schemes	• Waste exchange
Downstream	Waste processing	• Minimum standards for the use of secondary materials	• Subsidies for processing plants	• Waste exchange • Certificate schemes
	Building material production	• Minimum standards for the use of secondary materials	• Virgin material tax	• Certificate schemes • Specifications
	Design of buildings (for increased use of recycled products)	• Minimum standards for the use of secondary materials	• Subsidy for the use of secondary materials	• Environmental labelling • Certificate schemes • Specifications

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5.4.2. *Supply chain and options of instruments*

The building sector has a very complicated supply chain. Various actors at various stages affect how the market for reused/recycled building materials will develop. Consequently, as Table 18 shows, there are many policy instrument options for the minimisation of C&DW at each stage.[50]

It is important to note that the points of government intervention are closely related to policy goals that instruments are aiming to address. In general, the demolition stage is the most important stage to achieve Goal I, because crucial decisions regarding the destination of present waste are usually made at this stage.[51] Therefore instruments that, for instance, encourage demolition contractors to send demolition waste to processing facilities need to be implemented at this stage. On the other hand, at downstream stages (*i.e.* waste processing, material production and building design), building material manufacturers or designer/contractors make important decisions on whether to use recycled/reused building materials or virgin materials. Therefore, these are very important stages for achieving Goals II. Finally, instruments at the upstream stage, such as design stage, have a direct impact on the performance of buildings related to waste generation (such as the recyclability of building materials and physical durability of buildings), and directly linked to Goal III. It is important to note that policy instruments that are implemented at the demolition, downstream, and upstream stages are nonetheless closely interrelated.[52] In the following sections, options for policy instruments will be discussed according to their relevance to the various stages in the supply chain.

5.4.3. *Policy instruments at upstream stages*

Changing design practices (Goal III) may have great potential for reducing C&DW, although this will not contribute to the actual reduction of C&DW for decades after construction. There are mainly two factors that determine the recyclability/reusability of buildings. The first is the choice of materials. If designers avoid using materials that are difficult to recycle, buildings could be more easily recycled. The second is how materials and components are connected. If materials and components are connected without consideration for how they can be disassembled, it will be very difficult to disconnect them on-site and, moreover, they are likely to be mixed together. However, it should be noted that the long-term impact of buildings on waste generation is determined not only by the recyclability/reusability of buildings, but also by other factors affecting their service lives, such as their physical durability, adaptability and maintainability (OECD, 2001b).

The Extended Producer Responsibility (EPR) approach is being increasingly used in other sectors. The approach assigns producers significant responsibility for the treatment or disposal of post-consumer products with the aim to promote environmentally friendly product design and support the achievement of public recycling and material management goals (OECD, 2001f). However, this approach is difficult to implement in the building sector because it seems unrealistic to assign "producers" of buildings, contractors and designers, responsibility for treating waste that will be generated decades after construction work has been completed.[53] Another problem derived from the long-lived nature of buildings is that it is impossible to predict how technologies related to waste management will develop by the time buildings that were constructed today will be demolished. Therefore, it is relatively uncertain to what degree policy instruments at this stage could be effective for waste minimisation in the long run. As it is difficult to implement effective and efficient policy instruments at the design stage, it is not surprising that only a small number of policy instruments have been introduced at this stage in OECD countries.

The upstream stage is thus the most difficult stage for which effective policy can be designed. As will be discussed in this section, there does not appear to be a very promising policy instrument – whether it be a regulatory or economic instrument, or an information tool – to improve waste-generation-related characteristics of buildings. Under such circumstances, using public procurement policies to create a demand for buildings that generate less waste could be seen as one of few realistic and effective policy options available in this area.

Regulation on building design

If minimum standards for the waste generation performances of buildings[54] were introduced under building regulations, designers would take these into consideration. So far, there is no country that has introduced such standards. General arguments regarding the drawbacks of regulatory instrument can be applied here, and the effectiveness of regulation for waste minimisation is not very certain. Although minimum standards could change the design of buildings and contribute to Goal III, it is not clear to what degree minimum standards could contribute to, for instance, the promotion of recycling of demolition wastes. In practice, the design of minimum standards in this case is very difficult because many factors affect the generation of C&DW. The development of technically reasonable, flexible and reliable standards is essential for introducing regulation, but it is not technically easy to set such minimum standards for this kind of issue. Moreover, the regulation, whose effects on waste generation cannot be perceived for decades after it has been introduced, may not be easily accepted by stakeholders.

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Capital subsidy programs/tax exemptions schemes/premium loan schemes

Another approach to improve waste-generation-related performances of buildings would be to provide economic incentives – through capital subsidy programmes, tax exemption schemes or premium loan schemes – for designing buildings with a high level of such performances. These instruments may contribute to achieving Goal III. In practice, however, the large-scale introduction of such programmes or schemes, whose actual effects would not be perceived until decades later, may be very difficult when there is public pressure to reduce public expenditure. Moreover, such an approach would entail substantial administrative costs, and designing technically reasonable, flexible and reliable standards for these instruments (as for regulation) is very difficult. These may be the reasons why few instruments of this type were identified in the OECD survey.

Environmental labelling schemes

A possible measure for reducing waste generation by buildings may be to include criteria regarding performance in this area in environmental labelling schemes. In fact, many labelling schemes already do cover such building performances, but these tend to be of little concern to potential buyers, especially of dwellings, because they do not see any potential economic benefits this might bring.[55] Therefore much should not be expected from labelling schemes for dwellings.

Environmental labelling, however, may be more likely to have an impact on commercial buildings, if firms feel that improving the environmental performance of their office buildings will improve the public image of the firm and its products. If this assumption is right, then publishing the information on the environmental performance of buildings may indeed encourage firms to improve the performance of their office buildings. From June 2002, the Tokyo Metropolitan Government in Japan will require all those who construct buildings with a total floor area of 10 000 m^2 or more to submit a Building Environmental Performance Plan, explaining the environmental attributes of the building, which include waste-generation-related characteristics. The submitted plan will then be made public and posted on the Internet. It will be worth examining what effects this approach will have on improving the environmental performances of office buildings. It is also important to note that the environmental labelling, in effect, could prepare the ground for developing other policy instruments in this area.

5.4.4. Policy instruments at the demolition stage

Ban on landfill[56]

The most direct measure to reduce the final disposal of C&DW may be a total ban on landfilling a certain category of C&DW. There are two countries whose recycling rate of C&DW has already reached 90%: Denmark and the Netherlands. Both countries have implemented regulatory instruments, including a ban on landfill, and a landfill tax. In 1997, the Netherlands introduced a new regulation that banned some recyclable and combustible wastes from being brought to landfill sites. Under the regulation, landfill site operators can only accept waste that is accompanied by a certificate, issued by licensed sorting plants or demolition contractors, proving that more than 85% of the waste is composed of materials other than those defined as recyclable or combustible in the decree.[57] Denmark introduced a similar regulation in the same year.

Since a ban directly controls the flow of waste to landfill sites, it may be regarded as one of the most effective instruments for reducing the final disposal of waste, if it is effectively enforced. Since the composition of waste is not very visible, supplemental measures, such as the Dutch certification system, may be necessary for effective enforcement. It is also important to note that a ban on landfilling potentially encourages illegal dumping of waste.

Case studies in Denmark and the Netherlands could not find any empirical evidence to suggest that landfill regulation contributes considerably to the high recycling rate in these countries. In fact, the ban was introduced after the recycling rate had already reached a high level due to a landfill tax that was introduced in both countries. In this case, it is difficult to isolate the effect of the ban from that of the tax. In the case of the Netherlands, it was reported that the ban on landfill has not been enforced very effectively due to some cases of fraud regarding the above-mentioned certification process. In addition, exemptions from the landfill ban have been granted for several kinds of C&DW since the beginning of 2000, because of a shortage of capacity at incineration sites. With regard to illegal dumping, there has not been much of an increase in either country since the regulation was introduced. A possible explanation may be that other regulatory instruments, such as mandatory reporting, have had an effect to prevent these illegal activities.[58]

A landfill ban imposes uniform standards on all demolition contractors.[59] Theoretically, if there were a large disparity in the marginal cost of changing the destination of per unit waste – from landfill sites to processing facilities, between buildings or demolition contractors – this would mean that the ban is economically inefficient. Furthermore, like other regulatory instruments, a ban on landfill provides demolition contractors or their clients with little incentive to make further reductions in waste once they have stopped disposing banned waste. However, such regulation may stimulate innovation in using recycled materials at downstream stages. The Dutch and Danish case studies found neither empirical evidence related to economic efficiency or incentives for innovation, nor criticism from stakeholders regarding these aspects of the regulation.

The administrative cost for implementing a ban on landfill may be considerable because it usually requires waste to be certified, as in the Netherlands. In the case of non-combustible waste, the fee for issuing a certificate for 24 m^3 of waste is around € 200 in the Netherlands.[60] In addition, provincial governments, which are responsible for implementing these policies, incur some costs for monitoring enforcement.

Mandatory separation

According to the OECD survey, mandatory separation is one of the most commonly used instruments, together with a landfill tax, for the minimisation of C&DW. For instance, since 1995, Danish local regulation requires the on-site collection and separation of some building materials, including asphalt, concrete, stony materials, *etc*. In the Netherlands, all municipal governments introduced a new local regulation obliging demolition contractors to separate recyclable materials on demolition sites.

The rationale for mandatory separation is that proper on-site separation is usually a requisite for recycling/reuse. Since buildings are composed of a wide variety of materials, they can be easily mixed during demolition. Even highly recyclable materials may often become unrecyclable once they have been mixed with other materials. However, mandatory separation does not ban disposal, and the impact that mandatory separation has on waste minimisation depends more on conditions of the recycled materials market, and on complementary instruments implemented at downstream stages. Unlike a ban on landfill, the regulation on demolition activities targets a great number of geographically dispersed sites operated by a number of small-scale demolition contractors. Effective enforcement of this regulation is bound to be not easy.

Case studies in Denmark and the Netherlands could not find any empirical evidence to support that regulation on mandatory separation has had a large impact on the recycling rate. On the other hand, some evidence suggests that enforcing this regulation is difficult. For instance, the Dutch study found that the local regulation has not been enforced very effectively.

Mandatory separation might not be economically efficient if there were a more cost-effective way to recycle building materials without on-site separation, but it is difficult to imagine a more efficient method with currently available technologies. Case studies did not identify any empirical evidence to suggest the degree of economic efficiency of the regulation. In addition, the administrative cost of controlling a great number of demolition sites is likely to be significant.

Mandatory delivery of waste to processing facilities

In some countries, demolition contractors are obligated to deliver some materials from demolition sites to processing facilities. Basically, most of the arguments regarding mandatory separation could be applied to this type of regulation. Since few *ex post* evaluations have been undertaken on this approach, there appears to be no empirical evidence to suggest its effectiveness.[61]

Mandatory reporting

Mandatory reporting requires that owners of buildings submit a waste management plan to authorities before their buildings are demolished. In Sweden, a waste management plan must accompany the notification of building demolition that is submitted to authorities, and it must explain what the destination of the waste will be. Danish local regulations require owners of buildings to submit reports (including the items indicated in Box 13) to municipalities at least 4 weeks before the start of demolition work if the weight of the generated waste is estimated to be more than 1 tonne. Although this obligation does not have a direct impact on demolition work, authorities have more information on the flow of C&DW and are able to track how the waste is actually treated. This could also be an effective deterrent to illegal dumping.

Box 13. **Contents of waste management reports that building owners are obliged to submit to authorities before the demolition in Denmark**

- Address and name of buildings
- Kinds of waste to be generated by demolition
- Quantity of waste
- Timing of waste generation
- Name and address of waste carriers

Source: Danish Environmental Protection Agency.

In OECD countries, C&DW has been a main source of illegally dumped waste,[62] and it is presumed that policy instruments for the reduction of final disposal, such as a ban on landfill and a landfill tax, could increase illegal dumping. Therefore, supplemental measures to control illegal dumping may be necessary. Once removed from building sites, C&DW is mobile and can be illegally dumped in geographically dispersed ways. In addition, C&DW is usually handled by a number of small-scale demolition contractors. All these factors make it almost impossible to closely monitor all demolition and disposal activities. Under these circumstances, it may be reasonable to provide effective deterrents to illegal dumping, such as mandatory reporting.

Case studies found that mandatory reporting could work effectively for preventing illegal dumping. In Denmark, for example, all municipalities have established databases into which they enter the information they receive on demolition activities, destination of demolition waste, *etc.* These databases have enabled the municipalities to have tighter control over the treatment of C&DW. This may be one reason why illegal dumping, which increased in some other countries when economic or regulatory instruments were introduced, has not become a big problem in Denmark.[63]

The administrative cost for mandatory reporting may depend largely on the volume of information incorporated into the report and how the received information is handled by authorities. Although no empirical data on this aspect could be found, the administrative cost would presumably be substantial if the collected information is to enable authorities to accurately trace the destination of C&DW.

Demolition permission

Demolition permission requires owners of buildings to submit a waste management plan to authorities in order to obtain permission to start demolition work. As with mandatory reporting, authorities receive some information regarding the management of demolition waste, and demolition permission is expected to be a deterrent to illegal dumping. The case study in the Netherlands, where demolition permission has been implemented, found that the introduction of a landfill tax has not caused increased illegal dumping, although it is not certain to what extent the demolition permission has functioned as a deterrent.

Theoretically, demolition permission could play a more important role in waste minimisation than being just a deterrent to illegal dumping. Under the scheme, demolition contractors are required to carefully establish a waste management plan well before starting demolition. This may provide opportunities to explore various possibilities of minimising C&DW.

Despite these arguments, there appears to be no empirical evidence suggesting that demolition permission could be effective in minimising C&DW. However, it is reported that such schemes are not always systematically applied (European Commission, 2000). This may suggest that there is much room for improving the implementation of demolition permission schemes. In light of the potential that these may have to improve C&DW management, further analysis on how to effectively implement this instrument is needed.

Licensing system

In many OECD countries, some demolition and disposal activities can be carried out only by those who have obtained licences from authorities. As discussed in previous sections, it is not easy to control demolition and disposal activities because many of them are done at a great number of sites in a geographically dispersed manner by a number of demolition contractors. Since it would be extremely costly to try to monitor all of these activities, it is more realistic to try controlling their activities by providing a deterrent to illegal activities. In this regard, licensing systems could provide an effective deterrent because they permit authorities to suspend a licence if illegal action has been identified. As such, the licensing system could effectively supplement other policy instruments.

Landfill tax

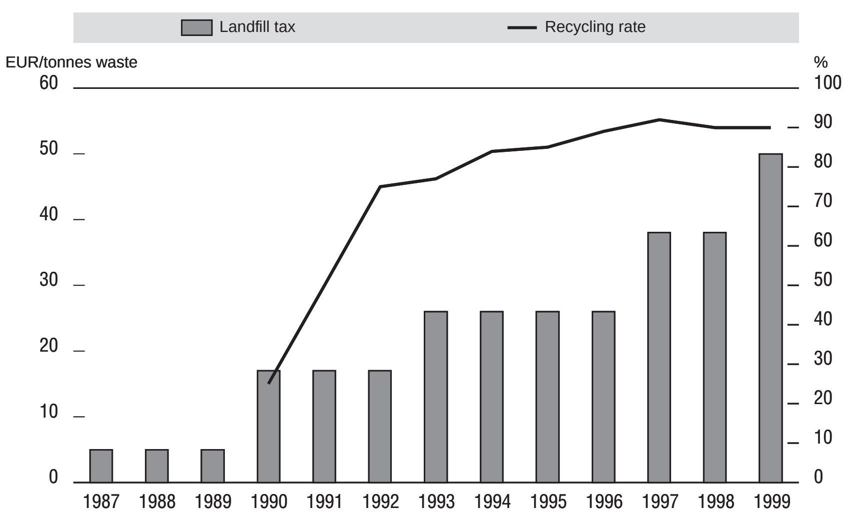
Traditionally, tipping fees for C&DW have been relatively low, partly because these wastes are generally inert and non-hazardous. It is also argued that the environmental cost of landfilling is not fully internalised in the fees, and demolition contractors are not paying for the real cost of landfills. By internalising the environmental cost in the fees, the landfill tax makes the option of recycling waste more attractive and is an incentive to reduce the C&DW that is brought to landfill sites. In general, a landfill tax, together with gate fees, are paid to the operator of the site by owners of the waste when demolition contractors or waste carriers bring the waste to landfill sites.[64] The received tax is then passed on to government tax authorities.

Theoretically speaking, the effectiveness of landfill taxes is not certain because it is difficult to predict in advance how demolition contractors. may react to an increase in landfill cost. In order to improve the tax's effectiveness, its rate has to be repeatedly reviewed, taking into account results from the monitoring of disposal activities. In addition, like a ban on landfill, such a tax could encourage illegal dumping.

With regards to the empirical evidence related to landfill taxes, case studies in Denmark, the Netherlands and the UK clearly demonstrate that the tax is a very effective instrument for the reduction of final disposal if the tax rate is set at an appropriate level. In the case of the Danish landfill tax, an analysis of the relationship between the tax rates and recycling rates of C&DW clearly indicates that the tax has contributed greatly to the increase in the recycling rate (Danish Environmental Protection Agency, 2001). Although the tax did not appear to be effective for the first three years when the rate was as low as € 5 per tonne, the recycling rate began to increase rapidly after the rate was more than tripled in 1990, and the recycling rate has kept on rising with increases in the tax rate (see Figure 16). An analytical study on the effectiveness of the policy instruments also found that municipalities, which are directly responsible for the management of C&DW, believed that the successful increase of the recycling rate could be attributed mostly to the tax. One reason may be that the recycling rate had already reached a very high level before other policy instruments, such as a ban on landfill, was introduced in the late 1990s.

In the Netherlands, the landfill tariff, including a tax for non-combustible wastes such as C&DW, was set at around € 12/tonne when it was introduced in 1996. After repeated minor increases, the tarifs was greatly increased in 2000 to € 70/tonne. It is widely believed that the landfill tax is the instrument that has contributed the most to the high recycling rate of C&DW

Figure 16. **Recycling rate for C&DW and the landfill tax rate in Denmark**



Source: Danish Environmental Protection Agency, 2001.

Table 19. **Recycling rate of construction and demolition waste in the Netherlands**

	1985	1990	1995	1996	1997	1998	1999	2000
Recycling	49.5%	73.5%	91.6%	91.5%	92.5%	93.0%	92.1%	94.3%
Incineration	0.9%	1.3%	1.1%	1.1%	1.5%	1.4%	1.2%	1.1%
Landfill	49.7%	25.2%	7.3%	7.4%	6.0%	5.7%	6.8%	4.6%

Source: RIVM.

in the Netherlands. As indicated in Table 19, he yearly trend of the recycling rate highlights the large impact the landfill tax has had on recycling. The recycling rate exceeded 90% in 1995 when the landfill tax was announced and the other instruments had not yet been implemtented.

It is also important to note that even after exemptions from the landfill ban have been granted for several kinds of C&DW at the beginning of 2000,[65] the recycling rate reached its highest level in 2000 with the increase of the landfill tax rate. This appears to be additional evidence that the tax has been more effective in promoting recycling than regulation (*i.e.* the landfill ban).

In the UK, which has not implemented any of the main regulatory instruments discussed in previous sections(a ban on landfill, mandatory separation and mandatory delivery), introduced a landfill tax in 1996. Although the rate of the UK landfill tax is quite low (£2 per tonne of inert waste),[66] reviews of the tax found that it has had a considerable impact on reducing the C&DW brought to landfill sites, although it is not quite clear just how great this impact has been.

It is important to note that while landfill taxes have successfully reduced the final disposal of C&DW in these countries, they have not greatly contributed to promoting the use of recycled materials in building construction. Even in Denmark and the Netherlands, which have the highest rates of recycling C&DW, a significant proportion of recycled building materials is used for construction projects that can use materials of lesser quality, such as road foundations. The British case study found that the reduction of C&DW brought to landfill sites after the introduction of the landfill tax is largely attributable to the increased use of the waste for landscaping leisure facilities, such as golf courses. It has been pointed out that the UK landfill tax has diverted materials from landfill without necessarily displacing primary aggregates (Powell, 2001).

With regard to the effects of the landfill tax on illegal dumping, case studies show mixed results. In the UK, while evidence of an increase in fly tipping is anecdotal, the overwhelming majority of submissions from industry, regulators, local authorities and the Department of Environment, Transport and Regions indicate that the practice has increased since the introduction of the landfill tax (UK Select Committee on Environment, Transport and Regional Affairs, 1998). On the other hand, Dutch and Danish studies found that illegal dumping has not become a big problem with the introduction of the tax. As was discussed in the sub-section on mandatory reporting, one possible explanation is that the implementation of regulation that enables municipalities to track the treatment of C&DW has become an effective deterrent to illegal dumping.[67]

The landfill tax does not impose any specific standard of the behaviour for demolition contractors *etc.*, and encourages recycling only by internalising the environmental cost in the fees. Therefore, it is theoretically presumed that the landfill tax could lead to the least-cost option for encouraging waste disposal reduction among demolition contractors or building sites, although no empirical evidence was found to prove this. Moreover, the tax may provide continuous incentives for innovating in ways of reducing waste more cost effectively. The Danish study indicates that these instruments are generally perceived to have contributed to innovation in technologies related to the recycling of building materials, though no clear evidence could be identified to support this.

The administrative cost of implementing the tax may be modest, especially in countries where landfill sites are operated by municipalities. In the Netherlands, where the number of landfill sites has decreased from more than 200 in 1990 to 35 today (partly due to the landfill tax), and where most of these sites are operated by municipal governments, the cost for collecting the tax is estimated to be modest.[68]

Strict regulation on landfill sites

It is important to note that solid waste disposal differs from air and water pollution. If authorities introduce stricter regulation that requires landfill operators to implement some extra measures to prevent landfill sites from causing environmental damage to their surroundings, the cost of running the landfill is bound to increase, and this increase in cost will most likely be reflected in the tipping fees. In fact, it is sometimes argued that this approach is better than the landfill tax because while both instruments may increase tipping fees for the landfill, only the former makes sure that the protection of the surrounding environment can be improved. Although landfill taxes can reduce the amount of waste that is landfilled, they provide site owners with no incentive to improve waste management at the sites (as emission taxes do) to limit emission sources.

However, as an instrument to minimise C&DW, the effectiveness of strict regulation on landfill sites may be less certain than that of landfill taxes because it is difficult to predict how much tipping fees will increase when stricter regulation is introduced. Also, strict regulation on landfill sites inevitably involves a greater administrative burden as the design of the sites needs to be checked for compliance with prescribed standards, and site activities need to be regularly monitored.

Tradable permit scheme

The potential for using permit trading schemes in the field of waste management has long been discussed among experts, but the UK appears to be the only country that has already applied a permit trading mechanism to this area. In addition to the Packaging Waste Recovery Notes that have rapidly evolved into a functioning tradable compliance credit system, a "cap and trade" scheme for limiting the disposal of biodegradable municipal waste (BMW) to landfill is currently in its final design phase (OECD, 2001g). The latter system of tradable permits will give authorities who are responsible for the disposal of BMW the right to send only as much waste to landfill as their permit holdings will allow. Since the permits are tradable among authorities, they will have the flexibility to share the burden of meeting the targets. In areas where the costs of diversion from landfill are high, they could choose to continue to landfill waste by buying permits from local authorities where the costs of diversion are lower. It is expected that the scheme will make it possible to meet the targets at the least possible cost. (UK Department of Environment, Transport and the Regions, 2001.)

The UK experience may suggest that tradable permit schemes could also be applied to the management of C&DW. Theoretically, tradable permit schemes are a very attractive instrument. If relevant rules are effectively enforced, the schemes could be the most effective way of reducing C&DW with the least compliance costs.

However, in practice, there are some obstacles to applying this mechanism to C&DW. In general, unlike municipal waste, the collection and disposal of C&DW is not the responsibility of authorities. A large number of demolition contractors or waste carriers bring C&DW to landfill sites. It would be much more difficult to establish a market for permit trading among a large number of demolition contractors than for trading among a limited number of authorities. In addition, effectively enforcing the scheme's rules with so many participating bodies would require significant administrative capacity. Consequently, the administrative cost of operating tradable permit schemes for C&DW could be high enough to offset the benefits of total compliance cost reduction.

However, experience has shown that start-up costs and transaction costs for well-designed tradable permit schemes are often less than initially anticipated. Moreover, the sheer number of firms involved in C&DW markets is likely to improve efficiency in the market, particularly in so far as it reduces the potential for market power to be exercised by some participants. Further studies on the design of tradable permit schemes for C&DW are needed.

Waste information exchange

A more effective use of C&DW is often hampered by a lack of timely information on its source and availability, and on potential construction projects or production processes where such waste could be utilised (Collins, 1998). Electronic marketplaces, such as waste exchanges, can provide useful information on the availability of secondary building materials, and at the same time reduce asymmetrical information by providing additional information for the buyer (user) without increasing search costs (Powell, 2001).

One example of a waste information exchange in the building sector is the Material Information Exchange system in the UK, which is an Internet-based waste information exchange (see Box 14). Launched in 1998, the exchange allows contractors with unwanted materials or wastes to post their availability on the Internet and then wait to hear from someone who wants them. The system is operated by the Building Research Establishment, and the service is free to both sellers and buyers, being funded by the UK government as part of its programme to increase the use of recycled materials. The

Box 14. **Materials Information Exchange for the building sector in the UK**

The Building Research Establishment, with support from the UK government, has developed an Internet-based Materials Information Exchange system that consists of four parts:

- a "board" showing materials for free collection or sale, with text and menu boxes indicating the source, quantity, location, cost and timing;
- a catalogue of unutilised materials, such as over-ordered stock that is available;
- a "materials wanted" board with text and menu options; and
- an "up and coming" demolition board to notify potential users of C&DW of where and when it may become available.

The system is designed to be self-maintaining and users are free to enter or exit information directly from the system without the need to contact a third party.

Source: Collins (1998).

Flanders region of Belgium is operating a similar scheme. It is reported that both schemes have not been widely used, but no *ex post* evaluation on these schemes has been identified.

5.4.5. *Policy instruments at downstream stages*

There are two important requisites for developing recycled building materials markets:

- recycled materials should be competitive with virgin materials in terms of price and quality; and
- potential buyers should be assured of the quality of recycled materials.

The second condition is particularly important for achieving Goal II because buyers usually have enough reasons to feel anxious about the quality of the materials they choose. For instance, some recycled concrete aggregate can be used not only for low-grade applications such as road foundations, but also for structural parts of buildings. However, recycled aggregate concrete generally has less strength and workability than virgin aggregate concrete, and may cause structural problems unless the quality of recycled aggregates is strictly controlled.

Minimum standards for the use of recycled materials

The most direct method to promote the use of recycled materials in building construction (Goal II) is to impose minimum standards for using recycled materials. According to the OECD survey, no country has implemented this type of regulation, although a new Japanese law requires contractors to make efforts to use as much recycled material as possible. In practice, it is very difficult to design such minimum standards. Many different kinds of materials are incorporated into one building, and the feasibility of replacing virgin materials with recycled materials varies considerably, depending on the kinds of materials, how they are used and many other contextual factors. In addition, various sectors supply various materials to the building sector, so it may be very difficult to establish standards that are technically reasonable and perceived as fair by all stakeholders.

There appears to be a large difference in the marginal cost of replacing virgin materials with recycled materials between buildings. In general, building materials are heavy and big, and dense networks for supplying recycled materials have not yet been established. Consequently, even under the assumption that there is no difference in the materials used in buildings and in the expertise of contractors, there will nevertheless be a large disparity in transport costs of recycled materials depending on the geographic location of sites. Therefore, the implementation of uniform minimum standards for using recycled building materials is bound to entail considerable compliance costs, particularly before a market for recycled materials has been fully developed.

Although administrative cost could be largely reduced by using existing regulatory frameworks, enforcing standards for recycled materials is probably more difficult than enforcing regular building standards. Many common building standards prescribe the size of components (*e.g.* width of columns and beams) and the location of components (*e.g.* distance between walls), or performances that have been calculated using them, which can be easily checked during on-site inspections. On the other hand, minimum standards for using recycled materials only concern the origin of the materials, which is difficult to evaluate on-site due to their invisibility. That means these standards cannot be effectively enforced without implementing a reliable labelling scheme for recycled materials, and this would inevitably entail significant administrative costs.

Minimum standards for the quality of recycled materials

One obstacle to promoting the use of recycled building materials is the sceptical attitude that designers and contractors have towards their quality. Many research studies have suggested that most recycled building materials can have the same quality as virgin materials if they are appropriately processed. However, users – whose past experience tells them that virgin materials are reliable and who do not have sufficient information on the quality of recycled materials – may not be easily convinced that recycled materials will not diminish the performances of buildings or cause damage the surrounding environment. As a result, users may hesitate to choose recycled building materials. One approach for changing this attitude would be to impose a minimum standard for the quality of recycled buildings materials or products containing them.

In 1999, the Netherlands introduced the Building Materials Decree that imposes a minimum standard for materials containing hazardous chemicals that could potentially damage surface water or soil. Under the Decree, owners of buildings are required to confirm that only materials certified as meeting this standard are used in their buildings. Although this involves significant administrative costs for monitoring compliance, such a measure could potentially alleviate fears that hazardous chemicals may leach from such materials.

However, it is doubtful that this approach would alleviate the concerns that users have over the potential deterioration of other building performances, such as structural strength, if they were to use recycled building materials. While the risk of leaching hazardous chemicals is directly linked to the quality of the materials, this is not the case with other performances of buildings. For instance, while the quality of materials affects the structural strength of buildings, it does not determine the strength alone. In many cases, the loss of strength resulting from the use of low quality materials can be recovered by improving other determinants, such as the size of components. However, many countries are currently introducing performance-based standards into their building regulations to provide more flexibility in building design, and introducing specific minimum standards for recycled materials is clearly inconsistent with this trend. By narrowing down the choice of materials, a relatively high compliance cost will be imposed on the construction industry, and may have adverse effects on innovation.

Virgin material taxes

One requisite for developing a recycled building materials market is to make recycled materials competitive with virgin materials. However, recycled building materials are often not as competitive as alternative virgin materials, and this is partly because the environmental cost of consuming virgin materials is not reflected in their price. One potential approach is to increase the price of virgin materials by levying virgin material taxes. To reduce material extraction, an aggregate tax has been levied in Denmark since 1977 on raw materials, such as stones, gravel and sand, that are commercially extracted or commercially imported.[69] In the UK, the Aggregate Tax, which will come into force in April 2002, aims to reduce the environmental impact associated with quarrying and to increase the rate of recycling of construction materials. The tax will be applied to sand, gravel and crushed rock, with a flat rate of £1.60 (€ 2.55) per tonne. Presently the price of aggregates in the UK is around £5 per tonne, so the effect of the tax is estimated to increase prices by some 30%.

Like other types of taxes, the virgin materials tax may theoretically not be a very effective measure unless its rate can be flexibly adjusted to reach the level where it could have a large impact on the use of materials. It is difficult to precisely predict how users will react to an increase in the price of virgin materials because there are other factors, such as transportation cost, perceived quality of the materials and their availability, that are likely to affect their choice of materials. Moreover, it is important to note that the links between the material that is taxed and the externalities associated with ultimate waste generation can be weak (*i.e.* depending on how it is used, where it is disposed, *etc.*).

Although an *ex ante* estimate in the UK suggests that the tax may have great potential to promote recycling in the building sector,[70] the Danish and Swedish experience shows unclear results. A review of the Danish aggregate tax concludes that the tax has a limited impact on the promotion of recycling because the tax rate is not high enough, and that the landfill tax has had much more impact (ECOTEC, 2001). In Sweden there was a larger reduction (*i.e.* 6%) in the use of virgin material during the 2 years after the tax was introduced in 1996, than during the corresponding 2-year period from 1994 to 1996. However, this may simply reflect an on-going downward trend, and it is not clear to what extent the tax has contributed to a reduction in the use of sand and gravel.

There appears to be no clear evidence that a virgin material tax has actually brought much environmental improvement in any of the countries where it has been introduced. A landfill tax, whose effectiveness for reducing waste going to final disposal has been proven, appears to be the more attractive option. However, it should be noted that a landfill tax is not as likely to encourage the use of recycled (rather than primary) materials, and that the displacement of primary aggregates is more likely to be encouraged by the introduction of an aggregate tax (Powell, 2001). There are few instruments, other than virgin material taxes, that can provide economic incentives to a great number of users to substitute primary materials with recycled ones. Although there is no empirical evidence to support this argument so far, it is expected that virgin material taxes will play an important role in the choice of building materials in the future.

With regard to economic efficiency, it is obvious that this tax could provide the least-cost solution for reaching a given level of virgin materials replacement. The tax would also provide incentives for finding more innovative and cost-effective ways for replacing virgin materials.[71] One of the advantages of virgin material taxes is that they can be easily administrated (Stavins, 1993). The implementation of virgin material taxes does not require checking design documents and on-site inspections. It was reported that the administration and control of the Danish aggregate tax constitute a small burden (ECOTEC, 2001).

Table 20. **Total sand and gravel use as a proportion of total aggregate use in Sweden**

Year	Proportion of sand and gravel to total aggregate use
1984	82%
1994	48%
1996	46%
1998	40%

Source: ECOTEC, 2001.

Capital subsidies for the use of recycled materials

Another approach to the development of a recycled building materials market would be to provide economic incentives – through subsidy programmes, tax credit schemes or premium loan schemes – for using recycled materials. These may effectively promote the replacement of virgin materials with recycled materials, but they contradict the Polluter Pays Principle. Moreover, it may be difficult to implement such instruments, which are aimed at a large number of buildings and would require tax revenues, when there is public pressure to reduce public expenditure. Such an approach would also entail much higher administrative costs, not only because it would require complicated administrative processes for checking and approving applications, but also because the labelling of recycled materials would be essential for operating these subsidy programmes, tax credit and premium loan and schemes.

Capital subsidies for processing plants

Small-scale mobile plants have traditionally been widely used for processing aggregates in OECD countries. The advantage of small-scale mobile plants is that they involve small capital costs and can reduce the cost of transporting material. Although they are quite useful in processing C&DW for low-grade uses, such as road foundations, they do not have some of the functions required for qualified use, such as the separation of materials into different grades (Cairns *et al.*, 1998). In order to shift the destination of recycled materials to the construction of buildings, large-scale fixed plants that can produce high-quality recycled materials will be needed. However, in many OECD countries there is a shortage of fixed plants. For example, it is reported that only 2 or 3 recycled aggregate plants for concrete are available in Japan, though there are more than 250 plants for road-base aggregates (Kasai, 1998). Fixed plants are in such short supply clearly because there is not a large demand for high-quality recycled materials. On the other hand, the shortage of fixed plants is in effect making recycled materials more expensive by increasing transportation costs. In addition, this shortage of plants is making it difficult to deliver recycled materials on time. In fact, concern over the lack of availability of recycled aggregates has often been expressed by concrete producers (Cairns *et al.*, 1998).

Capital subsidies for the capital cost of fixed processing plants may be one measure that could break this vicious circle although, like other subsidy programmes, these may be difficult to implement efficiently. The UK has been subsidising the purchase of crashing plants, and the Walloon government of Belgium is investing in recycling companies.[72] Such a capital subsidy programme requires a considerable amount of financial resources but has some advantages over other subsidy programmes that target buildings. The main advantage is that a capital subsidy programme does not have to last as long as other subsidy programmes and it can be removed once the market for recycled materials has been developed and a dense supply network has been created. The programme also involves lower administrative costs because the number of recipients is limited. Moreover, the programme is not directly related to the design of buildings, so it can be implemented without a labelling scheme. However, it should be noted that such measures are only likely to be efficient if investments in processing plants can overcome specific barriers in the capital market. So far, no *ex post* evaluation studies have been done on how such subsidies may affect the promotion of recycling C&DW.

Certification schemes and specifications

The development of a recycled building materials market may often be hampered by a feeling on the part of potential buyers that the use of recycled materials contains an element of risk (which often is greater than the actual risk). For those who specify materials used in buildings, virgin materials whose performance has long been proven could be a safer option to avoid the possibility of legal action. In fact, some existing specifications are thought to discriminate against the use of recycled materials (Powell, 2001). The lack of specifications for recycled materials and mechanisms to prove the quality of recycled materials has long been identified as one of the major constraints on their use, especially for their high-grade use in buildings. In order to overcome these barriers, designers and contractors should be provided with specifications that take into account the use of recycled products, and there should be a certification scheme proving the quality of recycled products. This type of specifications have been established in some countries. For instance, recommended specifications regarding recycled aggregate concrete have been established in Germany.[73] Once such specification and certification schemes have been fully developed and implemented, end-users of building materials can obtain reliable information on the quality of the materials and be assured that they meet required performance standards.

The establishment of specification and certification schemes does not always require the commitment of governments. However, as the construction industry is generally conservative and very slow to change its production practices, it may be necessary for governments to render these instruments credible by providing technical and financial support as well as approving certifying bodies. It is also important for these instruments to be designed to be as flexible as possible so that they do not discourage the use of newly developed cost-effective technologies.

The operation of certification schemes involves considerable administrative costs which are usually covered by application fees paid by the applicants. An important factor that affects the application fee level may be the competitiveness of the certification service market. In this regard, newcomers should not have to face unreasonable barriers to enter the market, and competition should be promoted so as to minimise the administrative cost of operating certification schemes.

Environmental labelling schemes

Many voluntary environmental labelling schemes, such as the BREEAM in the UK and the LEED in the US, assess to what extent recycled materials are used in buildings. These schemes may help potential buyers to understand one of the environmental characteristics of buildings. However, in the case of dwellings, it is doubtful that consumer decisions could be significantly influenced by this information because potential buyers, as discussed in Section 2.1, usually pay little attention to the use of recycled materials. In the context of environmental performances that are not linked to direct economic benefits, environmental labelling schemes are more likely to have a positive effect in the commercial building sector.[74]

5.5. Policy instruments for preventing indoor air pollution

It is very difficult to identify what is responsible for indoor air pollution. First, as the causal mechanism of indoor health problems is complicated, some basic questions concerning the relationship between symptoms and the environmental characteristics of buildings (*i.e.* choice of materials) have to be answered. While pollutants commonly found in indoor air are responsible for many harmful effects, there is considerable uncertainty about what concentrations or periods of exposure are necessary to produce measurable health problems (US Environment Protection Agency *et al.*, 1995). In addition, it is not quite clear to what extent the pollutant sources in building materials are responsible for the concentration of pollutants. Pollutant levels can rise with an increase in temperature or humidity, or if products containing pollutants are present indoors.

Under such circumstances, one of the most important measures for coping with the issue of indoor air pollution may be to undertake basic research to collect empirical data and analyse the causal mechanism. In France, the concentrations of more than thirty indoor pollutants have been measured in 1 000 dwellings across the country. In Japan and the UK, similar research is underway in respectively 5 000 and 1 000 dwellings, and such research has also been undertaken in the US. The results of this empirical research are expected to contribute to the development of policy instruments discussed in the following sections.

5.5.1. *Regulatory instruments*

Regulation on the indoor pollutant level

Since the immediate target of policy instruments for preventing indoor air pollution is usually to keep indoor pollutant concentration below the target level, the most direct approach to control indoor pollutant levels is to impose maximum standards on the actual pollutant level itself. These standards also allow for great flexibility in the design of buildings. However, in practice, it is technically not very feasible to enforce such standards. It is very difficult to monitor the actual pollutant level in a great number of buildings and the level often fluctuates in accordance with humidity, temperature, *etc.* Consequently this type of regulation would entail enormous administrative costs.

Regulation on ventilation methods and quality of building materials

A more realistic approach to the problem would be to enforce minimum standards for the design of building elements. In general, two factors largely affect the indoor pollutant level. One is the design of ventilation systems. By increasing the ventilation of buildings, indoor pollutant levels could be lowered. The design of ventilation may be particularly important for large-scale buildings that have fully mechanical ventilation systems. Minimum standards for estimated air exchange through ventilation have traditionally been included in building regulations with the aim to keep indoor air fit for human consumption, and some countries have introduced new provisions to address building material-related indoor air pollution.[75]

The other factor is the pollution emission-related quality of building materials incorporated in buildings. By avoiding the use of building materials that contain pollutants, indoor pollutant levels could be greatly lowered. There has been some discussion on the relative significance of these two factors. In the US, it was reported that 80% of indoor air problems might have been due to the faulty operation of ventilation systems in the 1970s when a very strict air-tightness standard was introduced. However, it has often been argued that improved air-tightness is less of a problem than the inherent existence of pollutants (Bell *et al*, 1996). Today it may be widely argued that for most indoor air quality problems, the most effective method is to eliminate or reduce the pollutant sources inside buildings (US Environment Protection Agency *et al.*, 1995).[76]

One of the most common indoor pollutants in OECD countries is a formaldehyde that is contained in pressed wood products and urea formaldehyde insulation foam. Denmark was the first country to introduce regulation regarding the quality of building materials. The Danish government introduced a new provision in its building regulation on the use of building

Box 15. **Controlling formaldehyde concentration under the Danish building regulation**

- Chipboard, wood fibre and plywood panels, and similar materials containing synthetic resin binders that emit formaldehyde, may only be used if they are subject to a control scheme approved by the Ministry of Housing.
- Thermal insulation materials, which are made by foaming urea and formaldehyde, may only be used if they are subject to a control scheme approved by the Ministry of Housing.
- The general aim of these provisions is to ensure that the concentration of formaldehyde in air – corresponding to room air, and with a realistic use of the building materials in question and prescribed ventilation, temperature and relative humidity – does not exceed 0.15 ppm.
- An approved inspection and testing scheme has been established under the Danish Control Organisation for Wood-Based Panels. Methods and test conditions are prescribed in the organisation's approval and inspection rules.

Source: Danish Ministry of Housing and Urban Affairs, 2000.

materials containing formaldehyde together with a minimum standard for ventilation in 1979.[77] The regulation aims to ensure that chipboards, wood fibre and plywood panels and similar materials containing synthetic binders that emit formaldehyde are used in building construction only when it has been proven that their use in buildings under predetermined conditions does not lead to concentrations of formaldehyde that exceed the target level (0.15 ppm) (see Box 15).

Since the amount of chemicals contained in building materials is invisible and difficult to control, the government has established a new quality control system on pressed wood products in order to enforce the standard effectively. Under this system, the government does not directly check the quality of the products but checks the reliability of the quality control system. The government has approved an inspection and testing scheme for the production of wood products operated by the Danish Control Organisation for Wood-Based Panels (Danish Ministry of Housing and Urban Affairs, 2000).[78] Furthermore, thermal insulation materials are also regulated in this way.

In Germany, the government added a new provision regarding formaldehyde to the relevant regulation in 1986. As indicated in Box 16, the

Box 16. **German ordinance on bans and restrictions on the placement of dangerous products on the market (excerpt)**

1. Coated and un-coated derived timber products (particleboard, wood core plywood, veneered board and fibreboard) must not be placed on the market if the estimated concentration of formaldehyde resulting from the derived timber products in the air of a test chamber exceeds 0.1 ppm. The estimated concentration is to be measured in accordance with test procedures that reflect the state of the art. The Federal Environmental Agency, in agreement with the Federal Institute for Material Research and Testing and after hearing experts, publishes the list of test methods that satisfy these requirements.
2. Items of furniture containing derived timber products that do not satisfy the requirements of Paragraph 1 may not be placed on the market. Paragraph 1 shall, however, be deemed to be fulfilled if the items of furniture comply with the equilibrium concentration specified in Paragraph 1 in a whole-body test.

Source: German Federal Ministry of Transport, Building and Housing, 2001b.

ordinance prohibits the sale of products containing formaldehyde in quantities that may lead to indoor concentration levels that exceed the target value (0.1 ppm) in the standardised test chamber. Under this regulation, manufacturers of engineered wood products are required to be able to prove that their products satisfy the requirement indicated in the ordinance. In addition, under the framework of building regulation, another regulation on the quality of wood-based panels used in buildings was introduced in 1980 and then revised in 1994. The regulation requires that only products that have been certified as "E1 class" by an approved testing laboratory can be used in building construction. "E1 class" has to be proved with a certain test, that the emission of formaldehyde from products should be below the target value level (0.1 ppm) under standardised conditions. In addition, manufacturers are required to establish reliable quality control systems with a combination of self-inspection and third-party inspection. Only when these requirements are satisfied, are manufacturers allowed to put a special label on their products. When buildings are actually constructed, building owners are required to make sure that only labelled products are used in buildings. In some cases, local authorities conduct on-site inspections to confirm that only labelled products are used. The German government is also planning to implement a new regulation to control the quality of building products in terms of emissions of volatile organic compounds (VOC).

As the quality of building materials may be the most important factor affecting indoor pollutant levels, it is presumed that health problems related to indoor pollution could be effectively solved by the regulation on building materials. In comparison with directly regulating pollutant levels, enforcing standards for building materials may entail much less administrative cost because indoor pollutant levels will not need to be monitored. On the other hand, it is also theoretically presumed that the regulation on building materials may not be economically efficient. Since the set target does not allow for trade-offs between design elements, the least-cost solution cannot be achieved. Moreover, such regulation may also have a negative effect on the innovation of relevant technologies.

It is also important to note that the regulation on the quality of building materials cannot solve all potential health problems. Even if the standards were to be completely enforced, there remains a slight possibility that indoor pollution levels could exceed the target level depending on other factors that might affect indoor pollution. Furthermore, even though the target value level was attained, a particularly sensitive person could suffer health problems. That is why it is sometimes argued that this type of regulation or other instruments indicating a single "acceptable" standard could result in misleading information and confuse consumers.

Case studies in Denmark and Germany found some empirical evidence to support the argument that the regulation on building materials is an effective measure to solve the indoor pollution problem. In both countries, when the regulation was introduced, manufacturers of regulated products responded positively and started to supply only products that complied with the standards, making it almost impossible to find products that did not meet the standards in the market. As a result, the introduction of the regulation has improved the environmental performance of not only new buildings, but also that of existing buildings because the same materials are often used in refurbishment or remodelling work as in new construction. While many other countries are still struggling to cope with indoor concentrations of formaldehyde, this is generally perceived as a "solved problem" in Denmark and Germany. One reason for the success is that the regulations in both countries target a small number of large-scale engineered wood product manufacturers. It is obviously easier to control their activities than those of a great number of small-scale contractors. In addition, such manufacturers are likely to pay more attention to the public image of their firms and products, and this may also have contributed to the effective enforcement of the standards.

As for "misleading effects", the case studies could not identify such criticism among stakeholders in either country. Even if safe building materials are used in buildings, indoor pollutant levels could still exceed the target value if occupants bring in furniture that contains a considerable amount of pollutant. In order to avoid such a risk, both countries have implemented a similar regulation on furniture.

Despite the theoretical argument that this sort of regulation may harm flexibility in building design, case studies in both countries could not find any such criticism among stakeholders. This may be because, in many cases, removing the pollutant source has actually been a cost-effective way to reduce indoor pollution relative to alternative methods. It is also noteworthy that, in Denmark, performance criteria for the approval of engineered wood products have been introduced in an effort to minimise the negative effects of the regulation on flexibility in building design.

Case studies also found that the administrative cost for implementing the regulation on building materials is modest. In Denmark, although municipalities may have done on-site inspections of materials shortly after the introduction of the regulation, they soon became almost unnecessary because manufacturers stopped production of low-quality products. As a result, municipalities rarely do such inspections today, so there is almost no administrative cost directly incurred by the government. The only administrative cost burden comes from quality control of engineered wood products. Since it is a limited number of factories, rather than a large number of building sites, that need to be checked under the quality control scheme, administrative cost is bound to be limited. Similarly, in Germany, the main target of the regulation is factories rather than building sites. While production processes of engineered woods products are tightly controlled, the process of on-site building inspection has been simplified to only checking whether engineered wood products have a special label. This administrative structure should reduce the administrative cost of the regulation.

5.5.2. *Economic instruments*

The unique characteristic of indoor air pollution is that its environmental costs are incurred only by the occupants of the building. Therefore, it is not productive to consider overall emissions of pollutants to indoor air for the entire building stock, as in the case of CO_2 emissions. Due to this characteristic, economic instruments are not very attractive for addressing indoor air pollution. Given that there are set acceptable levels of pollutant concentrations in buildings, there is little room to lower the overall costs for achieving these goals by introducing economic instruments. It may be meaningless in this case to seek the most cost-effective way of distributing responsibilities between buildings.

While the role of economic instruments may be limited in this area, some potential uses can nonetheless be identified. When a hazardous pollutant source has been discovered in building materials and it is costly to eliminate it from buildings, subsidy programmes may be an effective measure for protecting low-income households who cannot afford the cost of eliminating the potential health risk. Second, economic instruments could give incentives to landlords in the rental sector to avoid using hazardous materials in their buildings.

Another economic instrument that could be effective here may be to impose more liability on designers and contractors for health problems due to buildings. Although no country has implemented such measures for the building sector, general liability regimes in OECD countries are already providing incentives to reduce the supply of buildings that may be detrimental to human health.[79] This approach may also be effective to incite employers to provide a healthful work environment for their employees.

5.5.3. *Information tools*

In many instances, the effects of indoor air pollution on human health are uncertain and not life threatening. In such cases it may be difficult for governments to introduce regulatory instruments. Less-binding information tools, which appear to have great potential in this area, could be more promising options.

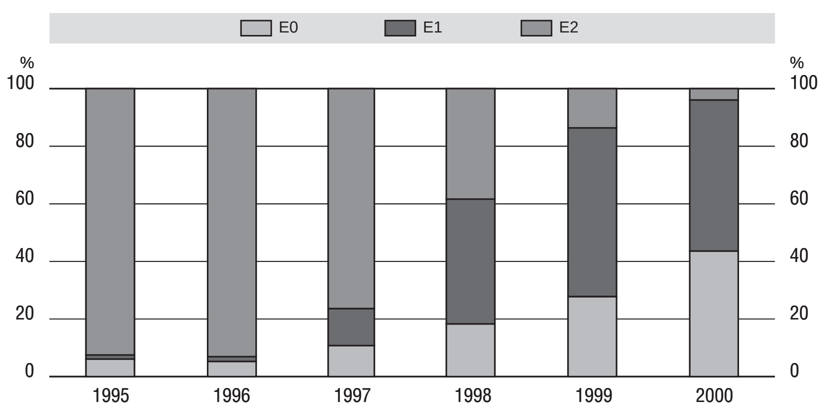
Environmental labelling schemes

Environmental labelling schemes often include (either or both) the ventilation methods used and the pollution-related quality of building materials in their assessment criteria. For instance, the Housing Performance Indication Scheme in Japan indicates the estimated amount of formaldehyde emissions from building materials according to 3 ranks.[80]

Although the effects of indoor air pollution are directly experienced by occupants, potential buyers of buildings generally do not have information regarding the levels of indoor pollution of the buildings they are going to buy. This is especially true in the absence of government policies to provide this information. It is therefore theoretically presumed that labelling schemes would encourage buyers to choose buildings with safer materials or better ventilation, and that subsequently this change in buyer behaviour would incite sellers to supply buildings with better environmental performances. This is illustrated by the fact that about 80% of respondents in the German survey answered that "health compatibility of building material" is "essential" for environmental labelling schemes for buildings (see Figure 12).

The case study on the Housing Performance Indication Scheme in Japan indicates that environmental labelling schemes are very effective for improving the indoor air environment, even though the process of improvement is different from what had theoretically been predicted. The case study could not find any empirical evidence to suggest that the behaviour of buyers was influenced by the labelling schemes. However, the labelling schemes do appear to have a direct impact on building material manufacturers. Figure 17 indicates that the market share of particleboard that is certified as "E0 level" (*i.e.* containing the least amount of formaldehyde) has rapidly increased since the government first proposed the Housing Performance Indication Scheme in 1997. It is widely argued that the scheme has encouraged particleboard manufacturers to produce more low-emission type products. It is important to note that low-emission particleboard is used not only for new dwellings, but also for other kinds of new buildings and for the refurbishment or remodelling of existing buildings. Although the labelling scheme focuses on new dwellings, its positive impacts are much wider. As with labelling for energy efficiency, the effectiveness of environmental labelling schemes for buildings may be largely dependent on how performance levels are indicated to consumers. Since there is uncertainty regarding the impact of building design on human health, the "seals of approval" type of labelling may not be suitable here. This could potentially give the misleading impression that because such a label was granted, there is no risk to human health at all. Moreover, labelling schemes with ranks or indexes may provide incentives for innovation, particularly for developing more healthful building products.

Figure 17. **Breakdown of Japanese particle board market by the amount of formaldehyde contained**



Note: Under Japan Industrial Standards, particleboard which contains the lowest level of formaldehyde is categorized as "E0". In order for buildings to be evaluated as being in the top rank of safety for indoor air pollution, this category of boards must be used. Boards categorized as "E2" contain the largest amount of formaldehyde.
Source: Japan Particleboard Manufacturers Association.

It is sometimes argued that labelling schemes may potentially encourage the use of technologies that are not cost-effective if the schemes have rigid technology-based assessment criteria. In order to prevent such negative effects, the Japanese scheme was designed to have flexible performance-based assessment criteria, so that any new technologies could be properly evaluated. The Japanese study found that the labelling scheme appears to encourage the innovation of new technologies. It has often been reported that new building materials, such as low-emission interior finishes, were developed and launched targeting builders and developers who will be using the scheme.

As discussed in previous sections, the administrative cost for environmental labelling schemes may be considerable because they usually require that inspection bodies check design documents and conduct on-site inspections before issuing reports on the performances of buildings. It is important to design administrative frameworks so that the administrative cost of labelling schemes could be minimised (see Section 5.2.3).

Environmental labelling for building materials and products

Since buildings are usually custom designed, they contain a wide variety of materials and products. Unfortunately for designers, pollution emissions from certain materials and products are not always known and are consequently difficult to eliminate. A greater selection of "healthier" building materials should be supplied by manufacturers to increase options for designers. In this sense, environmental labelling schemes for building materials and products could greatly help designers. Moreover, these schemes may be necessary in order to make other instruments, such as labelling for buildings, work efficiently. Many of the existing schemes for building materials and products, *i.e.* the Blue Angel in Germany, already cover the impact of building materials on indoor air quality.

It is presumed that environmental labelling schemes for buildings and building materials are interrelated. The diffusion of the former scheme should help the implementation of the latter scheme. For instance, under the Housing Performance Indication Scheme in Japan, "Protection from indoor air pollution" is evaluated according to the rating on building materials and products used for interiors. Therefore it is important to design these schemes while paying full attention to their relationship.

Establishment of target values

Although there is still uncertainty regarding the relationship between indoor pollutant levels and health problems, it is possible to indicate indoor pollutant levels that could be unacceptable for a significant proportion of occupants. In fact, the World Health Organization proposed target values for indoor pollutant levels in 1983, and many countries have established similar targets since then. As targets values are less binding in nature than the minimum standards, they can be established in a more flexible manner. Due to this advantage and some disadvantages of regulatory instruments, it is sometimes argued that establishing target values should be prioritised over establishing minimum standards (Seifert, 1990; Leinster *et al.*, 1992). Such values may be a good starting point for making stakeholders aware of the potential risks of indoor air pollution, but these standards alone do not give adequate instructions as to how the problem could be prevented. Because there are so many factors that contribute to an increase in indoor pollutant levels, it is not clear, for instance, to what extent the pollutant sources are contained in building materials. Leinster *et al*. propose that the indication of a series of target values for each of the factors that affect indoor pollutant levels could be more useful (Leister *et al.,* 1992).

In Germany, guidelines were published in 1977 with the objective of providing guidance on the risk of formaldehyde emissions; these guidelines set the target value of formaldehyde concentration at 0.1 ppm. While the regulation on the quality of building materials has contributed greatly to the prevention of formaldehyde-related indoor health problems, the German case study also found that many manufacturers had already improved the formaldehyde emission-related performance of their products before the introduction of the regulation. It appears that the announcement of the target value and subsequent studies on ways to avoid health problem risks from formaldehyde had encouraged manufacturers to place safer products on the market. Furthermore, it is apparent that the announcement of the target value in 1977 significantly helped to prepare the ground for implementing the regulation on building materials in 1986.

5.6. General policy instruments

5.6.1. Greener public purchasing

Greener public purchasing (GPP) policy is increasingly used as an environmental policy instrument in various OECD countries. Since government procurement usually covers a large share of the market, government procurement has a large potential to increase the demand for environmentally friendly products and services.[81] As in other sectors, the use of GPP policy in the building sector does not have a long history, but this instrument may have much to offer. The government sector generally accounts for a significant proportion of construction investment in OECD countries. For instance, in the UK, public construction procurement accounts for some 40% of total construction investment (UK Department of

Environment, Transport and the Regions, 2000c). Similarly, in Japan, about 44% of total construction investment was attributable to the government sector in 1999 (Japanese Ministry of Land, Infrastructure and Transport, 2001b).

While many GPP policies are primarily designed to improve the government's own performance, such policies may also have impacts on private sector procurement. By increasing the demand for "green products", public procurement can induce cost reductions for environmentally-preferable products either by allowing for the realisation of economies of scale or by helping firms to shift along their learning curves. This can result in increased diffusion of green products and services throughout the economy as a whole. Further upstream, public procurement can also encourage innovation. In addition, GPP policies can have effects on the demand side, helping risk averse private firms to overcome their wariness to invest in newer (and untried) technologies that have fewer environmental impacts. For instance, the government can set a good example or prove the effectiveness of green products in terms of specific performance criteria, which are then adopted by private purchasers (OECD, 2002b).

These discussions can be applied to the building sector. The cost for incorporating some new environmentally friendly building components (*e.g.* photovoltaics) may be reduced by creating a large demand for the products with government construction procurement, allowing for cost reduction through economies of scale and shifts down the "learning curve". In general, designers and contractors in the construction industry are hesitant to use new building components or construction methods partly out of fear of liability problems (*e.g.* use of recycled building products), and tend to stick to current construction practices. Government building projects which incorporate new environmentally friendly products and methods should nevertheless have significant demonstration effects on the diffusion of new technologies across the building sector.

Some unique characteristics of buildings as products appear to increase the potential for the demonstration effects of green public purchasing in this sector. Buildings are usually custom designed, and many building performances are affected not only by the design itself but also by other factors, including construction practices on building sites. Consequently, unlike products in the manufacturing sector, it is difficult to precisely predict the actual performances of buildings with laboratory test results before the construction work has been completed. In other words, new building products or methods can be demonstrated most effectively when they are being used in real construction projects.

As various stakeholders influence building design and other building activities, the effects of demonstration may not be limited to designers and contractors. For instance, if highly energy efficient measures are incorporated into new government buildings, and subsequent monitoring shows that these are quite cost-effective, then potential owners of buildings might ask designers to consider implementing the same measures. As government building projects have the potential to create demand for, and demonstrate the effects of, a wide variety of products and methods, greener public purchasing can help meet most environmental objectives related to the building sector. The role of this instrument should be particularly important in areas where no other instruments have proven their effectiveness. For instance, as discussed in Section 5.4.3, there may be no other promising policy instrument to effectively deal with waste-generation-related characteristics of building at upstream stages.

While GPP policies in the building sector may be able to help improve the environmental performance of the building sector, there appear to be some obstacles to the effective implementation of the instrument. Environmental characteristics of procurement are often influenced by budget, financing and accounting systems (OECD, 2002b). This is also the case with construction procurement. For instance, the effect of split departmental responsibility for capital and operating costs may discourage the implementation of energy efficient measures in buildings. Another obstacle that is more unique to the building sector may be the difficulty of defining "green products". Since buildings have an impact on a wide variety of environmental objectives, it is not easy for departments in charge of construction procurement to make a judgement as to which kind of building is green and which is not. In order to implement the instrument effectively, it is necessary to provide clear guidance as to which products should be prioritised in the procurement process for the departments. It is important to note that this guidance should cover a wide variety of environmental performance attribute of buildings because improvements with respect to one environmental effect, may result in negative impacts of another sort.

Some OECD countries have already established such guidance. In 2001, the German Federal government published "Guidelines for Sustainable Buildings", which provide practical guidance for the design and management of buildings. The guidelines are intended to gear the design, construction and use of buildings toward sustainability objectives with the main emphasis put on a wide range of environmental issues. Today, all federal government buildings must be designed following these guidelines (German Federal Ministry of Transport, Building and Housing, 2001a). In 1998, the Japanese government published "Design Guidelines for Green Government Buildings" which include a wide range of design guidelines to make government buildings as environmentally friendly as possible. The guidelines are being applied to most new national government buildings whose total floor area exceeds 2 250 m^2.

British experience in this area suggests that clear targets for building procurement can be efficiently provided with establishing the linkage between greener public procurement policy and environmental labelling. In 2000, the UK government published a new strategy of government procurement policy for construction projects, "Achieving Sustainability in Construction Procurement". In this strategy, main targets of construction procurement are expressed with the rating of the BREEAM.[82] For instance, the strategy states that all new building projects conducted by the government should achieve an "excellent rating" using the BREEAM or equivalent by 2004 (Government Construction Client's Panel, 2000). Such a specific target may help to effectively implement this instrument.

Including the assessment criteria used for environmental labelling schemes in the procurement process may have great potential for improving the environmental characteristics of government buildings. Another approach is to integrate the environmental cost in tendering procedures. For instance, Swiss authorities have set reference energy prices for public building procurement purposes, and required that the lifecycle energy consumption of new buildings is accounted for in tenders. As the new prices include environmental externalities, they became considerably higher than market prices (but the overall lower costs for managing the building compensate for the higher construction price). Through the combination of higher energy prices and a life cycle approach, Swiss authorities have been able to modify the environmental quality of buildings (OECD, 2000a).

Since greener public purchasing policy in OECD countries does not have a long history of implementation, few *ex post* studies have been conducted to date on the impacts of greener public purchasing on the building sector.

5.6.2. *Support for R&D and diffusion of technology*

In addition to designing environmental policies that provide incentives for innovation, governments can promote technology development and innovation with technology-directed policies. For this purpose, governments can support research and development (R&D) in the private sector, commit themselves directly to R&D activities or establish a partnership with the private sector. The importance of technology-directed policies is reflected in the fact that there is surprisingly little evidence that standard environmental policies have appreciable effects on technological development and innovation.

Technology-directed policies may be particularly important for the construction industry, which is generally characterised by a lack of investment

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in R&D activities and slow innovation. There are various explanations for this. First, the construction industry is dominated by small-scale firms and a competitive market, making it difficult for the industry to both invest in uncertain R&D projects and appropriate the returns to R&D (Jaffe *et al.*, 2000). The project-based and custom designed nature of building production may also have a negative effect on innovation. The ability to systematically develop new knowledge, building and renewing technological know-how, and maintain a high level of scientific and technological competence has seemingly not been possible in the building sector. Furthermore, fluctuation in demand for construction projects could also be a disincentive for making substantial investments in new technologies by contractors. Partly due to these problems, most construction-related research is not carried out by the core of the industry such as contractors and designers, but by upstream industries, such as material and components manufacturers, whose main primary markets are not necessarily construction markets (Gann, 1997).

The promotion of environmental R&D in the construction industry should help improve the environmental performance of buildings and building activities. Although a limited number of studies have been undertaken on R&D policy for the building sector, some studies in other sectors could provide insights for policy design in this area. A survey of American firms in the environmental technology sector revealed a wide consensus that firms had insufficient commercial incentive to undertake basic research, concentrating more on applied research that will produce short-term benefits. This is significant since the firms also reported that almost half (48%) of the original basic research which eventually generated important environmental technology innovations was not directly targeted toward an environmental problem (Environmental Law Institute, 1997). This illustrates both the difficulty of influencing technological change and predicting how it will evolve, and the importance of a public role in generating innovations (OECD, 2000b). These results point to serious market failure in inducing sufficient investment, especially for the basic end of the R&D spectrum, and to the importance of the serendipity factor in R&D for environmental innovations. These characteristics of R&D point to the importance of public support for research and development directed at environmental sustainability (Fukasaku, 2000).

However, government policies for supporting environmental R&D cannot work effectively unless the scope of support is appropriately chosen. For example, it has been reported that R&D subsidies in the Netherlands for environmental technology development have been of limited effectiveness. Innovator firms develop environmentally beneficial technologies not because a subsidy is available but because they believe a market exists for the new technology (Fukasaku, 2000). In this regard, it has been argued that the support for R&D activities should be restricted to environmentally beneficial technologies for which a market does not yet exist but for which there are good reasons to believe there is commercial potential. For example, technologies with long development times or technologies for which there are problems in appropriating the benefits of innovation by the innovator may be appropriate candidate for support. R&D programmes may also be used to increase the number of technological solutions when there is uncertainty about environmental solutions (Kemp, 2000).

In light of this, it could be assumed that the role of government in the support for R&D activities in the building sector may be particularly important. For many building products and construction methods that are required to improve the environmental performance of the building sector, the market has not been fully developed because the development of these technologies may not provide short-term benefits to innovators themselves. For instance, it is not certain to what extent the development of new construction methods or products that make the recycling of building materials easier could provide short-term economic benefits to innovating firms. Furthermore, while building components and materials are usually produced by relatively large companies that have the capacity to do some R&D, most of contractors and designers who deal with design, construction and demolition processes may not have such capacity. Therefore, the support for R&D related to design, construction and demolition processes may be particularly important.

Since the construction industry is generally slow to adopt new technologies, even those whose performance has already been proven, it is important to note that the support for R&D in the building sector may have to be coupled with technology diffusion programmes. It is widely argued that the environmental performance of this sector could be much improved by diffusing existing technologies across the industry.[83] Since many new technologies which could reduce the environmental impacts of buildings do not necessarily provide economic benefits in the short term, the small firms that dominate the industry are unlikely to incur the costs for collecting information on relevant technologies. Under such circumstances, gathering and disseminating information on “best practices” may overcome information cost barriers (OECD, 2001h).

As there are a great number of firms in the construction industry and they are geographically widely dispersed, it is not an easy task to disseminate information among them. One possible measure to overcome the problem is the use of IT technology. For instance, in 1999 the UK government launched the Construction Best Practice Programme, which aims to raise awareness of the benefits of best practice and provides guidance and advice to construction and client organisations, mainly through Internet web sites. The sites contain a wide variety of technical information, including information for improving the environmental performance of construction activities.

When implementing technology diffusion programmes and providing support for R&D activities, it is important to establish a close partnership between government and industry associations. The construction industry generally has industry associations that have an extensive network of firms. By establishing a partnership with such associations, government could efficiently disseminate technological information. For instance, the US Environmental Protection Agency (EPA) initiated R&D activities through grants with a research institution that is affiliated with the National Association of Home Builders (NAHB), the largest organisation of home builders in the US. The research projects focused primarily on residential building and provided various useful guides and information related to waste management for home builders and remodelers. Information from all these projects has been disseminated to a number of audiences. Publications produced in partnership with the NAHB have been distributed to approximately 30 000 members of the building community, in addition to being made available over the Internet. In light of the fact that a significant proportion of homebuilders and other contractors tend to be slow to adopt new technologies or knowledge and that improvements in waste management, especially the reduction of construction waste, could lead to economic benefits for them, such an approach may have great potential to encourage a proactive response from them.

Technical expertise may not be the only type of information that could lead to improving the environmental characteristics of the construction industry. In many cases, the diffusion of policy-related information across the industry could also help. For instance, environmental labelling schemes cannot work effectively unless designers and contractors have full knowledge of assessment processes and criteria. In order to ensure that a new environmental labelling scheme – the Housing Performance Indication Scheme introduced in 2001 – would be properly understood, the Japanese government implemented a large-scale training programme on how to use it. During two years before the scheme was introduced, about 2 800 training programmes were organised at the expense of the government for those who were working for small firms; some 230 000 attended.[84] This training programme appears to have contributed significantly to the large number of applications that the labelling scheme received in the first year of implementation.

5.6.3. *Voluntary instruments*

Depending on the nature of the relationship between the government and the firms, voluntary environmental programmes can be classified into these four categories (OECD, 1999):

- Unilateral commitments: consists of environmental improvement programmes set up by firms and communicated to their stakeholders (employees, shareholders, clients, *etc.*) without any public organisation being involved.

- Private agreements: this type of programme involves a contract between a firm and those who are harmed by its emissions or their representatives.
- Negotiated agreements: this type of programme involves a contractual arrangement between public authorities and industry.
- Public voluntary programmes: within this type of programme, the government provides the framework for the policy; private firms can comply on a voluntary basis and receive some advantages in return, such as public recognition, labels, *etc.*

In comparison with other policy instruments discussed in this report, voluntary instruments represent a relatively new approach. Although the instrument has not yet been widely used in the building sector,[85] it has been increasingly used in recent years in other industries, such as the chemicals industry. From the viewpoint of government, the main argument for using voluntary approaches has been that they could achieve environmental improvement at a reasonable cost by promoting pro-active actions by industry. Although available evidence suggests that the environmental effectiveness of voluntary instruments is likely to be modest, voluntary approaches may improve the flexibility and cost effectiveness of policy mixes, and potentially reduce administrative costs. In addition, voluntary instruments often constitute a first step in exploring a new policy area, and can be regarded as a policy instrument with a transitional function. They are suitable for this role, since they are likely to generate "soft" effects and promote learning, and hence can help improve the design of more traditional instruments for the future (OECD, 1999).

Voluntary approaches are particularly attractive to industry. A commonly expected gain associated with voluntary abatement is lowering target or compliance costs which tend to be higher under mandatory regulations. Benefits from voluntary abatement, however, are not limited to such regulatory gains. Additional pollution abatement may result in a better use of, and access to, input.[86] Another expected gain for firms is provided by product differentiation on environmental performances and their signalling to consumer *via* advertisement and labelling. Once the environmental performances are known, green consumers can express their willingness to pay for the environment in purchasing green goods, and high quality products may then be sold at higher prices.[87] A third benefit is reputation gains *vis-à-vis* stakeholders. In addition to its shareholders and clients, a firm's constituency includes its employees and local communities. These stakeholders may exert a strong influence on a firm's profit.[88]

Voluntary instruments have been successfully introduced into the building material manufacturing industry in some countries. For instance, it is reported that the KWS-2000 programme in the Netherlands to reduce VOC emissions has successfully stimulated research into low-solvent paints, especially for the housing market (Kemp, 2000). However, it is not certain that voluntary instruments, in particular negotiated agreements, have a large potential to improve the environmental performance of the construction industry itself for several reasons.

The construction industry comprises a large number of small-scale firms, and this is likely to be a serious obstacle to voluntary approaches because of contracting costs (OECD, 1999). For instance, although the introduction of negotiated agreements between the government and organisations representing the construction industry are likely to reduce implementation, monitoring and enforcement costs for achieving a certain environmental target, they may generate other types of costs, such as transaction bargaining costs, both at the negotiation and implementation stage, needed to reach consensus between firms and the government. Even though any agreement could in effect be established across the industry, it is doubtful that the target could be achieved in a flexible and cost-efficient way.

It is also doubtful that firms in the construction industry would be as motivated to participate in, for instance, negotiated agreements as those in manufacturing sectors, because it seems unlikely that they could receive some of the above-mentioned benefits from participation. Since buildings are usually custom-designed, the benefits from product differentiation are bound to be fewer than in manufacturing sectors. Moreover, small-scale firms in the conduction industry are less likely to benefit from an improved reputation by participating in voluntary agreements than the large-scale and more visible firms in manufacturing sectors. In addition, since various stakeholders affect the environmental performance of buildings and building activities, in some cases several types of industries need to get involved to achieve one environmental target. For instance, in order to effectively promote the recycling of building materials, not only demolition contractors but also recycling facilities and material manufacturers need to participate. This may make the process of establishing voluntary agreements more complicated and costly. In fact, in the context of C&DW management in EU countries, it is reported that the construction and demolition industry has not expressed any wish to implement any such instrument (European Commission, 2000).

Despite these difficulties, voluntary instruments have been implemented in the construction industry in some OECD countries. In Australia, in 1995, the Australia and New Zealand Environmental and Conservation Council

(ANZECC)[89] and the Chief Executives Officers of five major Australian construction companies signed a waste reduction agreement (Box 17), and initiated the Waste Wise Construction Programme. The programme is designed to pioneer industry best practice in waste reduction within the

Box 17. **Waste Reduction Agreement under the Waste Wise Construction Programme in Australia**

Participating company's responsibility

- The participating company will prepare a written Waste Minimisation Plan that:
  - ❖ documents the major waste types expected on each project, and method of waste collection;
  - ❖ sets out what steps will be taken to reduce, reuse and recycle wastes; and
  - ❖ adopts a wide range of waste minimisation measures that are practical and cost effective.
- The participating company will submit the Project Waste Minimisation Plan to the ANZECC liaison officer upon its completion and implementation.
- Where the participating company has responsibility for project design, it will encourage the client to consider opportunities for incorporating waste minimisation principles in the design.

Government's responsibility

- ANZECC will recognise the participating company's responsible waste management by:
  - ❖ publicising the programme to achieve widespread community knowledge and support;
  - ❖ publishing a twice-yearly newsletter promoting the participating company's success; and
  - ❖ sponsoring an annual award programme for outstanding performance.
- ANZECC agrees to designate a liaison officer who will regularly brief ANZECC on the progress of the programme.
- ANZECC will endeavour to provide sufficient resources to administer the programme and support participation in the programme.

Source: Andrews, 1998.

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construction and demolition industry and significantly reduce the quantity of waste material going to landfill sites with a special emphasis on the reduction of construction wastes. A review of the programme in 1998 found that it has effectively encouraged participating companies to improve the performance of their construction activities. For example, one participating company had reduced the quantity of construction wastes going to landfill sites by 25%, and in one of its projects this was reduced by 90%. In many cases, the improvement in waste management resulted in the reduction of waste management cost (Andrews, 1998). With the termination of the original agreement, the second phase of the programme was initiated in 1998 with 12 participating companies and industry associations.

One example of a public voluntary schemes aimed at improving the energy efficiency of buildings is the Energy Star for Building programme in the US.[90] This programme does not target the construction industry itself, but its clients. Under the programme organisations that possess or manage non-residential buildings voluntarily sign a partnership letter with the US Environmental Protection Agency (EPA) that acknowledges the importance of, and steps for, improving the energy performance of their buildings. The government then supports the adoption of energy upgrades by providing participating organisations with a benchmarking method and technical guidelines for improving energy efficiency, and issues labels for highly energy efficient buildings. The programme has been applied to a large number of buildings. According to the 1999 annual report of the Climate Division of the US EPA, by the end of 1999 more than 5 500 organisations had signed a letter of partnership with the US EPA to improve the energy performance of their buildings, committing over 10 billion square feet or 15% of the total commercial, public, and industrial building market in the US. Over 2 billion square feet of investor-owned commercial real estate property has joined Energy Star, representing over 25% of the investor owned commercial real estate market. The 1999 annual report of the US EPA suggests that the programme has had a large impact on the energy efficiency of buildings by saving a total of 22 billion kWh of emissions and thereby preventing emissions of 4.5 million metric tonnes of carbon equivalent (MMTCE).

It is important to note that both Australia and the US have successfully promoted pro-active action of participating firms by establishing a linkage between participation in voluntary programmes and economic benefits, and with appropriate choices of environmental performances and targets. The Waste Wise programme in Australia emphasises the reduction of construction waste and focuses on a small number of large companies which are bound to be concerned by their reputation due to their visibility. The Energy Star for Building programme in the US, on the other hand, does not target the construction industry itself but its clients who are likely to benefit more directly from energy efficiency improvements.

As introducing voluntary instruments to the entire construction industry is not easy, these approaches appear to be realistic way of developing this instrument for the building sector. Nonetheless, the possibilities of applying voluntary instruments to a wider range of environmental issues and stakeholders should be further explored.

5.7. Characteristics of main policy instruments: conclusions

On the basis of discussions in previous sections, this section summarises the characteristics of the main policy instruments for reducing the environmental impact of the building sector.

Policy instruments for reducing CO_2 emissions from buildings

Mandatory energy efficiency standards in building regulation for new buildings appear to be a dependable instrument for achieving a given goal of energy efficiency of new buildings if effectively enforced. Although it is usually difficult to set standards that are strict enough to have a real impact on a significant proportion of all new buildings, there may be room for upgrading the standards and improving the effectiveness in many OECD countries. This instrument may not be economically efficient and provide little incentives for innovation, although the introduction of performance-based standards is likely to improve these characteristics to some extent. Moreover, the instrument does not entail significant administrative cost due to pre-existing complementary regulatory frameworks. In the context of existing buildings, although this instrument could work effectively, it appears to be difficult to introduce totally new mandatory standards for a wide range of existing buildings because they are unlikely to be accepted by stakeholders. The effect of the regulatory instrument which imposes upon utilities companies an obligation to improve the energy efficiency of customers' buildings is not known. However, this instrument would be an attractive measure if the companies were able to improve energy efficiency in a very economically efficient manner, making the best use of the information they have obtained on the energy use of their customers.

Since investors usually pay disproportional attention to the minimisation of capital cost, capital subsidies may have a large potential to encourage energy efficiency investment. However, they are generally against the Polluter Pays Principle, and it is likely that a significant proportion of total subsidies or tax credits is received by free riders; addressing this free rider problem is key to an effective implementation of capital subsidy programmes. Moreover, it is unlikely

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that they could have a major impact on a wide range of buildings because they require expenditures of tax revenue. Empirical evidence is generally consistent with these arguments. In light of the high discount rate in energy efficiency investment, it is presumed that premium loan schemes could not have a large impact on the decisions of buyers of new buildings who have access to savings or capital markets, though empirical studies have found that such schemes could encourage the improvement of energy efficiency to some extent.

In the context of existing buildings, it is presumed that capital subsidy programmes targeting low-income households could improve the energy performance in a cost-effective manner, but a significant proportion of energy saving potential is used to make homes warmer rather than actually saving energy. Since the cost-effectiveness of energy efficiency measures may depend largely on the specific condition of buildings, on-site inspections by technical experts is usually required for the implementation of such programmes, resulting in relatively high administrative cost. In general, empirical evidence supports these arguments. In addition, empirical studies suggest that the cost-effectiveness of energy efficiency measures that have been adopted could be improved if measures from a wide variety of options could be co-ordinated. Since the amount of financial resources that are required for energy efficiency investment in existing building is likely to be relatively small, it is presumed that premium loan schemes may have a limited impact in this area.

Views on the potential impact of energy taxes on investment in energy efficiency measures, which are supported by empirical evidence, are mixed and further studies are necessary to draw any conclusion on the effectiveness of energy taxes in improving the energy efficiency of buildings. Energy taxes could achieve the least-cost solution, provide continuous incentives to seek more cost-effective technologies and entail modest administrative cost.

Theoretically speaking, tradable permit schemes appear to be the most certain and cost-effective way of reducing overall CO_2 emissions from the building sector. Although it may not be realistic to establish a permit market directly for emitters of CO_2 in the building sector due to high administrative cost, the scheme could be applied to the sector by establishing a permit market for utilities companies. In light of the high discount rate, the potential of a tax imposed on investors in disproportion to the energy efficiency of buildings is worth examining as one future policy instrument option for improving the energy efficiency of buildings. It is also important to remove taxes that have counterproductive effects on the promotion of energy efficiency investments.

Due to the close association between private incentives to reduce energy costs and the public objective to reduce CO_2 emissions, environmental labelling schemes could potentially play a large role in this area. However, no clear empirical evidence to indicate how the schemes could actually affect building design was found. The economic efficiency and the impact on innovation of the schemes may depend highly on the way environmental performance levels are indicated to potential buyers. Labelling schemes usually entail significant administrative costs, but the costs could be largely reduced by making the best use of the existing policy framework and promoting competition between inspection bodies. In the context of existing buildings, the effectiveness of labelling schemes remains uncertain due to a lack of empirical evidence. Energy audit programmes are expected to encourage energy efficiency investment by providing information on the energy saving potential of each building, and empirical evidence indicates that they are an effective instrument, although the administrative cost can be considerable.

Policy instruments for minimising C&DW

In this area, the point of intervention is closely related to the goals that policy instruments are aiming to address. The immediate policy target at demolition stage is usually the reduction of the final disposal of C&DW that is presently generated. Policy instruments at downstream stages may aim to increase the use of recycled building materials in the building sector. Instruments at upstream stages may contribute to improving the waste-generation-related characteristics of buildings that are constructed today.

At upstream stages, it is very difficult to implement effective instruments to improve the waste-generation-related characteristics of buildings. Mandatory standards for building design cannot be easily introduced due to the difficulty of establishing reasonable standards that stakeholders can accept. Buyers of buildings usually pay little attention to these performances, so much cannot be expected from environmental labelling schemes. Furthermore, an Extended Producer Responsibility approach can generally not be applied to buildings due to their long service lives. One realistic instrument at this stage may be the use of greener public purchasing policies.

At demolition stage, although it is theoretically presumed that the effectiveness of a landfill tax is not certain, empirical evidence clearly demonstrates that such a tax is the most effective measure for reducing the final disposal of C&DW if the tax rate is high enough. It is sometimes argued that the tax could increase illegal dumping, but this illegal activity can be deterred when governments also introduce mandatory reporting and demolition permission schemes. Although no supporting evidence was found, it is theoretically presumed that the tax could be the least-cost option for

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encouraging waste reduction among demolition contractors or building sites, and provide continuous incentives for innovation in cost-effective ways of reducing final C&DW disposal. Theoretically, tradable permit schemes could be the most certain way for reducing a predetermined amount of C&DW in an economically efficient way, but there are some obstacles that have to be overcome before such a scheme can be applied to minimise C&DW.

A ban on landfill is presumed to be the most certain measure for reducing the final disposal of C&DW, but there appears to be no supporting evidence that clearly proves the effectiveness of such a ban. This is mainly because it is difficult to isolate the effects of the ban from those of a landfill tax. A landfill ban is presumed to be not economically efficient and provide little incentives for innovation, and its administrative cost may be considerable. Mandatory separation on-site may be difficult to enforce effectively because the instrument involves controlling demolition activities that are conducted at a great number of geographically dispersed sites. These arguments are consistent with findings from empirical studies. Although there is no supporting empirical evidence, demolition permission schemes appear to have great potential to reduce the final disposal of C&DW. Such schemes could potentially encourage demolition contractors to explore various possibilities of minimising C&DW at earlier stages of the demolition process.

The links between taxing virgin building materials and the externalities associated with ultimate waste generation can be weak and the impact of an increase in the price of virgin materials is not certain. However, if the tax rate for virgin materials is flexibly adjusted according to the situation of building materials market, then the tax may significantly encourage the substitution of virgin materials with recycled materials. The tax could also provide the least-cost solution for reaching a given level of virgin materials replacement and provide incentives for innovation with modest administrative cost.

Capital subsidy programmes, tax credit schemes or premium loan schemes for the use of recycled materials in buildings may promote the recycling of building materials, but require tax revenues and entail significant administrative cost. Capital subsidies for fixed processing plants may be effective in making recycled materials cheaper and increase the demand for recycled materials, but this requires a considerable amount of financial resources for a certain period of time. Also, all of these instruments generally contradict the Polluter Pays Principle.

The development of a recycled building materials markets is sometimes hampered by the concerns of users over the quality of recycled materials. Regulations on the quality of recycled materials could reassure potential buyers of the quality of the materials, but such regulations are economically inefficient and would have adverse effects on innovation.

The development of building specifications that take into account the use of recycled products, coupled with reliable certification schemes, may effectively encourage the use of recycled building materials. It is doubtful that environmental labelling of buildings that indicate to what extent recycled materials are used can influence the decisions of potential buyers: available evidence indicates that consumers usually pay little attention to the use of recycled materials.

Policy instruments for preventing indoor air pollution

It is technically not very feasible to enforce minimum standards for indoor pollutant levels because it is very difficult to monitor such levels in a great number of buildings. One alternative approach is to regulate the quality of building materials. Empirical evidence indicates that building material-related indoor health problems, like emissions of formaldehyde, could be effectively solved at modest administrative cost with the introduction of building material regulation. Although it is theoretically presumed that this may harm the flexibility of building design, such criticism was not strongly expressed in empirical studies.

Economic instruments are not very attractive instruments for addressing indoor air pollution. As targets for acceptable pollutant concentration levels are likely to be uniformly set for all buildings, there is little room to lower the overall costs for achieving these goals by introducing more flexible economic instruments. Another economic instrument that could be used in this area is the imposition of liability. By imposing more liability on designers and contractors for health problems due to buildings, they may be incited to reduce the supply of buildings that could be detrimental to human health.

It is expected that environmental labelling schemes for buildings will encourage buyers to choose buildings with safer materials or better ventilation, and that subsequently this change in buyer behaviour will motivate sellers to supply buildings with better performances. Empirical evidence suggests that labelling schemes could effectively improve the indoor air environment, but in different ways than theoretically expected: environmental labelling schemes can in fact directly affect the behaviour of building material manufacturers. Another important information tool is announcing the target value of indoor pollutant levels. This may raise stakeholder awareness of the problem and help prepare the ground for the implementation of other policy instruments. This observation is consistent with the results of empirical studies.

General policy instruments

Since public construction procurement generally accounts for a large proportion of construction investment, greener public purchasing policies could have significant potential. This instrument could not only improve the environmental performance of government buildings, but also have an important demonstration effect, and be particularly useful in areas where there is no other promising policy instrument for improving the environmental performance of the building sector. To date, few empirical studies have been undertaken on the effectiveness of greener public purchasing in this sector. Since the construction industry does not have much capacity to do R&D, it is important to provide support for environmental R&D activities in the building sector. However, it is also important to note that such support cannot work effectively unless environmentally beneficial technologies, for which a market does not yet exist in the building sector, is targeted. It is often argued that the environmental performance of buildings could be greatly improved even with existing technologies, but firms in the industry are very slow to adopt technological solutions, let alone technological innovations. It is therefore important to help diffuse relevant technologies through a close partnership between government and industry associations.

Although voluntary approaches may have great potential to improve the environmental performance of the building sector with modest administrative and compliance costs, some unique characteristics of the construction industry may hinder their effective implementation. However, empirical evidence suggests that voluntary agreements can work effectively if they target the area where participating firms could receive economic benefits from improving the environmental performance of buildings.

Notes

1. Saving potential is defined as the potential reduction in energy use achieved by energy efficiency investments that have a pay-back period of eight years or less.
2. Those in the third column are instruments for existing buildings and will be discussed in the Section 5.3.
3. U-value expresses the ability of a building section to allow heat flow (lower U-value indicates higher energy efficiency).
4. ... or a minimum limit on the R-value, which is proportional to a reciprocal of the U-value and expresses the degree of resistance to heat flow.
5. In some countries, mandatory energy efficiency standards for equipment have been implemented by a regulatory structure that is different from building regulations. For instance, since 1987, minimum standards have been imposed on furnaces, heat pumps, air conditioners, water heaters and lamp ballast in the US under the National Appliance Energy Conservation Act.

6. This analysis presumes the energy efficiency standards of building regulation in EU countries in 1996, so revisions to the standards after 1996 were not taken into account.
7. It is also important to note that the introduction of performance-based standard may increase the complexity of the checking process on the government side, and the introduction of such standards could have a negative effect on enforcement unless sufficient resources for building inspection are made available.
8. For example, sampling tests of products.
9. It is nevertheless difficult to estimate the extra cost of incorporating energy efficiency standards into building regulations.
10. It is important to take measures to prevent inspecting bodies from seeking a competitive advantage by offering a reduced fee and a less stringent approach to enforcement; for instance, a severe penalty could be imposed on inspecting bodies that do not comply with regulation.
11. Although the subsidy is given to those who invest in building construction, the CBIP is not intended to cover a part of the capital cost, but to cover extra cost of designing an energy efficient building.
12. It is also important to note that while a tax will typically drive firms out of a competitive industry and so generally lead to a decrease in its output, a subsidy may increase entry and induce an expansion in competitive outputs.
13. The actual effects of an energy tax will depend very much on its perceived performance; and the comparison is solely in terms of technology diffusion, not in terms of residential energy demand.
14. It is estimated that the average energy efficiency of CBIP applied buildings is 32.2% better than the national model code level.
15. Tax credits are usually given in the form of a reduction in income tax or corporate tax.
16. In FY 2000, out of 1 213 thousand units of newly built housing in Japan, 364 thousand, or about 30%, were financed by the JHLC. In addition, the extra premium for energy efficient housing has been provided for up to 180 thousand units of newly built housing.
17. This is the fee for checking documents and conducting on-site inspections on a wide variety of performances, including energy efficiency, of one unit of detached dwelling.
18. It is also important to note that the JHLC started entrusting this task to private firms, as explained in the section of the Housing Performance Indication Scheme.
19. For instance, early announcement of tax details, including tax rates, and gradual implementation give taxpayers time to adapt their production, consumption and investment strategy to the new instrument (OECD, 2001d).
20. An *ex post* evaluation of a CO_2 tax in Sweden showed that CO_2 emissions from district heating, industrual and housing sector were 19% lower in 1994 than in 1987, and 60% of the emission reductions resulted from the CO_2 taxation (OECD, 2001d).
21. Please see Jaffe *et al*. 1994 for a discussion.
22. In other words, in proportion to the predicted energy use.

23. This argument is applied not only to improving the energy efficiency of existing buildings, but also to other environmental objectives discussed in this report.
24. Please see Section 5.3.1 for details.
25. In particular, by steadily reducing the total number of permits.
26. Complications arise for the chemical and cement sectors since the former uses fossil fuels as a material input (rather than just for combustion) and the latter generates additional CO2 emissions which are not related to combustion. The latter exception is clearly relevant for the building sector.
27. Although the point made above about cement needs to be borne in mind.
28. See OECD, 1997a, for details.
29. The Standardised Assessment Procedure rating expresses space and water heating costs of dwellings with a number index – the higher the number the more energy efficient the home.
30. A new scheme for industrial buildings is under development.
31. There are some corporate buyers who repeat transactions in the market and have deep knowledge of the performance of buildings.
32. Another positive finding in the case study is that more than 40% of the owners answered that they had achieved a higher rental income due to savings in fuel costs. If it is proved that higher energy performance certified under the BREEAM leads to higher rent, then owners may be motivated to choose more energy efficient design options for their rental units.
33. This argument is applicable to other environmental attributes that environmental labelling schemes of buildings cover.
34. The BRE has published the recommended level of assessment fees.
35. 10-year insurance for all major defects of houses.
36. In the case of the Ibaraki prefecture, it is estimated that the total inspection fee would be about 15% lower if applied to the same inspection body.
37. By September 2001, 83 inspection bodies had been approved by the government.
38. The structure of such incentives will depend upon the precise form of the regulatory structure applied. For instance, if energy providers can compete for customers directly in electricity markets, rather compete for the right to serve particular areas through tenders (as is often the case), these effects are likely to be much more pronounced.
39. Please see Section 5.3.2.
40. This programme was implemented on the basis of a review of the previous HEES programme.
41. This argument is basically applicable to other types of capital subsidy programmes.
42. This argument is also applicable to capital subsidy programmes for existing buildings that do not target low-income households.
43. The same phenomena can be identified in the results of another German premium loan scheme that also supports the energy efficiency upgrading of dwellings with a subsidy that can reduce the rate of the loan by 1%. Under the scheme, 44% of the loans were received by corporate landlords in 2001.

44. Please see Section 5.3.1 for details of the EEC.
45. In some cases, also other environmental and non-environmental attributes of buildings.
46. Industrial buildings, secondary homes and other special buildings, such as churches, are not covered by these schemes.
47. Energy labelling reports for large buildings have a similar structure.
48. The second part, the Energy Plan, is regarded as an energy audit programme, and will be discussed in the following section.
49. See Section 2.2 for details of this prediction.
50. It should be noted that this table shows a typical flow of building materials.
51. Destinations include landfill sites, incineration sites, processing facilities, on-site recycling/reuse and illegal dump sites.
52. Please see Section 6.3.1. for detailed discussion.
53. This is not the case with some building components. For instance, some carpet tile producers in the US are taking responsibility of removing the carpet tiles they supplied and recycling them (Kibert, 2001).
54. Such as recyclability of building materials, disassemblability of connections, physical durability, adaptability, *etc.*
55. See Section 2.1.
56. A ban on the disposal of hazardous wastes will not be discussed in this report.
57. Most landfill site operators are municipalities.
58. Please see the sub-section on mandatory reporting for detailed explanation.
59. This may include other bodies, such as waste carriers, who make decisions regarding the destination of demolition waste.
60. 24 m^3 is the typical volume of a container in the Netherlands.
61. As such, there are three principal points of intervention at the demolition stage to minimise demolition waste: demolition (mandatory separation), delivery (mandatory delivery), and disposal (ban on landfill). Though these instruments may have similar effects and complement each other, how they are combined varies greatly between countries. While the Netherlands has implemented all three measures, some countries rely on only one.
62. For instance, about 90% of illegally dumped waste comes from the construction sector in Japan (Research Group for Environment Friendly Building Technology, 1995).
63. It should be noted that many other factors, such as geographical conditions and cultural background, may affect the incidence of illegal dumping.
64. In the case of the C&DW, owners of demolished buildings are usually regarded as owners of waste.
65. Because there was a large shortage of capacity at incineration sites.
66. Although the rate for inert waste is not very high, the cost of bringing C&DW to landfill sites has considerably increased compared to what it had been; the gate-fee for inert waste had been as cheap as around £1-2.

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67. Special provisions have been introduced in the French landfill tax system to cope with the problem of illegal dumping. Under the French system, the last person or legal entity to pay any of the cost relating to the land used for illegal dumping is considered to be the operator in the case of illegal dump sites. But the owner of the land may be taxed if the economic operators cannot be identified. It is then up to the owner to take action against the operator (Fernandez *et al.*, 1995).
68. One of other strengths of the tax is that it can raise revenues. In France these revenues are used to fund R&D programmes, and in the UK 20% of the revenues generated by landfill taxes are used for funding projects and research related to waste management.
69. In 1990 the tax rate was sharply increased from DKK 0.5 (€ 0.067) to DKK 5.00 (€ 0.67) per cubic metre of materials. In Sweden, an aggregate tax was introduced, in 1996, at a rate of SEK 5 (€ 0.5674) per tonne of natural gravel (ECPTEC, 2001).
70. In 1991, it was estimated that introducing a tax on virgin concrete aggregates at a rate of 15%, 30% and 50% could increase the use of recycled aggregates respectively by 30%, 70% and 150% (Desai, 1998).
71. Though there may be no empirical evidence to prove this.
72. Although the objective of these programmes does not appear to be an increase in the use of recycled materials in building construction.
73. In Australia similar specifications are under development.
74. Please see Section 5.4.3 for detailed explanation.
75. It should also be noted that increasing the air exchange rate will result in greater energy use for heating.
76. For instance, engineered wood products containing urea-formaldehyde glues should be replaced with low formaldehyde-releasing products or alternative products, such as lumber.
77. Like in most of other OECD countries, Danish building regulation basically covers only newly-built buildings, and existing buildings are required to comply with the standards only when large-scale refurbishment or remodelling work have been conducted.
78. Under the quality control system, a special label is put on wood products that have been approved as compliant with the provision. Municipalities in charge of building control usually do not check whether labelled products are actually used in buildings. However, municipalities are allowed to conduct on-site inspection to check the quality of building materials.
79. The case of asbestos is revealing, with liability regimes in many countries being at least as important a factor in dealing with this issue as regulatory regimes.
80. Please see Section 5.2.3 for details of the Housing Performance Indication Scheme.
81. Please see OECD 2002a.
82. See Section 5.2.3 for details of the BREEAM.
83. The lack of technological capacity in the construction industry appears to be one of the main obstacles to the improvement of environmental performance of the sector (OECD, 2001e).
84. This figure is the sum of programme participants, and many attended more than two programmes.

85. Though many voluntary information tools discussed in previous sections, such as environmental labelling schemes, could also be included here.

86. The classical example is the case of energy savings. Environmental improvement of a process may be associated with a lower consumption of energy and, therefore, may result in a reduction of energy costs (OECD, 1999).

87. For instance, in Germany most of the products labelled with the "Blue Angel" are more expensive than non-labelled alternative goods (OECD, 1999). It is important to note that such gains are not likely to be realised if firms are "forced" to meet certain environmental standards. The "voluntary" element of the programme allows firms to market themselves and their products more effectively in environmental terms.

88. Please see OECD, 1999, for detailed discussions regarding the characteristics of voluntary instruments.

89. ANZECC includes Ministerial representation from Commonwealth, State and Territory Governments.

90. Please see *www.energystar.gov* for more information abut Energy Star program.

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Environmentally Sustainable Buildings
Challenges and Policies

Chapter 6

Designing and Implementing Policies for Environmentally Sustainable Buildings

6.1. Establishing a national strategy

The establishment of a national strategy is an important process for the development of environmental policies. By clearly announcing government objectives and basic principles regarding the way to achieve the objectives, the strategy could establish a basis from which effective and efficient policies could be developed. In OECD countries, it is common to establish a national strategy regarding environmental policies in general, but only a few countries have already established a national strategy for improving the environmental performance of the building sector.[1] The establishment of such sector-based strategies should help in the design and implementation of effective and efficient policy instruments in various ways.

First, as discussed in Section 4, the building sector has unique characteristics that considerably influence the effectiveness of policy instruments. As a result, the design of environmental policy in this sector may often require special consideration, which is not usually included in the national strategy on general environmental policies. A sector-based strategy could fully reflect such unique aspects of the sector and could provide specific and useful guidance for policy makers.

In many cases, the main objectives for improving environmental performance of buildings vary depending on the context of each country or region. For instance, the recycling of building materials could be promoted for the purpose of reducing the use of primary resources, reducing the burden on scarce landfill capacity or reducing the negative impact of landfill and incineration sites on the local environment. Since different policy instruments have different impacts on these policy goals, the priorities of policy goals need to be clarified so that policy makers can direct policy instruments in the right direction. In addition, the establishment of quantified policy goals with varied time-spans, for example, may provide policy makers with more detailed instructions on how to design policy instruments. Such quantified goals also make it possible to monitor the progress of the instruments, which may help with an appropriate reform of the policies later on.

The building sector has impacts on a wide range of environmental issues, and responsibilities for designing environmental policies for the building sector are often divided among more than two ministries and departments. Since the environmental performances of buildings and building activities are interrelated, proper co-ordination of policy instruments for different environmental objectives, and between different ministries and departments, is often required to avoid that policy instruments conflict.[2] By including the basic principles of policy co-ordination, the establishment of a sector-based strategy may provide good opportunities for relevant ministries and departments to discuss the issues and prevent confusion in the subsequent process of policy implementation.

The announcement of a sector-based strategy will help not only policy makers in government but also other stakeholders. Such a strategy can encourage stakeholders to commit themselves to voluntary actions to improve the environmental performance of the building sector. Moreover, the announcement of the government's short-, medium- and long-term goals may encourage them to prepare for the future introduction of policy instruments, and help with the creation of an environment where new policy instruments can be accepted by stakeholders, even though the instruments may affect them negatively in some cases. As the building sector is characterised by a great variety of stakeholders and a dominance of small firms, announcing a sector-based strategy might be one efficient way to inform stakeholders of government views on how environmental impacts of the building sector could be addressed and to promote positive stakeholder action.

6.2. Targeting the point of intervention

In practice, governments design and implement environmental policy instruments with limited financial and human resources. Consequently, they need to set appropriate targets for the policy instruments so that they can achieve the most with the resources they have. Discussing the options and then choosing the right targets is particularly important in the building sector. Due to the complicated structure of the sector, governments must weigh the various options for reaching the targets, and the effectiveness and efficiency of the policies they adopt will be largely influenced by their choice.

There are two basic elements that determine the choice of targets in the building sector. First, governments need to decide what the policy instruments will cover in terms of categories of buildings. Buildings can be categorised in various ways, such as new or existing, use (residential, commercial, industrial), construction method (wooden, reinforced concrete, steel frame) and tenure (owner-occupied, rented), etc. Such distinctions often affect the results of policy instruments. The other important element is determining where government intervention will be most effective in terms of targeted stakeholders (*e.g.* owners, users, designers, contractors, demolition contractors.) and stages in the life-cycle of buildings (*e.g.* design, use, demolition). This section will discuss how the choice of targets influences the effects of policy instruments and how policy makers should set the targets.

6.2.1. *Categories of buildings*

Buildings have various dimensions, many of which have important implications for policy design. It is often the case that a policy instrument that can greatly improve the environmental performance of a certain category of buildings has little impact on another. In some cases this means that the effectiveness and efficiency of policy instruments can be greatly improved by choosing an appropriate target. However, only a small number of studies have been undertaken on the implications of differences in building categories for policy design, and further studies on this aspect of the designing process should provide much insight for the design of effective and efficient policy instruments.

New buildings and existing buildings

One of the most important distinctions made between types of buildings is to categorise them as either "new" or "existing". These two sub-sectors often require different approaches for improving environmental performances, and government intervention in these two sectors sometimes has totally different effects. In the context of energy use in buildings, energy efficiency improvements generally lead to a reduction in CO_2 emissions from both new and existing buildings. However, when implementing energy efficiency measures, there are many differences in terms of cost-effectiveness, size of contractors, difficulties in assessing environmental building performances, and the contacts that owners have with building experts.[3] For all of these reasons, the effective implementation of policy instruments is more difficult for existing building than for new buildings, and so the main target of energy efficiency policies in the building sector has thus far been new buildings. For instance, energy efficiency standards in building regulation have mainly focused on new buildings, and since the fixed cost for implementing energy efficient measures is generally lower in new buildings than in existing buildings, it makes economic sense to target new buildings. However, since marginal costs rise with the stringency of the objective, once the "gap" between the performance of new buildings and existing buildings becomes sufficiently large, it can become more efficient to include existing buildings into target of policy instruments. In some OECD countries we may well have reached this stage. Moreover, since new buildings account for only a tiny fraction of building stock, existing buildings should have great energy saving potential. It is thus important for governments to aim their energy efficiency policies more at the existing building sector.

In the context of C&D waste minimisation, it is important to note that policy instruments for new and existing buildings have totally different effects on waste generation with regard to the timing of their impacts. While policy

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instruments targeting existing buildings that are being demolished today have a direct impact on present waste generation, improving the waste-generation-related characteristics of new buildings will show results in decades (or more) from now. Most policy instruments for minimising C&DW that are implemented in OECD countries target buildings that are presently being demolished. There is an immediate necessity to reduce the final disposal of C&DW, and governments have made policy instruments that can have an impact in the short run a priority. However, as policy instruments targeting new buildings have the potential to drastically increase high-grade recycling and reuse of building materials in the future, it is expected that more policy instruments will be developed for new buildings, and that these will be coupled with policy instruments for existing buildings.

The distinction between new and existing buildings may not be as important for designing policy instruments to prevent indoor air pollution. Indoor air problems related to building materials usually occur sometime between the construction of a new building and some years afterwards. Although the same problem could arise when existing buildings are refurbished with building materials that contain pollutants, it is likely to be less severe unless the existing building is as air-tight as a new building. While many policy instruments for improving indoor air quality target new buildings, they have in effect improved the indoor air quality of existing buildings as well (see Section 5.5). This is because the same kinds of building materials are often used in both new construction and refurbishment work, and the improved quality of these materials has had the same beneficial effect on both categories of buildings.

Residential buildings and commercial buildings

Residential and commercial buildings account for a significant proportion of the building stock. The differences between these two categories of buildings have some important implications, especially for the design of energy efficiency policies.

First, it is noteworthy that the owners of the two categories of buildings greatly differ in nature. While the main owners of residential buildings are individual consumers, those of commercial buildings are firms. In general, individual consumers have little knowledge of building technology, and as a result of high capital costs, they tend to have fewer opportunities to participate in the building market than in markets for cheaper products, preventing consumers from "learning by buying". In other words, consumers often have limited opportunities to obtain valuable information through past transactions in the building market.[4] Consequently, individual consumers often lack basic information on the environmental performances of the dwellings that they are going to buy or possess. The residential building sector may thus be an appropriate target for instruments that can provide this basic information, such as voluntary comprehensive labelling schemes and energy audit programmes. On the other hand, many of commercial building owners may not need such basic information, and more detailed technical information would be of more help to them. Present environmental labelling schemes are already taking these different information needs into account.[5]

Since the energy cost of operating residential buildings is directly incurred by households and the financial burden is, in some cases, significant, special consideration associated with social objective is sometimes needed when designing polices to cover this sector. One example is the distributional effect of the energy tax, which is sometimes criticised as hitting the poor more than the rich. Because of this, the Climate Change Levy in the UK is designed to target commercial buildings only. In the UK and US, subsidy programmes for encouraging energy efficiency upgrades in existing residential buildings essentially target low-income households and have the primary objectives of improving the comfort of their dwellings and preventing health problems caused by the cold, rather than saving energy. Low-income households tend to live in dwellings that have a low level of energy performance, but in general this level can be improved more cost-effectively than in buildings which already have a high level of energy performance. It is reported that a significant proportion of the energy saving potential achieved by the efficiency improvement is in effect usually used for the improvement of comfort rather than saving energy.[6]

It is also important to note that residential buildings, excluding large flats, are usually constructed by small-scale contractors, and commercial buildings are usually constructed by relatively large-scale contractors.[7] Small-scale builders tend to be slow to adopt new technologies and other sorts of innovations. Therefore, when governments are to implement policy instruments targeting the residential building sector, it is sometimes necessary to implement some supplemental instruments that can provide relevant information for small-scale firms and help them to develop their capacities. A good example is the training programme that was launched it Japan to support the introduction of a new environmental labelling scheme (see Section 5.6.2).

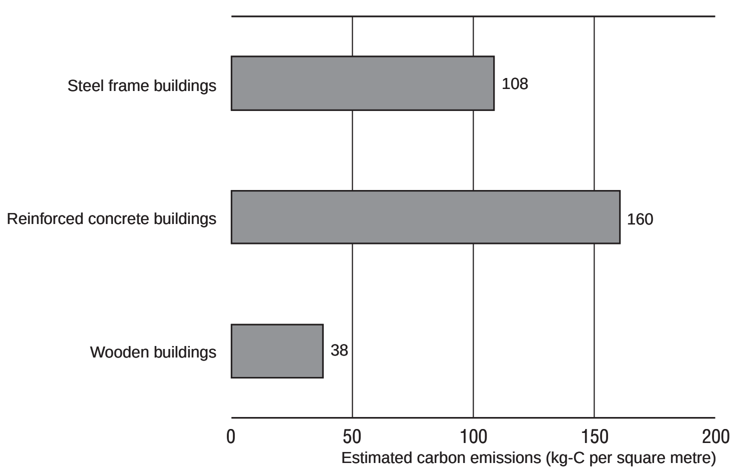
Construction methods

Buildings are constructed with various methods and materials. (*e.g.* wooden buildings, reinforced concrete buildings, steel frame buildings). It is apparent that construction methods are closely related to the environmental impact of buildings. For instance, in the context of minimising material use and waste management, differences in the materials used for the structural parts of buildings largely affect the environmental impacts of buildings. Buildings made with reinforced concrete consume large amounts of gravel and sand, and the extraction of these materials could have a negative impact on landscape and waster resources. On the other hand, the construction of wooden buildings generally has much less environmental impact if the lumber that is used is supplied by appropriately managed forests.

Construction methods also affect how energy is used in the construction of buildings and when they come into service. Figure 18 shows a comparison of embodied energy in the construction of wooden, reinforced concrete and steel frame buildings. The results show that the construction of reinforced concrete buildings consumes more than four times as much energy as the construction of wooden buildings. Construction methods also affect the energy efficiency of buildings. In general, buildings constructed with traditional methods, such as masonry, are less air-tight than those built with more modern construction methods.[8]

Although there are some instruments for waste minimisation that target specific construction methods, such as an aggregate tax, there appear to be few policy instruments for reducing CO_2 emissions that target specific construction methods. The large differences in the energy performance of

Figure 18. **Comparison of estimated carbon emissions during the manufacturing of building materials incorporated in standard buildings by construction method, Japan, 1993**



Note: The quantity of carbon which is emitted during the manufacturing process of main building materials that are incorporated in standard buildings is estimated according to construction methods.
Source: Okazaki *et al.*, 1998.

buildings due to different construction methods suggest that there might be an untapped potential to improve the effectiveness of policy instruments by focusing them on specific construction methods. An extensive analysis of the cost-effectiveness of energy efficiency measures with regard to a wide variety of construction methods could provide useful insight for policy makers.

Tenure

As has been repeatedly mentioned in this report, it is relatively difficult to improve the energy efficiency of rented buildings due to their cost structure. It is landlords who usually pay the capital cost for doing upgrade works, while tenants pay the running cost of buildings. Under such circumstances, both landlords and tenants have little incentives to improve energy efficiency.[9] In this case, economic instruments and information tools may be less effective to improve the energy efficiency of rented buildings than on owner-occupied buildings. As non-regulatory instruments are increasingly being used in OECD countries, it is becoming more important to find ways for dealing with energy efficiency improvement in the rental sector.

It is presumed that landlords would invest more in energy efficiency if they can, in effect, pass on the capital cost to tenants by increasing the rent after they have made their investment. However, it is not common for potential tenants to compare the energy efficiency between buildings they are considering to rent. This may be partly because energy efficiency is invisible and sufficient information on energy performance is often not provided to potential tenants. Although mandatory energy labelling schemes are expected to provide more information on energy efficiency to potential tenants when they are choosing a rental, the impact that the schemes will have is still uncertain. It may be appropriate in this case to focus energy efficiency policy more on owner-occupied buildings, unless there are special reasons for targeting the rental sector.

Theoretically the same problem may arise in the area of indoor air pollution. Both landlords and tenants here also have little economic incentive to improve the indoor air quality of their buildings. However, experiences in OECD countries suggest that many policy instruments in this area directly affect the behaviour of building material manufacturers and help create a situation where polluting building materials are difficult to find in the market. Thanks to this effect, it appears that in practice principal-agent problems are not so big an obstacle for improving indoor air quality as they are for improving energy efficiency.

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6.2.2. Point of intervention

The environmental performance of buildings and building activities is influenced by the actions of various stakeholders in the long lifecycle of buildings. When designing environmental policies for the building sector, it is important to make an appropriate choice of what should be targeted (*i.e.* which stakeholders) and where (*i.e.* at the design, construction, or demolition stages). Theoretically, if the appropriate signal could be transmitted through the supply chain, the choice of the target would make no difference. However due to unique characteristics of the building sector, such as heterogeneity and longevity of its products, the signal is often not properly transmitted. Under these circumstances, choosing the right target does matter as this can influence the effectiveness of policy instruments in various ways. In general, it appears that environmental policies for the building sector could be effectively implemented by targeting stakeholders who make crucial decisions regarding the environmental performance of buildings and building activities, and who, in many cases, are at the same time closely associated with the main obstacles that stand in the way of improving environmental performance.

This can be illustrated by how targets for the minimisation of C&DW should be chosen. As discussed in Section 5.4.2, the right point of government intervention may vary depending on the policy goals that policy instruments are aiming to achieve. With regard to reducing the final disposal of waste, demolition contractors usually decide on the destination of waste at demolition stage. Demolition contractors, in the absence of government policies, often lack an economic incentive to reduce the amount of waste going to final disposal partly because they do not take the environmental cost of the disposal into account when they make their decision. In this case, it is apparent that policy instruments for reducing C&DW to final disposal should target demolition contractors at the demolition stage. On the other hand, for promoting the use of recycled materials in building construction, the focus should be another target. When users of building materials at downstream stages (*i.e.* building materials manufacturers, designers and contractors) try to decide on whether or not to use recycled materials, they often lack economic incentive to use recycled materials as well as reliable information on the quality of such materials. It seems obvious here that users of building materials at downstream stages should be the prime target for achieving the goal of increasing the use of recycled materials.

In some cases, it is not quite clear who the real decision makers are. For instance, in the context of improving the energy efficiency of new buildings, the designers may draft the design documents, but the actual energy performance of buildings is usually fixed through repeated interactions between designers and their clients, who set out a number of requirements concerning building design.

In recent years, policy design in this area appears to be shifting its emphasis from designers to investors. Traditionally, building regulation directly controlled the design process by imposing minimum energy efficiency standards.[10] Today, many policy instruments that are being introduced, such as environmental labelling schemes and capital subsidy programmes, target investors. It is not yet clear how this shift in focus is affecting the effectiveness of policies. However, by targeting the demand side, it is possible that this change may improve the economic efficiency of policy instruments and provide more incentives for innovation because designers are provided with more flexibility in building design. Taking these strengths into consideration, it seems important to continue developing policy instruments that target the demand side.

Another example of this policy shift which may increase the economic efficiency of policies is imposing an obligation on utilities companies to improve the energy efficiency of customers' buildings. If utilities companies could make good use of the information they obtain on the energy use of their customers to meet the mandated target, then governments might be able to improve the overall energy efficiency of buildings with modest administrative cost on their part by shifting them on to utility companies (see Section 5.3.1). Moreover, in many cases they will be better placed to identify opportunities, and thus overall administrative costs (public and private) should fall. Moreover, by targeting a small number of utilities companies, this type of policy instrument could form the basis for introducing tradable permit schemes which may contribute to further reducing the overall cost of achieving given energy benefits.

It should be noted that the point of intervention also affects administrative cost. Although the most direct and economically efficient form of regulation to prevent indoor air pollution is presumed to be a regulation on the indoor pollutant level, this type of regulation is generally very difficult to implement due to significant administrative cost (see Section 5.5.1). In Denmark and Germany, regulations that target the quality of engineered wood products have successfully solved the problem of indoor formaldehyde emissions. These regulations have effectively encouraged building materials manufacturers to stop supplying products that contain relatively large amounts of formaldehyde. Consequently, the regulations have been effectively enforced with modest administrative cost; however, this type of regulation prohibits a flexible trade-off between design elements. As such, due to the shift of the target to a small number of building materials manufacturers, who may have great capacity to respond to government policies, the administrative cost of regulatory instruments for prevention

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indoor air pollution has been greatly reduced in exchange for a loss of flexibility in building design.

6.3. Co-ordinating policy instruments

All policy instruments have some strengths and weaknesses and it is unrealistic to expect any single instrument to solve all environmental problems in the building sector. Consequently, it is necessary for policy makers to create effective and efficient policy packages by appropriately co-ordinating policy instruments. Proper co-ordination of policy instruments could create great synergies for improving the environmental performance of the building sector. On the other hand, the effectiveness of some policy instruments could be largely lost when they are coupled, without careful consideration, with some other instruments. Furthermore, the way instruments are co-ordinated also affects the economic efficiency and administrative cost of policy instruments. With regard to policy design for the building sector, two-steps of policy co-ordination are necessary. First, different kinds of instruments for the same environmental objective should be well co-ordinated. Second, it is also necessary to properly co-ordinate policy instruments for different environmental objectives. This section discusses how co-ordination affects the effectiveness of policy packages, and how policy makers can establish effective and efficient policy packages.

6.3.1. Co-ordination of different policy instruments for the same environmental objective

The proper co-ordination of different policy instruments for the same environmental objective is necessary for a wide variety of reasons. First, co-ordination could have large positive or negative impacts on the effectiveness of policy instruments. Some policy instruments can work more effectively when they are implemented with another instrument. For instance, when there are two principal obstacles to improving a certain environmental performance, a policy instrument that could address one of the obstacles but not the other may not reveal its capacity unless it is coupled with another instrument that copes with the other obstacle. In addition, when a policy instrument has negative side effects, it is usually necessary to implement another instrument to mitigate the negative impact. Furthermore, it is sometimes the case that a policy instrument is able to have an impact on only a limited category of buildings. In such cases, governments may need to introduce other instruments that can cover the other categories of buildings.

Second, co-ordination also affects the economic efficiency of policy packages. The flexibility of some economic instruments could suffer if rigid regulatory instruments were also implemented but not in a harmonised manner. On the contrary, policy instruments that help to develop the capacity of industry, such as support for technology diffusion, could enhance the flexibility of economic instruments, and may improve their economic efficiency. Third, policy co-ordination also has an impact on the scale of administrative cost. Since most buildings are custom designed, many policy instruments for the building sector require checking design documents and on-site inspection. Consequently, administrative processes sometimes overlap, increasing total administrative cost. By avoiding the duplication of administration processes, this cost could be reduced.

Policy instruments for reducing CO_2 emissions from buildings

The most important issue regarding the co-ordination of policy instruments for reducing CO_2 emissions from new buildings may be the combination of regulatory instruments and non-regulatory instruments. Although energy efficiency standards of building regulation may be the most certain measure to improve the energy efficiency of buildings, it is often difficult to set standards that are strict enough to produce real improvements on a significant proportion of new buildings. Consequently, the standards affect only a limited number of buildings whose energy efficiency, in the absence of the regulation, would be well below the average level. In this case, it is necessary for governments to combine the regulation with non-regulatory instruments, such as economic instruments and information tools, which could improve the environmental performance of buildings not covered by the regulation.

In the co-ordination of these instruments, policy makers need to pay special attention to harmonising the structure of regulatory and non-regulatory instruments. For instance, environmental labelling schemes would not be effective for energy efficiency improvement unless the schemes could help potential buyers understand to what extent the energy performance of each building is better than the building regulation level. Similarly, capital subsidy programmes would not be effective unless the subsidy were provided only when the energy efficiency of buildings is well above the minimum standard level. In Canada, under the Commercial Building Initiative Program, investors receive a subsidy based on the estimated energy savings achieved beyond the national building code level. Such careful co-ordination of policy instruments may also reduce the proportion of free riders, and contribute to improving the effectiveness of policy packages.

In general, the effectiveness of economic instruments depends highly on the availability of sufficient information to enable economic actors to make rational decisions in their self-interest (Gunningham *et al.*, 1998). This argument can also be applied to energy efficiency improvement in the building sector. With regard to investors, there appear to be two principal obstacles to improving the energy efficiency of buildings: inadequate

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economic incentives to make an extra investment for energy efficiency, and a lack of reliable information on the energy performance of buildings (OECD, 2001b). Under such circumstances, the combination of economic instruments (*e.g.* capital subsidy) with information tools (*e.g.* environmental labelling) may create synergies to increase investment in energy efficiency. For instance, if a capital subsidy programme were coupled with an environmental labelling scheme, investors would be more likely to understand the positive impact of the subsidy on the cost-effectiveness of the energy efficiency measures. This could be the case with the existing building sector.

Another example is the co-ordination of energy audit programmes with economic instruments, such as capital subsidy programmes and energy taxes. The impact of economic instruments on the cost-effectiveness of energy efficiency investment would be better understood by owners of buildings if they were coupled with energy audit programmes. In the Netherlands, a capital subsidy programme has been implemented in combination with an energy audit programme. In order to improve the positive effects of this policy package, the energy audit report contains details of subsidy programme for which the audited building may be eligible. In addition, an extra subsidy is provided if upgrades are conducted on the basis of proposals in the energy audit report. Similar potential could be identified in combining environmental labelling schemes for existing buildings with energy taxes.

Furthermore, it is noteworthy that voluntary instruments could have more impact on energy efficiency improvement if they were combined with other policy instruments. For instance, under the Climate Change Levy in the UK, reduced rates of the tax are applied to energy-intensive industry sectors, including many construction materials producers, who voluntarily agree to targets for improving energy efficiency based on the government's criteria. A possible increase of the tax should provide the industry with adequate incentives to voluntarily implement measures to achieve the agreed targets. Although there are some obstacles to the effective implementation of voluntary instruments in the building sector, the instruments could be used more widely if the potential of such combination effects were further explored.

It is important to note that public acceptance of policy instruments can be developed to a significant degree, if some different instruments are appropriately co-ordinated. For example, information campaigns on environmental issues could help the acceptance of various policy instruments. Economic instruments such as energy taxes, by making energy efficient investment more economically reasonable, can help the effective enforcement of building regulation and the implementation of higher minimum standards. Subsidy programs can increase the acceptance of energy taxes by mitigating the negative distributional effects of such taxes.

Another potential effect of policy co-ordination is the reduction of administrative cost. Most policy instruments for the building sector usually require checking design documents and on-site inspection. In the context of new buildings, most countries have long had a framework of building regulation where building experts undertake these administrative processes. This means that the administrative cost of other policy instruments could be largely reduced by making the best use of the existing regulatory framework. The overall administrative cost could be largely reduced, for instance, by allowing technical experts conducting on-site inspections for building regulations to do similar inspections at the same time for other schemes, such as environmental labelling.[11] A similar potential for reducing administrative cost could be identified in the existing building sector. Since the cost-effectiveness of energy efficiency upgrades may greatly differ depending on the specific condition of buildings, most policy instruments require on-site inspection by building experts. As with new buildings, administrative cost could be reduced here avoiding the duplication of inspection processes.

Policy instruments for minimising C&DW

The appropriate co-ordination of policy instruments is particularly important for the minimisation of C&DW because, in many cases, the effectiveness of the instruments depends on how the instruments are co-ordinated. With regard to policy instruments at the demolition stage, a landfill tax is found to be a very effective measure to reduce the final disposal of C&DW. However, it is important to note that, in some cases, a landfill tax could have the negative effect of increasing illegal dumping. Therefore governments may need to introduce some measures to prevent this negative effect when introducing a landfill tax. Case studies on Denmark and the Netherlands have found that although both countries have implemented a high landfill tax, illegal dumping has not become a big problem there. One possible explanation is that the implementation of some regulatory instruments, such as mandatory reporting and demolition permission, have become an effective deterrent to illegal dumping. This seems to show that a landfill tax would be more effectively enforced if combined with these regulatory instruments.

Some regulatory instruments at the demolition stage, such as mandatory separation, impose specific standards on the behaviour of demolition contractors. Theoretically speaking, the high economic efficiency of a landfill tax could be harmed if the tax were implemented in combination with these regulatory instruments. However, case studies in Denmark and the Netherlands could not find any evidence that such regulatory instruments are actually weakening the efficiency of the economic instrument. One possible explanation is that there may not be an alternative and more efficient method

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for recycling building materials that does not require, for example, on site separation of some materials, and thus such regulations are consistent with flexible and cost-minimising responses by the firm.

In addition to co-ordinating policy instruments implemented at the same stage, co-ordinating them between different stages is also important for the minimisation of C&DW. In particular, a proper combination of policy instruments between the demolition and downstream stages is essential for the development of a recycled building materials market and a sustainable materials flow within the building sector. At the demolition stage, policy instruments (such as a landfill tax) are implemented with the main objective of discouraging demolition contractors from bringing C&DW to landfill and incineration sites. It is important to note that these instruments could also help promote high-grade recycling of building materials at downstream stages. By making the choice of final disposal economically less attractive, these instruments, in effect, make the price of recyclable C&DW cheaper and thus contribute to increasing the competitiveness of recycled building materials with regard to virgin materials. On the other hand, at downstream stages, various instruments are implemented for the purpose of increasing the use of recycled materials in building construction. Some instruments, like an aggregate tax, provide material users with more economic incentive to choose recycled materials, and some other instruments, like certification schemes, aim to remove the users' doubt over the quality of recycled materials. These instruments, at downstream stages, could also have a positive impact on demolition and disposal activities. By increasing the demand for recyclable C&DW, they could help reduce the final disposal of C&DW as well as illegal dumping.

Thus policy instruments at these stages could mutually enhance their effectiveness and create great synergies for establishing a sustainable flow of building materials. Moreover, improving the waste- generation-related performances of buildings at upstream stages may have great potential to drastically change demolition and recycling processes in the future.

Policy instruments for preventing indoor air pollution

There is a wide variety of pollutant sources which could cause indoor health problems, and governments need to choose policy instruments depending on the characteristics of the pollutant sources. In cases where it is clear that a certain pollutant source causes a serious health problem, it may be necessary for governments to rely on dependable ways of preventing the pollution, which typically would mean regulation on buildings or building materials. When introducing regulatory instruments, it is usually necessary to set the minimum pollutant level that the regulation aims to achieve. It is sometimes argued that the announcement of such values, including those set out under other policy instruments, may give a misleading impression of the problem and confuse consumers. Therefore, when setting such target values, it is important for governments to implement supplemental information tools in order to sufficiently explain the meaning of these values to consumers.

In cases where the linkage between health problems and indoor pollutant sources is not certain or the health problem that is caused by the pollutant source is not serious, governments may rely on less-binding measures, such as environmental labelling schemes. Under environmental labelling schemes for buildings, indoor air quality is usually assessed according to the pollution emission-related characteristics of building materials, which are usually invisible. In order for labelling schemes for buildings to work, designers need to be able to understand which materials contain which (and how much) pollutant. Therefore, it is important to co-ordinate two information tools: one for communication between designers and their clients (labelling for buildings) and the other for communication between building materials manufacturers and designers (labelling for building materials).

6.3.2. Co-ordination of policy instruments for different environmental objectives

Since buildings and building activities are related to various environmental issues, improving one environmental performance sometimes has a negative impact on another. The most typical example of this is the relationship between energy efficiency improvement and the indoor air problem. Indoor air pollution has often been exacerbated by efforts to increase energy efficiency and reduce greenhouse gas emissions by making buildings more air-tight without eliminating sources of pollution. Moreover, in some cases, insulation materials contain some indoor air pollutant sources. It is important to note that such a conflict between environmental objectives in the building sector is not limited to these examples.

First, the management of C&DW has a considerable impact on the energy use in the building sector. With the promotion of recycling and reuse of building materials, the quantity of embodied energy in all building production processes can be reduced.[12] Energy consumption in the construction process, including the manufacturing of building materials, does not account for a large proportion of energy use in the building sector today. However, as the energy efficiency of buildings improves, embodied energy is likely to become a more important issue in the near future. Moreover, significant energy can also be recovered with appropriate combustion methods. In Sweden, it is estimated that of all the embodied energy that is released from the building materials of demolished buildings, 44% is currently recovered with recycling, reuse and energy recovery through combustion. Results of an analysis on the potential of energy recovery conclude that energy savings could be increased

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by 20-40% with better management of C&DW (Thormark, 2001). However, if more energy is needed to recycle certain building materials than to produce alternative ones from virgin materials, then recycling building materials has a negative effect on the reduction of CO_2 emissions. Also, measures that are aimed at improving energy efficiency can sometimes have a negative effect on waste minimisation. In the case of wooden buildings, for example, improving their air-tightness might facilitate the erosion of lumber used to build them, and make their service lives shorter unless sufficient consideration was given to this problem at the design phase.

Similarly, there are some linkages between waste management and indoor air quality. Some chemicals that are used to increase the physical durability of wooden buildings by preventing the erosion of lumber contain indoor air pollutant sources. Without some preventive measures, indoor air quality could deteriorate from these chemicals. It is often argued that disassembling buildings would become more difficult when different building materials are joined with glue, and that reducing the use of glue could promote recycling and reuse of building materials. Since some glues contain harmful pollutant sources, limiting their use may also help to improve indoor air quality.

As environmental attributes of the building sector are interrelated in some way, it is important for governments to note that a certain policy instrument aimed to improve one environmental performance could harm another. When there is a risk of such conflicts, special consideration should be given to the design of policy instruments. For instance, in the Energy Star for Building Program in the US, which awards the Energy Star label for highly energy efficient commercial buildings, good indoor air quality is included in the awarding criteria. Similarly, the Dutch government is planning to revise its energy audit programme, the Energy Performance Advice scheme, to extend coverage of the energy audit report to include explanations of how energy upgrades might affect indoor air quality. These two measures may mitigate possible conflict between the two environmental goals.

It is sometimes the case that policy instruments for different environmental objectives are designed by different government ministries or departments, and so there may not have been much co-ordination between ministries or departments before the policy instruments have been implemented. It is therefore important that basic principles for the co-ordination of policy instruments for different environmental objectives be established and communicated to all relevant ministries and departments. In this regard, the sector-based strategy discussed in Section 6.1 could play an important role by including the principles for co-ordination.[13]

6.4. Monitoring and reform of policies

For the implementation of effective and efficient environmental policies for the building sector, it is necessary to regularly monitor the environmental performance of buildings on a nation-wide or region-wide basis. A monitoring framework could provide useful information on the effectiveness of on-going policy instruments to policy makers, and contribute to the improvement of environmental policies in various ways.

First, a monitoring framework could help governments to develop clear policy targets. For instance, without such a framework to monitor the recycling rate of C&DW it would be difficult for governments to clearly announce to what extent recycling of C&DW should be promoted. A monitoring framework can thus enable governments to announce quantified policy targets, which provide useful and instructive information for policy makers.

It is difficult to predict precisely the effects of policy instruments in advance of their implementation, and they often do not work as effectively as theoretically expected. That is why it is very important for governments to conduct *ex post* evaluations of the instruments. The results of monitoring environmental performance can considerably help governments to precisely evaluate on-going policy instruments and may provide them with many useful suggestions for reforming their policies. Similarly, it is sometimes the case that a new instrument has unpredicted negative effects on environmental performance. Monitoring may then help governments to identify these effects and to quickly introduce supplemental measures to address the negative impact.

Even an instrument that is initially as effective as anticipated may lose some of its effectiveness due to changes in circumstances; monitoring can help governments with the fine-tuning of policy instruments. For instance, the energy efficiency standards of building regulation might lose their effectiveness unless the standards are repeatedly upgraded in line with the evolution of average energy efficiency levels. Similarly, technical standards for subsidies under capital subsidy programmes have to be repeatedly upgraded in order to avoid an increase in the proportion of free riders. A landfill tax, as the Danish experience suggests, could be effective if the tax rate were flexibly increased based on the monitoring results of the recycling rate of C&DW. Moreover, the assessment criteria of environmental labelling schemes also need to be revised, taking the general improvement of environmental performance of buildings into account. Furthermore, the monitoring of environmental performance may have a positive impact on stakeholders. As more stakeholders become aware of the current status of the building sector and learn of recent progress through the announcement of monitoring results, they might be encouraged to take more voluntary actions to help improve environmental performance.

A monitoring framework would contribute significantly to the improvement of environmental policies in the building sector, yet in many OECD countries such a framework has not been sufficiently developed. Since building activities are conducted in geographically dispersed and not standardised ways, extensive monitoring of the performance of the sector is no easy task. This would require choosing indicators and ways to collect and use the data. Possible choices according to environmental objectives are discussed below.

Energy use and energy efficiency of buildings

There are many possible indicators to show the energy performance of the building sector. At the most aggregate level is annual final energy consumption in domestic and commercial sectors.[14] OECD countries usually have such basic data on energy consumption, and they provide a useful overview of energy use in the building sector, which is essential information at the first stage of policy design. However, since a wide variety of factors, including macro-economic developments, demographic trends, climate and energy prices, affect such aggregate-level indicators, they may not be very useful for monitoring the effectiveness of policy instruments and for a subsequent reform of these instruments. For instance, such aggregate-level indicators would provide policy makers with little practical guidance on whether or not (and to what extent) energy efficiency standards of building regulation should be upgraded.

In order to provide more guidance for policy makers, it is thus also necessary to collect disaggregate-level data on the energy performance of buildings. Possible indicators include average energy efficiency expressed with some type of index, the diffusion rate of certain energy efficiency measures, the proportion of buildings which satisfy recommended standards, *etc.* If such disaggregate level indicators are regularly monitored, governments can obtain much information regarding the impact of on-going policy instruments and insights for the reform of their policy. However, it should be noted that collecting such data to represent a national or regional trend would be difficult as it would involve collecting a large amount of site-specific information from many different sites.

Some OECD countries conduct surveys on the energy efficiency level of buildings on an ad-hoc basis,[15] but in order to obtain useful information regarding on-going policy instruments, good time-series data are necessary. However, collecting this data requires so much administrative cost that it is usually not feasible just for the purpose of monitoring. The Danish and

Japanese experiences suggest that these site-based data could be collected with modest extra administrative cost by making best use of the administrative framework for environmental labelling schemes. Results of all assessments under the Danish energy labelling scheme are reported to a council that consists of representatives for various stakeholders. The council enters all collected information into its database which helps the council and the government to understand how the scheme is actually working. Findings from the analysis of the database can provide useful insights not only for the revision of the scheme itself, but also for the design of all policy instruments for energy efficiency improvement. Similarly, under the Housing Performance Indication Scheme in Japan, all assessment results are collected by an organisation approved by the government, which creates the database on housing performance and does various analyses on them.

Minimisation of C&DW

With regard to the minimisation of C&DW, the recycling rate of C&DW is often used as an indicator to show the progress of waste minimisation,[16] although many OECD countries have not yet established a framework to annually monitor the recycling rate. It is apparent that the recycling rate of C&DW is one of the most important indicators for the building sector, and it provides many suggestions for policy design. For instance, on the basis of the monitoring results for the recycling rate of waste, the Danish government repeatedly increased the rate of the landfill tax, succeeding in increasing the recycling rate to 90%. Governments sometimes need to take different approaches to different types of C&DW, so it would provide more guidance for policy design if the recycling rate could be monitored by its source (construction activities, refurbishment and demolition) and according to the kind of material (concrete, wood, *etc.*).

Although the recycling rate can provide useful insight for the design of policy instruments at demolition stage, it cannot provide useful guidance for achieving the other policy goals related to the minimisation of C&DW.[17] Since the concept of "recycling" usually includes both "low-grade" recycling for road construction and "high-grade" recycling for building construction, the recycling rate does not indicate to what extent the recycled materials are used in the building sector itself. In this regard, more detailed data regarding the use of recycled materials should be regularly collected to monitor the effectiveness of policy instruments aimed to close the loop of the building materials flow at downstream stages.

In the long run, improving the waste-generation-related characteristics of new buildings at upstream stage should have a great impact on the promotion of the recycling and reuse of building materials. However, as such performances will not affect the recycling rate for coming decades, it is

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apparent that a totally different monitoring framework is needed for policy instruments at upstream stage. Since the collection of site-based information is necessary, discussions on monitoring energy efficiency could be applicable. Without the use of a framework for other policy instruments, such as the framework for environmental labelling schemes, the collection of reliable data on waste-generation-related performances will be very difficult.[18]

Indoor air pollution

For the reduction of indoor air pollution (unlike other environmental objectives), it is meaningless to monitor the aggregate-level indicator – for instance total emissions of formaldehyde in the building stock – because indoor health problems are directly related to the pollutant level in individual rooms. Site-based or room-based data are therefore particularly important in this area. With an objective to analyse the causal mechanism of indoor air problems, indoor pollutant levels have been measured in a number of buildings in France, Japan, UK and the US. Such an approach is quite important in the relatively early stage of developing policy instruments for reducing indoor air pollution. However, as such measurement entails considerable administrative cost, it would be difficult to regularly measure the actual indoor pollution level for the sole purpose of monitoring the effectiveness of policy instruments.

Despite this difficulty, there may be a few alternative methods to monitor the scale of indoor health problems caused by indoor air pollution. First, environmental labelling schemes may help with the collection of site-based data related to indoor air quality. Second, as building material-related indoor air pollution is largely affected by the quality of building materials, data on the supply or production of building materials could indirectly indicate indoor air quality. For instance, the market share of engineered wood products that contain less than a predetermined amount of formaldehyde may be a useful indicator for formaldehyde-related indoor health problems.

Third, the number of complaints from users regarding health problems caused by indoor air pollution is a good indicator of the scale of the problem. Therefore it is important to set up a framework for collecting and analysing information on users complaints concerning the indoor health issues, and convey the results to policy makers. In 2001 the Japanese government approved more than 40 non-profit organisations across the country as institutions to deal with consumer complaints regarding housing. All received complaints are reported to another approved organisation which is in charge of collecting and analysing reported cases, as well as providing the results of the analysis to the government. With such a framework, it is expected that policy makers will be able to better understand the significance of indoor air health problems. It is sometimes the case that newly developed building materials can cause new types of indoor air problems. However, because indoor air pollutants are invisible and indoor health problems are often mistaken for other types of health problems, it is generally difficult for governments to identify such new problems before a large number of people have suffered from it. This sort of framework should help governments to identify such new indoor health problems and to immediately introduce necessary measures.

Notes

1. One example of such a strategy is the UK's sustainable construction strategy announced in 2000. The sector-base strategy aims to create a framework within which the construction sector can make a contribution to the progress of the UK's sustainable development strategy. Another example, focusing on the issue of CO_2 emissions from the residential sector, is the German Climate Change Program. This program not only lists 13 policy instruments, but also designate quantified targets for some instruments for 2005.
2. Please see Section 6.3.2 for details.
3. Please see Section 5.3 for a more detailed explanation of these differences.
4. Please see Section 4.5.
5. Please see Section 5.2.3 for more discussion on this issue.
6. Please see Section 5.3.2.
7. Though many contractors deal with the construction of both residential and commercial buildings.
8. On the other hand, buildings with a high level of air-tightness are more likely to cause indoor health problems.
9. On the other hand, in cases where landlords have to pay all the energy costs of their buildings, they may have incentive to improve energy efficiency, but occupants may not have any economic incentives to save energy.
10. Though, officially, the obligation is usually imposed on the owners of buildings.
11. Please see an example of the Housing Performance Indication Scheme in Section 5.2.3.
12. Although in some cases recycling materials requires more energy than the production of virgin alternative materials.
13. Please see Section 6.1.
14. Another aggregate level indicator is estimated CO_2 emissions from these sectors.
15. In some countries the survey is conducted every few years.
16. Other common indicators include the absolute amount of C&DW that is disposed at landfill and incineration sites.
17. Please see three principal goals in minimisation of C&DW in Box 11.
18. Under the Housing Performance Indication Scheme, results of assessments regarding physical durability, flexibility and maintenance are collected and analysed by the approved organisation.

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Environmentally Sustainable Buildings
Challenges and Policies

Chapter 7

Conclusions: Policy Recommendations

This report has documented various aspects of discussions regarding the environmental impact of the building sector and the design and implementation of government policies to reduce this impact. It focuses on three environmental objectives closely related to the building sector: reduction of CO_2 emissions, minimisation of construction and demolition waste and prevention of indoor air pollution. The importance of policy design in this area has been illustrated by the previous chapters of this report. The building sector has, directly and indirectly, great impact on these environmental issues, and government intervention in the sector should have great potential to contribute to the achievement of environmental objectives. On the other hand, the building sector has various unique characteristics that create barriers to improving environmental performance. Consequently, discussions on policy design in other sectors are often not applicable to the building sector, and policy makers are required to give special consideration to how environmental policies for the building sector might be best designed.

With the objective of providing guidance for policy design, both theoretical and empirical studies were conducted, and characteristics of policy instruments were analysed. Some theoretical assumptions were found to be consistent with empirical evidence, and some others contradicted empirical findings. Although many questions remain which have not been sufficiently answered due to a lack of available data, the results of analysis in this report demonstrate that each policy instrument has both strengths and weaknesses, and that no instrument can be a panacea for environmental problems. The effectiveness of policy instruments depends highly on the decisions that policy makers take at every stage of designing and implementing environmental policies.

On the basis of discussions in previous chapters, this chapter summarises general policy recommendation for reducing the environmental impact of the building sector.

7.1. General policy framework

Establish a national strategy for improving the environmental performance of the building sector

The establishment of a national strategy for improving the environmental performance of the building sector should help improve the effectiveness of policy instruments in this area. Such a sector-based strategy may provide specific and useful guidance that fully reflects the unique characteristics of the sector, and help policy makers to implement environmental policies in the right direction. The strategy may also encourage stakeholders to be committed to taking voluntary action to improve the environmental performance of the sector. The sector-based strategy would be expected to include quantified policy goals with varied time-scales, which would provide more detailed instruction for policy design, and basic principles of policy co-ordination, which would prevent future conflicts of policy instruments for different environmental objectives. Last but not least, a national strategy can increase the acceptance of the instruments used in the building sector.

Establish a framework to regularly monitor the environmental performance of the building sector

It is important to establish a framework to regularly monitor the environmental performance of the building sector. A monitoring framework not only enables governments to set out quantified policy targets in the sector-based strategy, but also provides policy makers with information to help them reform policy instruments in the proper way. It is important to note that many policy instruments are not likely to keep their effectiveness without appropriate fine-tuning based on the results from monitoring. In order to obtain useful information on the effectiveness of on-going policy instruments, the monitoring framework needs to obtain good time-series data rather than ad-hoc measurements of environmental performance. As the collection of disaggregate-level data is usually time-consuming and costly, it is important to note that such data could be collected with modest administrative cost by making the best use of the administrative framework established for environmental labelling schemes.

Develop a close partnership between government and industry for the support of R&D and technology diffusion

The environmental performance of buildings and building activities is influenced by the actions of various stakeholders in the construction industry, and the technological capacity of the industry often affects the sector's environmental performance. In this context, as the construction industry is characterised by a dominance of small-scale firms which tend to lack R&D investment and be slow to adopt new technical expertise, governments need to support environmental R&D and the diffusion of environmental technologies across the industry. By establishing a close partnership with industry associations that have an extensive network of firms, government programmes that support R&D and the diffusion of new environmental technologies could be implemented more effectively, reaching a great number of geographically dispersed firms in the industry.

With regard to establishing a partnership between government and industry, there appears to be much room for further developing voluntary instruments in the building sector. Although some characteristics of the construction industry obstruct the effective implementation of voluntary instruments, they could work effectively if they were to target areas where participating firms could receive economic benefits from improving environmental performance. The effectiveness of voluntary instruments could also be enhanced if they were properly combined with other instruments that encourage proactive action of the construction industry.

Introduce a greener public purchasing strategy for construction procurement

Public construction procurement should be more directed towards "greener buildings". In OECD countries, construction procurement by government accounts for a considerable proportion of construction investment, and the introduction of a greener public purchasing strategy could have a great impact on the environmental performance of the building sector. It is important to note that such a strategy will not only improve the environmental performance of government buildings themselves, but if designed well may also have great demonstration effects on the demand-side and cost-reduction effects on the supply-side, encouraging wider diffusion in the economy as a whole.

In order to capture such benefits GPP measures should be used particularly in areas in which there are market failures which are slowing the "take-up" of "green" technologies which are likely to be economically competitive in the longer-run. Greener public purchasing may also play an important role particularly in areas where there are no other promising policy instruments, such as improving the waste-generation-related performance of buildings. Because buildings are associated with various environmental issues, it is important to clarify the definition of "green buildings" so that greener public purchasing policies can be effectively implemented.

Minimise administrative cost by eliminating the duplication of administrative processes

As buildings are constructed in a spatially fixed and custom-designed manner, many policy instruments involve significant administrative cost for checking design documents and conducting on-site inspections. It is important to note that when two policy instruments require the same administrative process (typically on-site inspection), the total administrative cost could be considerably reduced by eliminating the duplication of administrative processes. Moreover, in the context of on-site building inspection, administrative cost could also be reduced by allowing entry of new inspection bodies and promoting competition between inspection bodies.

Undertake more ex-post evaluation of policy instruments by means of a close international co-operation

Since policy instruments in practice often do not work as theoretically predicted, *ex post* evaluation of the instruments is important for improving policy design. Although many findings regarding the characteristics of policy instruments were obtained through discussions in previous chapters of this report, many unanswered questions remain due to a lack of empirical data. A good example is the evaluation of environmental labelling schemes. Over the past few years policy makers and building experts have been paying increasing attention to these schemes, yet there appears to be no clear empirical evidence to show to what extent the introduction of the schemes has improved the environmental performance of buildings relative to what the performance would have been in the absence of the schemes. It is therefore necessary to undertake more *ex post* studies on how on-going policy instruments are actually working, and to collect more empirical evidence. As different countries are implementing different policy instruments, it is clear that exchanging information on the results of *ex post* evaluations should be of great help in discussions regarding policy design. International co-operation on the research regarding the design of policy instruments for environmentally sustainable buildings should be continued.

7.2. Policy instruments for reducing CO_2 emissions

Appropriately co-ordinate regulatory instruments and non-regulatory instruments

Energy efficiency standards of building regulation have long played a central role in the energy efficiency improvement of new buildings. Although this regulatory instrument, in a sense, is the most certain measure to improve energy efficiency, it is often difficult to set standards that are strict enough to produce real improvements in a significant proportion of new buildings. Consequently, the standards can affect only a limited number of buildings whose energy efficiency, in the absence of the regulation, would be well below the average level. Under such circumstances, governments need to combine the regulation with non-regulatory instruments, such as economic instruments and information tools, which could improve the environmental performance of buildings not covered, in effect, by the regulation. In the co-ordination of these instruments, policy-makers should pay special attention to harmonising the structure of regulatory and non-regulatory instruments so as not to harm the effectiveness of the individual instruments.

Improve the environmental effectiveness and economic efficiency of building regulation

Despite its limited impact on buildings with a relatively high level of energy efficiency, building regulation is the most effective measure for upgrading the "bottom" end of energy performance of new buildings, and should continue to be seen as one of the most important policy instruments for the improvement of energy efficiency of new buildings. It is important to note that, in many countries, there seems to be much room for further upgrading energy efficiency standards. Such potential for energy efficiency improvement should be fully explored. Moreover, in order for the regulation to keep its current level of effectiveness, the standards have to be regularly upgraded in line with the evolution of average energy efficiency levels. Furthermore, governments should continue efforts to make the standards as flexible as possible so as to improve the economic efficiency of the regulation and provide more incentives for innovation.

Develop a synergy by combining economic instruments and information tools

Economic instruments and information tools could enhance each other's effectiveness if they were appropriately combined for both the new and exiting building sectors. A typical example is the co-ordination of energy audit programmes with economic instruments, such as energy taxes and capital subsidy programmes. Owners of buildings would better understand the impact that economic instruments have on the cost-effectiveness of energy efficiency investment if they were coupled with energy audit programmes. In light of this great potential, governments should develop significant synergies for energy efficiency improvement by appropriately co-ordinating these instruments.

Place more emphasis on energy efficiency improvement in existing buildings

Although policy instruments for the reduction of CO_2 emissions have long placed their emphasis on the new building sector, this sub-sector accounts for a small proportion of total building stock, and there is larger energy saving potential in the existing building sector. As investments in the energy efficiency of buildings generally have a diminishing rate of return, energy efficiency investment in the existing building sector has become, in relative sense, a more cost-effective option as the energy performance gap between new and existing buildings widens. Despite some difficulties in implementing effective measures that are specific to existing buildings,

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energy efficiency policy should nonetheless place more emphasis on this sub-sector. Since there is no existing regulatory framework to cover existing buildings in most OECD countries, non-regulatory instruments are expected to play a more important role here than they do in the new building sector.

Undertake extensive analysis on the cost-effectiveness of energy efficiency measures

One important dimension of policy design is the economic efficiency of policy instruments. However, as few studies have been conducted on this aspect of policy design for the building sector, it is not yet clear, for instance, to what extent the shift from building regulation to flexible economic instruments can contribute to the reduction of overall compliance cost. Therefore it is necessary to conduct an extensive analysis on the cost-effectiveness of energy efficiency measures according to various categories of buildings. The results of such an analysis should have many useful implications for improving policies to reduce CO_2 emissions from the building sector.

7.3. Policy instruments for the minimisation of C&DW

Create a synergy for the minimisation of C&DW by co-ordinating policy instruments across the stages of the life-cycle of buildings

In this area, the point of policy intervention is closely related to policy goals that instruments are aiming to achieve. The immediate policy target at demolition stage is usually the reduction of the final disposal of C&DW that is presently being generated. Policy instruments at downstream stages may be applied to increase the use of recycled building materials in the building sector. Instruments at upstream stages may contribute to the improvement of the waste-generation-related characteristics of buildings that are constructed today. Although principal policy goals may generally differ between stages, it is important to note that the policy instruments which are implemented at different stages are closely inter-related. For instance, instruments at demolition stage, such as a landfill tax, may indirectly promote the use of recycled building materials by reducing the cost of collecting recyclable C&DW. Conversely, instruments at downstream stages could make it easier to control the flow of demolition waste at the demolition stage by making the recycling option more economically attractive. In light of these relationships, governments should create a synergy for the minimisation of C&DW by co-ordinating policy instruments at different stages so that they can mutually reinforce their effectiveness.

Reduce the final disposal of C&DW with a combination of economic and regulatory instruments

With regard to the reduction of final disposal of C&DW, empirical evidence clearly demonstrates that landfill and incineration taxes may be one of the most effective instruments for reducing the final disposal of C&DW if the tax rates are set at a relatively high level. The use of some regulatory instruments at demolition stage, such as a ban on landfill and mandatory separation of building materials, could have great potential to reduce final disposal, although there appears to be no empirical evidence that clearly proves their effectiveness. It is also noteworthy that some other regulatory instruments (*i.e.* mandatory reporting and demolition permission) can prevent illegal dumping, which is often regarded as a main negative side effect of landfill and incineration taxes. Governments should properly co-ordinate these instruments so that the final disposal of C&DW can be largely reduced without significant negative side effects.

Establish a sustainable material flow within the building sector by promoting the use of recycled building materials in building construction

At present, a significant proportion of recycled C&DW from the building sector is not used for constructing buildings, but in construction projects that require materials of lesser quality, typically road construction. As the generation of C&DW is predicted to sharply increase in the coming decades, and the demand for recycled C&DW in road construction is not certain in the long run, governments need to promote the use of recycled building materials in building construction and establish a sustainable material flow within the building sector. Among various policy options discussed in this report, a virgin materials tax may have great potential to provide economic incentives to use recycled building materials if the tax rate is set high enough. A major obstacle for increasing the use of recycled building materials is a lack of information on the quality of these materials on the user side. Information tools such as certification schemes for recycled building materials, as well as specifications that take the use of recycled materials into account, may encourage the development of a market for recycled building materials. While establishing these information tools does not necessarily require government involvement, it may be necessary to ensure the credibility of these instruments.

Encourage proactive response from contractors to reduce construction waste

The wastes generated through construction processes could be significantly reduced through the improvement of site management, such as the reduction of surplus materials; and the reduction of waste could, in many cases, lead to economic benefit. However, in general, contractors in the building industry tend to be slow to adopt new technologies and/or knowledge which is necessary to improve their waste management. Therefore it is important to encourage contractors to become more proactive with technology diffusion programs and voluntary instruments.

Continue to explore possible measures for improving the waste-generation-related performance of buildings

Improving the waste-generation-related characteristics of buildings at upstream stage may have the potential to greatly increase the recycling and reuse of building materials in the long run, even though the actual impact on waste generation will not appear for decades. Despite this large potential, effective policy instruments are very difficult to design for upstream stages. Within the wide range of regulatory instruments, economic instruments and information tools, there does not appear to be a very promising policy instrument to improve the waste-generation-related characteristics of buildings. Under such circumstances, the use of public procurement policies to help create a demand for buildings with better waste-generation-related performances can be seen as one of few realistic and effective policy instruments in this area. Although this is a very challenging issue, governments should continue efforts to explore other possible measures to improve these performances.

7.4. Policy instruments for preventing indoor air pollution

Improve the quality of building materials by implementing instruments that target building materials manufacturers

Building materials that emit pollutants can greatly contribute to indoor air pollution. It is therefore important to improve the quality of these materials so that indoor health problems caused by indoor air pollution can be addressed. Building material manufacturers generally have great capacity to rapidly respond to changing circumstances, and governments should exploit this capacity to improve indoor air quality. For instance, a regulation on the quality of building materials may be a reasonable option when there is clear evidence that the concentration of a certain pollutant is the cause of an indoor health problem, and that there is a consensus among stakeholders to implement such regulation. This could effectively improve the quality of these materials with modest administrative cost. It is noteworthy that environmental labelling schemes could also encourage building material manufacturers to produce safer building materials.

Avoid providing misleading information to consumers

The establishment of target values for indoor pollutant concentration is an important step for raising awareness of indoor health problems due to indoor air pollution, and for developing other policy instruments. In fact, many policy instruments are designed with an aim to keep the pollutant level below the target value level. However, it is sometimes argued that announcing target levels could give a misleading impression of risk and confuse consumers. When setting such target values, governments should therefore implement supplemental information tools so that, for instance, the meaning of the values can be sufficiently explained to consumers.

Undertake more studies on the causal mechanism of indoor air pollution

Indoor air pollution is a very complicated issue. A wide variety of factors affect the indoor concentration levels of pollutants, and the impact of the same pollutant level on human health depends largely on the sensitivity of each person. Therefore, in some cases, it is not clear how building design is linked to indoor health problems. Under such circumstances, it is very important to collect empirical data to indicate the relationship between building design, indoor pollutant levels and their implications for human health. This is a time-consuming and costly task, but these results should provide much useful insight for designing policy instruments in this area.

Establish a framework to identify newly emerging indoor health problems

A number of new building products become available every year, and sometimes they may cause unpredicted indoor health problems. Indoor air pollutants are invisible and the health problems they cause are often mistaken for other types of illness. It is therefore usually difficult for governments to correctly identify such health problems before a large number of people have reported them. In order for governments to be able to identify newly emerging indoor health problems at an early stage and quickly take necessary measures, it is important to establish a framework under which users complaints linked to building performance (including indoor air quality) can be widely collected and analysed. The results of the analysis should then be reported to policy makers in government.

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Annex

Result of Survey on the Current Situation of Environmental Policies for the Building Sector in OECD Countries

Table 21. **Current situation of government policies for the reduction of the CO_2 gas emission**

Target of the reduction	Point of intervention	Required improvements	Approaches	Policy instruments	Australia	Belgium	Canada	Czech Republic	Denmark	Finland	France	Germany	Greece	Italy	Japan	Korea	Netherlands	New Zealand	Norway	Sweden	Switzerland	Turkey	United Kingdom	United States	TOTAL
Reduction of the CO_2 gas emission from the building sector in general			General policy instruments	Support for R&D																					12
				Support for technology diffusion, etc.																					12
				Voluntary instruments																					5
Use stage	Design and construction stage	Energy Efficiency of building envelopes	Regulatory	Standards for thermal insulation	*1	*2	*3							*5										*6	19
				Standards for airtightness	*1	*2	*3		*4					*5										*6	18
				Standards for transparent elements	*1	*2	*3							*5										*6	19
			Economic	Capital subsidy programmes																					6
				Tax exemption schemes																					2
				Premium loan schemes																					6
				Energy tax (environmentally related tax)																					5
			Information	Mandatory energy labelling							*7												*8		5
				Voluntary environmental labelling for buildings														*10							7
				Voluntary comprehensive labelling for buildings							*11														4
				Environmental labelling for building materials																					2
				Recommended standards, guidelines, etc.																					10
		Energy Efficiency for appliances	Regulatory	Standards for H/C appliances	*1	*2	*3																		14
				Standards for lighting appliances							*13												*14		7
			Economic	Capital subsidy programmes																					7
				Tax exemption schemes																					3
				Premium loan schemes								*9													5
			Information	Mandatory energy labelling							*7												*8		6
				Voluntary environmental labelling for buildings														*10							5
				Voluntary comprehensive labelling for buildings							*11														3
				Environmental labelling for building materials																					4
				Recommended standards, guidelines, etc.																					8

Table 21. **Current situation of government policies for the reduction of the CO_2 gas emission** *(cont.)*

Target of the reduction	Point of intervention	Required improvements	Approaches	Policy instruments	Australia	Belgium	Canada	Czech Republic	Denmark	Finland	France	Germany	Greece	Italy	Japan	Korea	Netherlands	New Zealand	Norway	Sweden	Switzerland	Turkey	United Kingdom	United States	TOTAL
Use stage	Design and construction stage	Use of renewable energy	Regulatory	Standards, etc.																					0
				Obligations for utilities companies																					1
			Economic	Capital subsidy programmes																					7
				Tax exemption schemes																					4
				Premium loan schemes																					3
			Information	Mandatory energy labelling							*7												*8		4
				Voluntary environmental labelling for buildings														*10							5
				Voluntary comprehensive labelling for buildings																					1
				Environmental labelling for building materials																					1
				Recommended standards, guidelines, etc.																					6
	Use and refurbishment stage	Energy Efficiency of building envelopes and appliances	Regulatory	Standards																					1
				Obligation for utilities companies																					2
			Economic	Capital subsidy programmes																					6
				Premium loan schemes																					4
			Information	Mandatory energy labelling																					3
				Voluntary environmental labelling for buildings																			*15		4
				Energy audits programmes																					5
				Recommended standards, guidelines, etc.																					3
Construction stage	Design and Construction stage	Embodied energy	Regulatory	Standards, etc.																					0
			Economic	Capital subsidy programmes, etc.																					0
			Information	Mandatory labelling																					1
				Recommended standards, guidelines, etc.									*16												2
		Service life	Regulatory	Standards, etc.																					0
			Economic	Premium loan schemes																					1
				Capital subsidy programmes, etc.																					0
			Information	Voluntary comprehensive labelling for buildings											*16										1
				Voluntary environmental labelling for buildings																					1
				Recommended standards, guidelines, etc.																					0

Table 21. **Current situation of government policies for the reduction of the CO_2 gas emission** *(cont.)*

Target of the reduction	Point of intervention	Required improvements	Approaches	Policy instruments	Australia	Belgium	Canada	Czech Republic	Denmark	Finland	France	Germany	Greece	Italy	Japan	Korea	Netherlands	New Zealand	Norway	Sweden	Switzerland	Turkey	United Kingdom	United States	TOTAL
Construction stage	Use and refurbishment stage	Embodied energy	Regulatory	Standards, etc.																					0
			Economic	Capital subsidy programmes, etc.																					0
			Information	Recommended standards, guidelines, etc.																					2
		Service life	Regulatory	Standards, etc.																					0
				Provision of a service handbook																					1
			Economic	Premium loan schemes																					0
				Capital subsidy programmes, etc.																					0
			Information	Voluntary comprehensive labelling for buildings																					0
				Voluntary environmental labelling for buildings																					0
				Recommended standards, guidelines, etc.						*17															1

*1. In two states only.
*2. Dwellings and hospital etc; in Flanders and Wallonia regions only.
*3. Several provinces and cities only.
*4. Dwellings only.
*5. Dwellings only.
*6. Many states and municipalities.
*7. Dwellings only.
*8. Dwellings only.
*9. Owner-occupied dwellings only.
*10. Dwellings only.
*11. Dwellings only.
*12. Dwellings only.
*13. Commercial building only.
*14. Commercial building only, physical durability and reparability.
*15. Office only.
*16. Physical durability and reparability.
*17. Maintenance manual.

Table 22. **Current situation of government policies for the minimisation of C&DW**

Target of the minimisation	Point of intervention	Required improvements	Approaches	Policy instruments	Australia	Belgium	Canada	Czech Republic	Denmark	Finland	France	Germany	Greece	Italy	Japan	Korea	Netherlands	New Zealand	Norway	Sweden	Switzerland	Turkey	United Kingdom	United States	TOTAL
Waste minimisation in the building sector in general			General policy instruments	Support for R&D																					10
				Support for technology diffusion, etc.																					12
				Voluntary instruments																					8
Demolition waste	Upstream stages (design and construction)	Recycling and reuse	Regulatory	Standards for the choice of materials																					0
				General obligation without specific standards																					4
			Economic	Capital subsidy programmes																					0
				Tax exemption schemes																					0
				Premium loan schemes																					1
			Information	Voluntary environmental labelling for buildings																					1
				Voluntary comprehensive labelling for buildings																					1
				Voluntary labelling for building materials																					1
				Recommended standards, guidelines,, etc.																					1
		Service life	Regulatory	Standards, etc.																					0
			Economic	Premium loan schemes																					0
				Capital subsidy programmes, etc.																					0
			Information	Voluntary comprehensive labelling for buildings											*1										2
				Voluntary environmental labelling for buildings																					2
				Recommended standards, guidelines, etc.																					1
	Upstream stages (use and refurbishment)	Service life	Regulatory	Standards, etc.																					0
				Provision of service handbook																					1
			Economic	Premium loan schemes, capital subsidy programmes																					0
			Information	Voluntary comprehensive labelling for buildings																					1
				Recommended standards, guidelines, etc.						*2															2

Table 22. **Current situation of government policies for the minimisation of C&DW** *(cont.)*

Target of the minimisation	Point of intervention	Required improvements	Approaches	Policy instruments	Australia	Belgium	Canada	Czech Republic	Denmark	Finland	France	Germany	Greece	Italy	Japan	Korea	Netherlands	New Zealand	Norway	Sweden	Switzerland	Turkey	United Kingdom	United States	TOTAL
Demolition waste	Demolition stage	Recycling and reuse	Regulatory	Ban on landfill																					5
				Mandatory separation			*5								*6										8
				Mandatory delivery		*3									*6										4
				Demolition permission																					4
				Mandatory reporting			*5																		4
				Standards for recycled products		*4																			2
				License system		*4																			6
			Economic	Landfill tax																					10
			Information	Waste information exchange																					3
				Guidelines for the management of C&DW																					4
	Downstream stage	Recycling and reuse	Regulatory	Standards for recycled products		*4																			3
				General obligation without specific standards																					4
			Economic	Aggregate tax																					4
				Capital subsidy for recycling facilities, etc.																					2
				Premium loan scheme																					1
			Information	Voluntary environmental labelling for buildings														*7						*8	4
				Voluntary comprehensive labelling for buildings																					0
				Voluntary labelling for building materials																					6
				Guidelines for the management of C&DW																					3
				Recommended standard for recycled products																					2
				Certificate scheme for recycled products		*4																			1
Construction waste	Design and construction stage	Reduction of quantity of materials, etc.	Regulatory	Standards, etc.																					0
			Economic	Capital subsidy programmes, etc.																					0
			Information	Recommended standards, guidelines, etc.																					3

Note: Policy instruments targeted at the demolition waste and implemented at demolition stage are usually applied also to construction waste.
*1. Physical durability and maintainability.
*2. Maintenance manual.
*3. Certain types of non-contaminated C&DW in Brussels region only.
*4. Flanders region only.
*5. Ontario province only.
*6. Concrete, asphalt, lumber.
*7. Dwellings only.

Table 23. **Current situation of government policies for the prevention of indoor air pollution**

Points of intervention	Required improvements	Approaches	Policy instruments	Australia	Belgium	Canada	Czech Republic	Denmark	Finland	France	Germany	Greece	Italy	Japan	Korea	Netherlands	New Zealand	Norway	Sweden	Switzerland	Turkey	United Kingdom	United States	TOTAL
Prevention of indoor air pollution in general		General policy instruments	Support for R&D																					8
			Support for technology diffusion, etc.																					9
			Voluntary instruments																					1
Design and construction	Minimisation of pollutant sources	Regulatory	Standards for building materials					*1	*2		*3											*4		6
			Standards for the release of pollutants		*6			*6		*7									*8			*9		6
			General obligation on materials																					8
		Economic	Capital subsidy programmes																					1
			Tax credit schemes																					0
			Premium loan schemes																					1
		Information	Mandatory labelling for buildings																					1
			Voluntary environmental labelling for buildings														*10							4
			Voluntary comprehensive labelling for buildings																					2
			Voluntary labelling for building materials																					7
			Target value, guidelines, etc.																					13
	Adequate ventilation	Regulatory	Standards for ventilation system																					15
		Economic	Capital subsidy programmes																					1
			Tax credit schemes																					0
			Premium loan schemes																					1
		Information	Mandatory labelling for buildings																					1
			Voluntary environmental labelling for buildings														*10							4
			Voluntary comprehensive labelling for buildings																					1
			Target value, guidelines, etc.																					13

*1. Formaldehyde.
*2. Formaldehyde etc. .
*3. Formaldehyde and VOC.
*4. Formaldehyde (urea formaldehyde foam).
*5. CO, CO_2, carcinogens.
*6. Radon, NO_2.
*7. Radon.
*8. Radon.
*9. Methane, Radon and CO_2.
*10. Dwellings only.

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