Skills and Occupational Needs in Green Building

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Foreword

Moving towards a greener economy is creating opportunities for new technologies, investment, and jobs. At the same time, environmental change and in particular climate change has detrimental effects on certain economic sectors and can cause job losses. Identifying and providing right skills for new and existing jobs can smooth transitions to greener economies and ensure that new opportunities benefit a broader share of society. The shortage of green-collar professionals with cutting-edge skills in energy efficiency, green engineering and green construction has already been identified in a number of countries as a major obstacle in implementing national strategies to cut greenhouse gas emissions or address environmental changes.

In this context, the European Commission (EC) and the International Labour Organization (ILO) concluded a joint management agreement on *Knowledge sharing in early identification of skill needs for the low-carbon economy* with the aim of enhancing cooperation and knowledge-sharing in the field of early identification of skill needs. What each organization has learned from extending state-of-the-art knowledge and analysing good practices through this research programme will inform their own ongoing activities, not only in the EU but worldwide. This study was supported by the European Union Programme for Employment and Social Solidarity PROGRESS (2007-2013),[1] and matched the

[1] This programme is implemented by the European Commission. It was established to financially support the implementation of the objectives of the European Union in the employment, social affairs and equal opportunities area, and thereby contribute to the achievement of the Europe 2020 Strategy goals in these fields. The seven-year programme targets all stakeholders who can help shape the development of appropriate and effective employment and social legislation and policies across the EU-27, EFTA-EEA, and EU candidate and pre-candidate countries. For more information see: http://ec.europa.eu/progress.

objectives expressed by the New Skills for New Jobs Initiative. For the ILO, the agreement supported the implementation of the Green Jobs Initiative, a partnership launched jointly with the United Nations Environment Programme (UNEP), the International Trade Union Confederation (ITUC) and the International Organization of Employers (IOE) in 2008.

Three mutually supportive global reports were produced under this joint management agreement:

- Comparative analysis of methods of identification of skill needs on the labour market in transition to the low carbon economy;
- Skills and occupational needs in green building; and
- Skills and occupational needs in renewable energy.

The studies build understanding of how to embark on a skills anticipation exercise for the low carbon economy, which is relevant for national, sectoral and enterprise level human resource strategies in mitigation and adaptation to climate change. Two sectoral analyses identified global employment and skill needs trends in renewable energy and in green building.

Buildings are responsible for almost a third of all energy related CO_2 emissions. Success of the transition to a low carbon economy depends on radical reductions in energy-consumption building; through green construction of new buildings and retrofitting existing buildings with energy efficient and renewable energy technologies. Demand for workers in retrofitting and new green construction is expected to grow over the coming years as part of government efforts to bring emissions of greenhouse gasses under control as green building technologies and techniques mature, and indeed as many governments seek to boost employment in construction, one of the sectors hit most severly by the recent economic crisis.

The success of governmental policies, financial incentives, regulations, and schemes in greening the building sector depends on the availability of a skilled workforce to implement these changes. Lack of skills is considered a bottleneck for the growth of the green building sector, so adequate training provision is vital to success. New skills needs related to energy efficiency, water management and renewable energies in buildings are emerging. Sometimes this leads to the development of new occupations, such as energy efficiency analyst. More frequently, skills for many existing occupations, such as plumbers and electricians, need to be upgraded. Workers displaced from declining sectors, including the traditional construction sector, may successfully relocate to green building if relevant retraining programmes are accessible.

Training offered in green building has increased notably over the past few years. However, employers still face difficulties finding qualified people to perform certain jobs because training is limited, too general, and not sufficiently practical. The hallmarks of an efficient training system for green building are: including training as an integral component of the green building strategy, involving social partners in the design and delivery of training, combining practical and theoretical knowledge, and targeting initiatives towards migrant and informal workers as well as small construction businesses, which account for substantial shares of construction employment and business.

The study of *Skills and occupational needs in green building* was prepared by an ILO research team consisting of Con Gregg, Jon Beaulieu and Mercedes Durán, under the leadership and coordination of Olga Strietska-Ilina and Christine Hofmann, and under general supervision of the Director of the ILO Skills and Employability Department Christine Evans-Klock. Jane Auvre provided administrative support throughout the project and assisted in publishing the reports.

The report benefited from surveys and case studies prepared by: Tatiana Cyro Costa, Adrian Atkinson, Shinyoung Jeon, Christopher Gully, Vipan Kumar, Yang Yan, Misug Jin and Christopher Dela Cruz. In addition to research undertaken within the ILO, the study draws on a survey of ILO constituents including governments, employers' organizations and workers' organizations. A number of experts provided comments at a focus group discussion in Geneva on 1 March 2011, and at the final technical validation workshop in Brussels on 29-30 March 2011, including: Patrick Bowen from ConstructionSkills, UK, Domenico Campogrande from the European Construction Industry Federation, Nathalie Cliquot from the EU Executive Agency for Competitiveness and Innovation, Christian Kornevall from World Business Council for Sustainable Development, Kyriakos Pininis from the International Union of Architects, Emilio Miguel Mitre from Green Building Council Spain, and ILO colleagues Kees Van der Ree, Edmundo Werna and Larry Kohler.

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Abbreviations

ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie
AIRAH	Australian Institute of Refrigeration, Air Conditioning and Heating
ALMP	Active Labour Market Programmes
ARRA	American Recovery and Reinvestment Act
BAU	Business as Usual
BCA	Building and Construction Academy in Singapore
BEEC	Building Energy Efficiency Certificate
BERDE	Building for ecologically Responsive Design Excellence
BPI	Building Performance Institute
BREEAM	BRE Environmental Assessment Method
BSD	Building System and Diagnostics Pte Ltd
CAC	California Apprenticeship Council
CAH	Club d'Amélioration de l'Habitat in France
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CDP	Continuing Professional Development
CEDEFOP	European Centre for the Development of Vocational Training
CENIFER	Centro Nacional Integrado de Formación en Energías Renovables in Spain
CERIK	Construction and Economy Research Institute of Republic of Korea
CHP	combined heat and power
DGNB	Sustainable Building Council in Germany
ECTS	European Credit Transfer and Accumulation System

EOI	Escuela de Organización Industrial
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
ESCOS	Energy Services Companies
ETF	European Training Foundation
ETUC	European Trade Union Confederation
FÁS	Foras Áiseanna Saothair in Ireland
FEE Bat	Formation aux Économies d'Energie des enterprises et artisans du Bâtiment in France
FFER	Fundación para la Formación en Energías Renovables in Spain
FGBDA	Future Green Building Design Academy
FLC	Fundación Laboral de la Construcción in Spain
FTE	full time equivalent
GBC	green building council
GBCA	Green Building Council Australia
GBCe	Green Building Council in Spain
GBI	Green Building Index in Malaysia
GDP	gross domestic product
HVAC	heating, ventilation and air conditioning
IEA	International Energy Agency
INES	Institute of Solar Energy in France
IPCC	International Panel on Climate Change
ISCO	International Standard Classification of Occupations
ISIC	International Standard Industrial Classification
JaGBC	Green Building Council in Japan
KfW	National Development Bank in Germany
KIRA	Korean Institute of Registered Architects
LED	light-emitting diode
LEED	Leaderdhip in Energy and Environmental Design
NACE	General Name for Economic Activities in the European Union
NHBC	National House Building Council in the UK
NYSERDA	New York State Energy Research and Development Authority
OECD	Organisation for Economic Co-operation and Development
PERI	Political economy Research Institute
PHILGBC	Green Building Council in The Philippines
PV	photovoltaic
QA	quality assurance
SENAI	Servico Nacional de Aprendizagem Industrial in Brazil
SME	small and medium enterprise

TAFE	Technical and Further Education, Australia
TESDA	Technical Education and Skills Development Authority in The Philippines
TVET	Technical Vocational Education and Trainig
UCSAL	Universidade Católica do Salvador
UFRN	Universidade Federal do Rio Grande do Norte in Brazil
UNEP	United Nations Environment Programme
UPC	Universidad Politécnica de Cataluña
UPM	Universidad Politécnica de Madrid
USGBC	United States Green Building Council
VAP	Weatherization Assistance Program in New York
VCB	Vlaamse Confederatie Bouw in Belgium
VDAB	Flemish Public Employment Services
VOC	volatile organic compounds
WBCSD	World Business Council for Sustainable Development
ZCH	Zero Carbon Hub Initiative in the UK

Executive Summary

Achieving a successful transition to the low carbon economy is one of the greatest policy challenges of facing governments and their peoples worldwide, and is of deep concern to businesses, workers and the organizations that represent them. One of the keys to the transition is in reducing building related emissions. The IEA, in its Blue Map scenario which envisions a low carbon future, sees building related emissions in 2050 being 83 per cent below what they would be under a baseline scenario based on no policy change but with living standards in emerging and developing countries rising rapidly.

Achieving this sort of improvement requires radical change. In developed countries where the rate of construction of new buildings is mostly low relative to the stock of existing buildings, the main focus must be on retrofitting existing buildings to reduce carbon emissions, while continuing to raise the standard of new buildings. In emerging and developing countries, where the main focus for people whose living standards are rising is on new construction, the main focus has to be on raising standards of new buildings. Initiatives using energy conserving technologies (such as solar water heating) to improve living conditions in existing buildings in emerging and developing countries are also important.

Reducing carbon emissions is not the only motivation for investing in green building. Water conservation, improved comfort, reductions in expenditure on energy, concerns about energy security and stimulating construction related employment are important considerations for many countries.

Green building standards and certification programmes such as the UK's BRE Environmental Assessment Method (BREEAM) and the US Leadership in Energy and Environmental Design (LEED) standards play a vital role in establishing

Core occupations in green building (from Table 3.1)

CONCEIVING, PLANNING, DESIGNING and ADVISING	Construction company managers and business functions		
	Architects and civil/structural/ environmental engineers		
	Architectural technicians and technical drawing specialists		
	HVAC, electrical, mechanical, sanitary, renewable energy and building services engineers/designers		
	Surveyors		
	Energy, water efficiency and waste management analysts, consultants and advisers		
CONSTRUCTION, INSTALLATION, MAINTENANCE	building site supervisors, site engineers/architects		
	Conservation	Insulation/ weatherization	Bricklayers, carpenters, plasterers, glaziers, masons, foofers, painters/ decorators, as well as semi-skilled occupations that assist.
		Efficient heating & cooling	Plumbers and heating installers/maintainers
			HVAC installers
			Electricians and IT technicians
		Conservation of electric power (other than electric heating & cooling)	Electricians and installers of energy management systems (At domestic level, mostly responsible for helping individual householders to choose energy efficient appliances and lighting technologies)
		Water conservation	Plumbers

CONSTRUCTION, INSTALLATION, MAINTENANCE (cont.)	Building level renewable energy (and high efficiency energy) systems	Heating/cooling	Installers/maintainers of solar thermal systems
			Installers/maintainers of wood pellet and other biomass Heating Systems
			Installers/maintainers of mass heating (large building or district) and combined heat and power (CHP) systems
			Heat pump installers/maintainers
		Electricity	Installers/maintainers of solar photovoltaics (PV)
			Installers/maintainers of small scale wind energy Systems
CONTROLLING	Energy auditors		
	Inspectors, certifiers and quality controllers		
ENABLING	Policy makers		
	Urban planners		
	Financing		
	Educators and information providers		
	Researchers		
MANUFACTURING & DISTRIBUTION	Manufacturers and distributors of green building materials and products		
	IT & system technicians		
GREEN BUILDING CLIENTS	Developers		
	Energy managers, facilities managers and building managers		
	Public servants working in procurement and management of buildings		
	Householders and tenants		

green building technologies, materials/design/construction techniques, developing skills and raising expectations about the environmental performance of buildings. However, the great challenge in green building is to raise the sustainability of the entire stock of buildings in active use. It is important to focus on the skills required to green the output of the building sector as a whole, not just the relatively small part that produces buildings meeting exceptional standards of sustainability.

The extent to which green building techniques and technologies are deployed on a large scale is largely shaped by public policy, and by how householders and businesses respond to this policy. While the cost of constructing new energy efficient buildings that will make substantial savings on energy costs is not necessarily significantly more than the cost of traditional structures, building regulations and other government interventions are centrally important in driving mass adoption of the techniques and technologies required. In retrofitting of existing buildings, governments play a central role in overcoming behavioural and economic barriers to investment. Public information campaigns, financing schemes, subsidies, advice services, obligations on energy companies, and training and certification schemes for service providers are among the strategies adopted.

An important contribution that this report makes is a table summarizing the core occupations in each part of the green building value chain (see table on page xviii), and describing the main skills requirements for each. Most of the occupations involved already exist, but require new skills and knowledge. A small number are quite new (energy auditors, for example). For some new functions that are related to existing occupations, such as installing wall insulation or solar water heating, different approaches are taken in different countries: in some cases, the functions is undertaken by a specific existing occupation; in some, jobs are split between different occupations; in some, new specialist occupations with specialist training (such as a solar panel installer) are emerging; and, in some, the function is being taken on by a workforce from a range of backgrounds, with add-on training.

In many contexts, the availability of skills forms a constraint on what can be achieved in green building. Without sufficient high quality professional-level skills in green building among architects and engineers, the energy performance of new buildings intended to be green may be compromised, and designs that achieve high standards of energy efficiency may be prohibitively expensive to build. Without sufficient high quality skills in green building among skilled construction workers, high prices and uneven quality may greatly slow the progress of retrofitting initiatives. Inadequate skills among policymakers may render schemes intended to promote green building ineffective.

While skills shortages can retard the development of green building, a strong supply of skills can itself help to drive green building forward, making

skills led strategies for green building viable. In many countries, initiatives that have developed green building skills at manual and professional levels have created pools of skilled people with a strong interest in selling and delivering green building projects out of their own economic self-interest, either through broadening the services they already provide or through establishing new businesses. These people make a major contribution to selling green building to householders and businesses.

Skills for green building can, therefore, be a very good investment.

Estimating the demand for skills in green building, and converting this into an estimate of training requirements is difficult. At one level, it is possible to say that everyone engaged in building requires skills in green building (in the case of the EU-25, for example, that is a number of the order of 10 million workers). However, a large part of the learning will be on the job and in short courses provided without external prompting by employers, unions, technology suppliers, and trade, professional and representative organizations. New entrants to the labour force will mostly acquire their basic skills in green building from existing providers of education and training if they update their provision to respond to the needs of the labour market or will require additional training if provision is not updated.

The more difficult question is how many people will need training to enable specific green building initiatives to proceed. In developed countries, this question most frequently arises in connection with retrofitting. Unfortunately, it is difficult to answer without a detailed understanding of the work that needs to be done, and a good estimate of how fast building owners will respond. These factors are hard to estimate well ex-ante or at a macro level; a Hungarian study provides scenarios under which peak employment associated with retrofitting is anything from approximately 30,000 to approximately 120,000 full time equivalents (FTEs); an Irish study has scenarios with peaks ranging from 6,000 to 25,000. As an example, scaling those ranges up to the level of the EU 27 yields a range of approximately one million to four million jobs at peak.

The main conclusions of the report are:

- skills can be used strategically to overcome barriers to green building;
- there is room for skills led green building development strategies to complement current demand led strategies;
- social dialogue has an important role to play in the design and delivery of skills interventions for green building;
- providers of education and training for the construction industries should prioritize green building;

- there is a need for initiatives to target the informal construction sector and migrant construction workers for green building skills development;
- there is a need for all green building initiatives to have a skills component;
- there is a need for substantial numbers of people with skills in building energy assessment and in providing advice on building energy efficiency;
- there is a need for a range of initiatives to increase the supply of trainers;
- there is a need for innovation in training delivery; and
- there is a need to ensure that employees of small construction businesses and independent contract workers have access to training in green building.

Section
1 Introduction

1.1 Importance of green building

1.1.1 Introduction

The theme of the project of which this study forms a part is skills for the transition to the low carbon economy. The transition to green building is a very important component of the wider low carbon economy transition.

However, green building approaches also address wider issues of sustainability. Recognizing this, the report addresses the skills requirements of the green building agenda as a whole, albeit with a particular focus on the skills required to save energy and reduce carbon emissions.

1.1.2 Green building to tackle global warming through low carbon emissions

Energy use in buildings makes a major contribution to carbon emissions, and measures to reduce emissions will form an essential part of any strategy to tackle the threat of climate change. This has been recognized by developed, emerging and developing countries, many of which have put in place initiatives and/or targets to tackle this imperative.

In its *Energy Technology Perspectives 2010 – Scenarios and Strategies to 2050* report, the International Energy Agency (IEA) studied how global energy related CO_2 emissions can be reduced.

The report sets out two scenarios for energy related CO_2 emissions:

- a Baseline scenario under which there are no policy changes and energy related CO_2 emissions roughly double by 2050; and
- a BLUE Map scenario under which many new initiatives contribute to cutting energy related CO_2 emissions by 50 per cent in 2050 relative to 2005.[2]

The BLUE Map scenario involves steep cuts in CO_2 emissions associated with buildings. Buildings account for 35 per cent of all savings in energy related CO_2 emissions under the BLUE Map scenario, with transport (36 per cent) and industry (29 per cent) accounting for the remainder.

- As of 2007, buildings accounted for 8.1 Gt of energy related CO_2 emissions, out of a total of 29 Gt. Under the BLUE Map scenario, they will account for just 2.6 Gt CO_2, 83 per cent below the 2050 level under the Baseline scenario.
- Savings under the BLUE Map scenario come from a combination of decarbonization of the electricity and heat supply sectors (6.8 Gt saved) and savings in buildings (5.8 Gt saved).

Responding to an earlier version of the IEA's analysis (originally from *Energy Technology Perspectives 2006*), the World Business Council for Sustainable Development (WBCSD) calculated that the IEA proposal would imply a cut of almost 60 per cent in building energy consumption per person by 2050, despite progress on decarbonizing energy production. Taking into account the impact of improving living standards on energy consumption in emerging economies, it estimated that building energy consumption in the most energy intensive countries would have to be at least 80 per cent below business-as-usual in 2050 if this was to be achieved (WBCSD, 2009).

Reductions in building energy consumption of this magnitude will only be feasible through radical greening of buildings globally, both through green construction of new buildings and through retrofitting existing buildings with energy efficient and renewable energy technologies. While 2050 is still a long way off, many new buildings now being constructed will still be in use by then, so building design choices being made now will have a direct impact on the feasibility of achieving these objectives.

[2] This appears to be coherent with the G8 target to reduce wider CO_2 emissions by 50 per cent by 2050.

1.1.3 Other reasons for green building

Tackling global warming is not the only policy reason to promote green building. For developing countries, some of the following reasons are particularly relevant.

- Green building measures can have environmental benefits beyond energy efficiency, in areas including water conservation, and use of materials and construction methods with a low environmental impact. As green building and green urban planning are associated closely, both in concept and often in practice, green building measures sometimes form a part of an integrated package of green town planning measures that provide complementary benefits in areas such as transportation, land and water management, management of waste and district heating.
- In many cases, green building measures improve the comfort of occupants, for example by cutting the cost of maintaining comfortable temperatures, by providing a supply of hot solar-heated water to a home that would not otherwise have hot water, or by providing a supply of electricity from a photovoltaic panel to a home in an area that is not electrified. In some cases, this can benefit health as well as comfort.
- While some green building investments cost more than they are likely to save, savings from energy efficiency mean that the net incremental cost of a green building approach over established building practice will almost always be substantially lower than the upfront cost difference.
- Many green building investments save enough money to more than pay for themselves; the discounted value of expected future energy savings exceeds, sometimes by a large margin, the initial costs involved. All other things being equal, energy efficient buildings may also have a higher market resale value than their less green equivalents.

  Under the IEA BLUE Map scenario described earlier, overall global additional investment in buildings of US$ 12.3 trillion is required over the period to 2050. This generates fuel savings of US$ 51 trillion, or US$ 18.6 trillion at a three per cent discount rate. Even at a ten per cent discount rate, the return on investment is significantly positive.
- Some green building measures are, essentially, free, based on building design choices that cost no more than less energy efficient approaches to meeting the same needs.
- Concerns about future energy prices and energy security have increased interest in energy-saving investments, particularly in investments that will

largely or wholly pay for themselves in reduced spending on energy. Many green building investments meet these criteria.

- Under circumstances where many countries, faced with elevated levels of unemployment, wish to stimulate activity that creates more decent employment, many have found that encouraging the retrofitting of existing buildings to reduce carbon emissions makes an effective and significant contribution to this goal. The work is labour-intensive, and often makes use of materials and products manufactured domestically. While strategies to promote retrofitting vary, in most cases they achieve a significant multiplier effect on government spending because they are designed so that householders and businesses pay a substantial share of the cost. Financing schemes often spread the cost to households over time, reducing the risk that investment in retrofitting will materially displace other consumer spending.

  Employment in construction and building materials sectors has suffered relatively badly during the economic crisis in many countries; in these countries, measures to promote green building target a key facet of unemployment and underemployment.

Consequentially, interest and activity in green building is growing rapidly, both in developed and in developing countries.

Developed countries are starting from a higher base; they have historically consumed large amounts of energy per capita to support a high standard of living, so they have had a strong incentive to improve energy efficiency in buildings since at least the time of the oil crises of the 1970s. This has been reinforced by concern about the climate change impact of carbon emissions, and about global energy supplies.

Most developing countries and emerging economies have a history of using much less energy per capita. As living standards improve, raising energy consumption, they face an increasing need to catch up with practices from developed countries that are suitable for diffusion. Many also face serious constraints on water supplies that can be addressed in part through green building techniques and technologies designed to conserve water.

1.2 Defining green building for purposes of this research

One of the challenges in studying occupations and skills in green building comes from the tension between focusing on achieving standards of sustainability well

in advance of general construction practice, and focusing on moving the sustainability of general construction practice forward.

Green building standards and certification programmes, such as the UK's BRE Environmental Assessment Method (BREEAM), the US Leadership in Energy and Environmental Design (LEED)[3] and various low energy and net zero energy building standards[4] play a vital role in maturing product markets for green building technologies, materials and design and construction techniques, developing an important base of skills and raising expectations as to the environmental performance of buildings. They thereby help bridge the gap between early adoption of technologies, materials and construction techniques and the point at which they are sufficiently mature and widely accepted to be adopted for mass deployment at an economically feasible cost.

The evidence of the research undertaken at country level for this project is that they also play a key role in bringing green building approaches from the countries where they are most developed to other parts of the world. In many of the developing countries where we undertook research, LEED and similar standards are being promoted by green building councils (GBCs), and building projects using these standards are driving the deployment of leading edge green building techniques and technologies.

Green building certification programmes are playing an increasing role in greening the inflow into the building stock, and are also having some impact on the sustainability of the existing stock of buildings. For example, the US General Services Administration announced in 2010 that it would require LEED Gold certification as a minimum requirement in all new US federal building construction and substantial renovation projects.[5] As of 2008, over 100,000 buildings had been assessed against the BREEAM standards.

However, the great challenge in green building is not to produce a minority of highly sustainable buildings, so much as to raise the sustainability of the entire stock of buildings in active use. This means achieving high standards of energy efficiency not just for new buildings identified as green, but also for the much larger number of new buildings not specifically identified as green, and across the stock of existing buildings.

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[3] LEED has been developed by the US Green Building Council (USGBC), and is promoted by many other national green building councils. Other major standards include Germany's Sustainable Building Council (DGNB) and Australia's Green Star; these, with the LEED and BREAAM, have all gone international. A number of other countries, including Japan, France, Republic of Korea and Abu Dhabi among others, have developed certifications of their own.

[4] For example, the IEA is working towards an international net zero energy solar building specification (2010).

[5] http://www.gsa.gov/portal/content/197325.

Both strands to green building are therefore important, and it is necessary that the report should address the occupational and skills requirements of both. This means, however, that the report cannot just focus on the relatively small part of the building sector, with associated professional and other services, that specializes in the delivery of buildings meeting standards of sustainability well in excess of the minima required under building regulations. It also has to focus on the skills required to green the output of the building sector as a whole. As many of these skills are located outside the building construction sector, it must take account of the wider value chain of which direct building construction activities form just a part.

While much of the current literature on skills for green building focuses mainly on skills to reduce energy use in buildings (which depends on climate and the building's current equipment for energy efficiency), this report defines green building as activities that contribute to:

- reducing energy and water needs in use of domestic buildings (heating and cooling is responsible for 58 per cent of household energy consumption, water heating for 17 per cent, cooking for five per cent, lighting for four per cent and sundry electrical and electronic appliances for the rest) and non-domestic buildings (more varied in energy use, heating and cooling are main consumers of energy, followed by appliances and lighting);
- reducing environmental impact of sourcing and manufacture of materials and components from which buildings are built and the negative impacts of the processes of constructing buildings including demolition and its potential for reuse and recycling of materials and components; and
- improving health and comfort of the occupants once the building is built.

1.3 Green building value chain

The building sector, as defined narrowly in systems of sectoral classification such as ISIC, forms just part of the value chain that produces and improves buildings. Other key parts include:

- production and distribution of building products and materials;
- professional services businesses, mainly in architecture and civil engineering, that conceive, plan, design and project manage construction and improvement of buildings; and

- clients for construction and improvement of buildings, including property developers and individuals and businesses that need a new building to be built or to have an existing building improved. End customers are included in this value chain because they have an active involvement in bringing a building project from first conception through implementation, even where significant parts of this role are delegated to others.

All of these value chain elements are important in building generally, but there are a number of additional elements that come to the fore in the green building context.

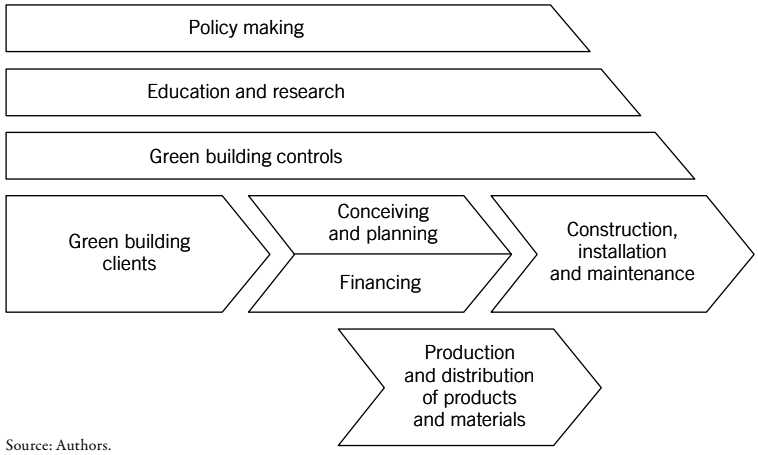
- **Control** and assurance functions are particularly important in green building, in areas including: ensuring compliance with building regulations, assuring clients that green building projects are properly completed and deliver promised benefits, and certifying compliance with green building standards. These control functions may belong to government bodies, independent certifying organizations, or other organizations (such as energy utilities under arrangements in some countries) with an interest in promoting building energy efficiency.
- **Research** is more significant in green building than for the building sector as a whole, as it is an area of rapid innovation. Research focuses on creating innovative products, materials and techniques, on measuring their effectiveness in saving energy when deployed, and on measuring impacts on energy consumption and carbon emissions over the building's lifecycle.
- **Education** is important to progress on green building in both a wide public education sense and in the narrower sense of developing knowledge and skills among people working, or likely to work, in the green building value chain. As is highlighted in the section that follows, the most cost effective interventions available in support of green building are in providing information to people such as householders and business managers to inform the choices they make about constructing and renovating buildings.
- Green building is an area where there is considerable **policymaking** activity underway within countries and internationally. As public policy does much to shape green building activity, it now forms a significant part of the green building value chain.
- Skills in **financing** of green building projects are required both in financial services businesses that finance building works as a part of their commercial business, and for the formation of policy on mechanisms for financing green building projects.

One of the major areas of policy focus in green building is on mechanisms to finance projects undertaken privately, in private homes and in commercial and industrial premises. Financing may also be an issue for public policy where governments act directly to retrofit their existing stock of buildings, or to construct new buildings to energy efficiency standards well in excess of the minimum set out in building regulations.

These elements are reflected in the green building value chain presented in Figure 1.1.

The structure of this value chain is reflected in the skills analysis presented in Section 3, and from that through the remainder of the report.

Figure 1.1. Green building value chain



Source: Authors.

1.4 Sectoral coverage

In addressing skills throughout the green building value chain, the subject matter of this report cuts across sectoral boundaries as defined in commonly used statistical systems.

In terms of ISIC Rev.4, the United Nations system of classification on which most others are based, relevant skills appear in at least the following sectors:

- Division 41, Construction of buildings
- Division 43, Specialized construction activities
- Division 61, Real estate activities

- Division 71, Architectural and engineering activities; technical testing and analysis
- Diverse classifications within Section C, Manufacturing
- Division 62, Computer programming, consultancy and related activities
- Division 46, Wholesale trade
- Division 35, Electricity, gas, steam and air conditioning supply
- Division 84, Public administration and defence; compulsory social security
- Division 85, Education

In addition, the 'green building clients' part of the value chain encompasses organizations from all sectors, as well as individuals in a position to make choices about retrofitting and about construction of buildings.

1.5 Opportunities and building categories[6]

To gain a general overview of the potential for greening the global building stock in the coming years, it is useful to discuss the current situation by focusing on seven building categories.

1.5.1 Unregulated existing and new build housing

Well over half the dwelling stock that has been built in recent years and that is currently being built is 'informal' in the sense that it is built without building permission. In the poorest areas, the inhabitants have little money to spend on energy, or anything else, and houses are often built from scrap materials that make few demands on resource flows or the environment, except for producing insanitary local environmental conditions that do need urgently to be addressed.

However, a growing proportion of this housing is being built with 'modern' materials and with inhabitants being able to afford heating, cooling and household appliances. Greening this housing stock cannot be controlled by building codes and its production would require 'lateral' approaches that train in new skills, and build a culture amongst informal builders of environmentally benign construction and structures. This represents a significant and growing issue global issue.

[6] This section is an edited extract from a background report prepared for the project by Adrian Atkinson, an architect who specializes in green building.

1.5.2 New build housing to current building code standards

Typically, single-family dwellings in a temperate climate built to current standards consume around 700MJ/m²/annum and apartments around 480MJ/m²/annum (based on cases in North America; the EU average is found to be around 610MJ/m²/annum). Each country may, in addition, have standards for materials and certain (e.g. electrical) fixtures that are not yet in general oriented to greening buildings, although in some countries the possibility of merging green assessment and certification systems into national building regulations is gaining attention.

In most developed countries, only a very small addition is made to the stock of dwellings annually. In the UK, which is probably typical of the OECD countries, new dwellings represented just 0.8 per cent of the total housing stock in 2007, a boom year. By 2050, according to the United Kingdom (UK) National House-Building Council (NHBC), "...at least 80 percent of the homes that will be standing in 2050 have already been built." This means that even if stringent green building standards were to be introduced today, less than 20 per cent of the UK housing stock would be built to these high green standards by 2050.

1.5.3 New build housing to higher standards

Even relatively simple design and building measures that add little to the cost of housing construction can reduce energy use in space heating and cooling by a third, or even by half relative to today's conventional building methods. Dwellings built to high energy-saving standards, such as Passivhaus (Germany), Minergie (Switzerland) or the Zero Carbon standards (UK) currently in development, can bring energy consumption in space heating and cooling down to 50MJ/m²/annum at an additional cost of five per cent to eight per cent . The amount of housing being built to these standards today is, however, very small. Nevertheless, in the UK the Zero Carbon Hub (ZCH) initiative, financed by the government and disseminated by the NHBC, aims to tighten building regulations to ensure that all new housing is built to the Zero Carbon standard by 2016. Similar targets are being undertaken in some other EU countries.

1.5.4 Green dwelling refurbishment

As can be seen from the above, if major reductions in residential building energy consumption in developed countries are to be achieved by, say, 2020, this will have

to be achieved through large scale green refurbishment programmes. Over recent decades, initiatives, mainly by individual households, have led to small investments such as in roof insulation (often to minimal standards) and 'weatherizing' windows and doors. An even smaller proportion of dwellings have been brought up to higher standards that include wall insulation, triple glazing and the introduction of more sophisticated green technologies.

Energy-saving lighting fixtures have progressively displaced incandescent fixtures, moderating an increase in appliance related electricity consumption, but there is still a way to go. Lighting based on still more efficient light-emitting diodes (LEDs) seems likely to drive further improvements as this technology matures sufficiently to be ready for mass market deployment.

Green technologies including ventilation with heat exchangers, heat pumps and small-scale combined heat and power (CHP), solar water heaters and photovoltaic arrays have been shown to reduce still further greenhouse gas emissions, but have been installed only on a small scale so far in most countries. The few exceptions include Cyprus, Barbados and Israel where solar water heating is very widespread and China where there is currently a major spread in the application of solar water heating technology.

Whilst some EU countries offer tax breaks and interest-free loans for green dwelling refurbishment, so far the only country where a significant green refurbishment has been organized as a coherent programme, thus indicating that this is possible given the political will, is in Germany where around two per cent of the housing stock (70 million m^2 of floor space) has had substantial energy saving measures installed; these were financed by incentives and grants made available through the National Development Bank (KfW). Left to householders and small landlords to take individual decisions, even in the context of generous tax breaks, interest-free loans and small subsidies, the evidence is that slow progress is likely to be made. It should be added that in practice much of the housing stock, especially in North America, lends itself very poorly to 'deep' green refurbishment as a consequence of the poor physical quality of the original structures.

1.5.5 Non-domestic new build

Non-domestic buildings, comprising around a third of the total building stock, vary greatly in terms of energy consumption per unit floor space and environmental impacts. Reasonable energy consumption rates for new non-domestic buildings today range from restaurants at 550MJ/m^2/annum to offices

at 300MJ/m²/annum. These are current Japanese standards with, for example, hospitals and schools between these extremes.

Whilst building codes throughout the developed world and in many emerging countries have, over recent years, been gradually moving in the direction of green standards (particularly reducing the limit for energy in space heating and cooling) these remain some way from more consistent and rigorous green building standards.

This is, however, the area upon which green building certification schemes are mostly focused. There are now many of these, including the UK's BREEAM, US's LEED, Australia's Green Star and Germany's DGNB, and each of these is now going international. More countries, including Japan, Republic of Korea, and Abu Dhabi, among others, have also developed their own.

These schemes have three to five levels of rigour in greenness to which buildings may be certified. So far a very small fraction of buildings recently constructed have been approved under these initiatives; with BREEAM well ahead of the others with, by February 2008, over 100,000 certified buildings compared with fewer than 2,000 LEED certified buildings. They have been used as the basis for training auditors and, more importantly, architects in green building, and it may be anticipated that in the future the proportion of the non-domestic building stock built to these standards will increase.

1.5.6 Non-domestic buildings designed to even higher green standards

It is possible to achieve considerably higher green standards even than those that are given the highest standard of certification. A good example is the EAWAG building of Zurich University that consumes just 17MJ/m²/an in heating and a further 48MJ/m²/annum in electricity, a third of which is generated by photovoltaic cells on the roof. A whole series of other green initiatives were undertaken in this building's construction and care was also taken in the choice of building materials. The cost of the building was within the government cost limit, and only some five per cent above the equivalent 'conventional' building, with a payback period from saved energy of 13 years.

1.5.7 Non-domestic green refurbishment

Older non-domestic buildings generally consume considerably more energy per unit of floor space than the relatively modest standards currently required

by building regulations. Furthermore, there are significant legacies of internal environmental problems such as asbestos and volatile organic compounds (VOC) emanating from synthetic materials and adhesives that have been used in construction in recent years. This building stock is everywhere extremely varied in construction and hence remediation work is often difficult, requiring different approaches building by building. There is, however, a substantial stock of such buildings throughout the world that requires considerable work in green refurbishment.

1.6 Methodology

The research conducted for this report draws on findings from case studies of a number of selected countries including: Australia, Brazil, China, France, Germany, India, Ireland, Japan, Malaysia, the Philippines, the Republic of Korea, Singapore, Spain, the United Kingdom, the United States. It also collected information through a survey among Ministries of Labour, workers' and employers' organizations from Austria, Belgium, Bulgaria, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, Italy, Latvia, Lithuania, Malta, the Netherlands, Norway, Portugal, Slovenia, Sweden, and Thailand. The response rate was 60 per cent among Ministries of Labour, 20 per cent among workers' organizations, and 20 per cent among employers' organizations. This information was complemented by additional literature review.

The preliminary findings were validated through a focus group discussion in Geneva on 1 March 2011, involving representatives of the ILO and the World Business Council for Sustainable Development.

The draft report was validated at a technical validation workshop in Brussels on 29-30 March which brought together representatives of the European Commission and the ILO, other international organizations such as OECD, UNEP, Cedefop and ETF, representatives of workers' and employers' organizations and of academia.

Section
2

Drivers and Barriers for Green Building

2.1 Introduction

The green building sector has the potential to deliver substantial energy savings, greatly reduced emissions of greenhouse gases, and a range of other benefits from improvements in comfort to boosting employment at a time of economic crisis. This section of report addresses:

- the main drivers underlying the increasing significance of green building;
- the major barriers to the adoption of green building techniques, technologies and design approaches; and
- the major types of policy response used to drive green building forward.

2.2 Underlying drivers

2.2.1 Introduction

The main underlying factors driving green building forward discussed are as follows. Some are interrelated and mutually dependent:

- the need for lower carbon emissions from buildings to respond to the threat of climate change
- broader issues of sustainability, including the need to conserve water and the desire to reduce the environmental impact of buildings
- energy prices and energy security

- environmental awareness among individuals
- population growth, urbanization and improving living standards
- employment creation in the economic crisis
- comfort
- quality of the existing stock of buildings
- ecological sanitation

2.2.2 Need for lower carbon emission to respond to the threat of climate change

Climate change and the global agenda to reduce CO_2 emissions are among the most pressing international challenges of the present day.

Improving energy efficiency in new and existing buildings is the most challenging but also cost-effective carbon mitigation opportunity according to the Working Group III report contributing to IPCC Fourth Assessment Report (Levine, M. et al, 2007).

> Our survey of the literature (80 studies) indicates that there is a global potential to reduce approximately 29 per cent of the projected baseline emissions by 2020 cost-effectively in the residential and commercial sectors, the highest among all sectors studied in this report (high agreement, much evidence).

Governments across the world, and particularly in the developed and fast emerging economies that consume the most energy, have recognized the potential to reduce building related carbon emissions. Most are raising the standards of energy efficiency required in new buildings (often progressively), and are adopting a selection from a wide range of strategies to encourage retrofitting of existing buildings so as to improve energy efficiency. Many are also encouraging construction of buildings to standards of energy efficiency well in excess of the minimum regulatory requirements they have specified.

Civil society, businesses and workers' organizations are also responding to the imperative to cut carbon emissions associated with buildings, for example through the establishment of green building councils, through the environmental strategies of many employers and employer organizations, and through a business focus on building energy efficiency that is more intensive than it would be if the only motivation was to reduce spending on energy. Many workers' organizations actively promote the pursuit of building energy efficiency, both as an objective in its own right and as a way to stimulate more building industry employment.

2.2.3 Broader issues of sustainability

While the main theme of this research project is about skills in the transition to the low carbon economy, the green building agenda goes beyond reducing carbon emissions to also encompass other aspects of sustainability.

Lack of access to sufficient water is already a major problem, which in many areas is getting worse over time. Water conservation has become a major theme in green building to address this, particularly in dry countries in which access to water poses the greatest constraint.

Other issues of sustainability, from waste reduction to avoiding pollution are also significant factors motivating governments and others to favour green building approaches.

2.2.4 Energy prices and energy security

High energy prices, and the threat that scarcity will drive them higher, are another major factor motivating governments, businesses and individuals to seek to improve energy efficiency in buildings, and elsewhere. The higher energy prices (and expectations of future energy prices) go, the more economically attractive investments in energy efficiency become. Investments in the most cost effective measures become even more cost effective. Investments in less cost effective measures at least become more attractive.

Energy security is an additional factor motivating governments and others to favour reducing energy consumption associated with buildings. With supplies of imported fossil fuels subject to disruption and price spikes, governments have an interest in reducing their reliance on these sources of supply. Reducing energy consumption in buildings, and supplying some of their energy needs locally using renewable sources at the level of the individual building, both improve a country's resilience in the face of threats to imported supplies.

2.2.5 Environmental awareness among individual consumers

Environmental consciousness has become a major factor shaping the behaviour of individuals across the world. As consumers, many will pay for environmental benefits. As citizens, many expect their governments to pursue environmental objectives, including reductions in emissions of greenhouse gases.

While few will pay very much more for a green building than for a building constructed more traditionally, when all other factors appear equal many favour the green alternative. As a well designed green building does not necessarily cost significantly more than a more traditionally constructed one, this can give a market edge to developers of energy efficient and sustainable new buildings.

Environmental awareness also influences individuals when deciding to invest in retrofitting buildings for energy efficiency. Even in the absence of subsidies, many in developed countries choose to invest in retrofitting measures with long payback periods that would not be attractive if the decision was based purely on saving money by using less energy. Factors including environmental awareness, the desire for comfort and the expected positive impact of retrofitting on the market value of the building contribute to this.

Information from manufacturers and suppliers of green products, governmental agencies and other interested stakeholders is contributing to developing consumer consciousness of green building. In Germany, for example, various information campaigns have been launched nationally and regionally and the Ministry of Transport, Construction and Urban Planning provides an online service to allow home owners and renters to calculate energy saving potential of green refurbishing.

Singapore is also striving to promote eco-awareness for home owners through campaigns such as "Let's Live Green" or the dissemination of 'eco-kits' for homebuyers.

These trends are not present only in developed countries. In India, for example, country level research showed that consumer awareness is one of the most important driving forces for green building as increasing numbers of young middle class Indians are becoming sensitized to environmental issues.

2.2.6 Population growth, urbanization and improving living standards

Population growth, a shift from rural to urban living and improving living standards are common trends in advanced developing countries that have a significant impact on building development and tend to drive higher levels of energy consumption.

India and China provide good illustrations. In China, rapid and continuous urbanization and GDP growth have produced an average of six per cent annual growth in the country's floor space from 2000 to 2006. While population growth and migration to cities is expected to continue in the next two decades

(300 million are expected to have moved into Chinese cities by 2030), it is estimated that floor space will double in the same period, from 42 billion (2005) to 91 billion square meters (McKinsey & Company, 2009). Although commercial and industrial floor space is growing at a comparatively faster rate, residential building still accounts for the greater part of these figures.

Trends in India are similar, with a fourfold rise in built commercial floor space and a fivefold rise in residential floor space by 2030, from one to four billion and from eight to 37 billion square meters respectively (McKinsey & Company, 2009b).

Energy consumption per capita tends to increase as living standards improve, with better off households likely to spend more on heating or cooling, and likely to operate appliances such as televisions and refrigerators.

To avoid unnecessary and excessive increases in carbon emissions associated with buildings, China, India and other emerging economies will have to embrace green building approaches. China, in particular, has already recognised this and has begun to require and regulate improved standards of building energy efficiency.

2.2.7 Employment creation in economic crisis

Building construction is labour-intensive. As activity rises and falls with economic conditions, a severe economic slowdown can put large numbers of workers in building trades out of work. This has happened in many countries during the current economic crisis, particularly in the developed countries where the crisis has been deepest.

Many governments of developed countries wishing to stimulate employment during the crisis identified encouraging retrofitting of buildings for energy efficiency as an activity that would simultaneously reduce carbon emissions, provide an economic payback in reduced energy consumption, and provide a significant boost to construction employment.
Examples include:

- retrofit projects under the US American Recovery and Reinvestment Act stimulus programme
- the Czech Republic's Green Savings programme
- Slovenia's Eco Fund
- Ireland's National Retrofit programme

The Czech Republic launched its Green Savings programme in 2010 as part of a stimulus package specifically focused on the construction sector, with quality job creation being a visible co-benefit. Subsidies were made available for replacement of inefficient heating systems for low emission biomass fired boilers and heat pumps (including installation work) and for the construction of passive houses.

Slovenia reported a positive impact on jobs generation from its Eco Fund, implemented to support initiatives that increase energy efficiency and the use of renewable energy in many sectors, including construction. It particularly boosted manufacture, distribution and installation of devices and material subject to grants such as wood fuelled biomass boilers, solar systems, heat pumps and refurbishing services.

While the above examples are specifically intended as crisis responses as well as environmental interventions, there is also a longer term employment agenda that extends to emerging and developing as well as developed economies. A greener economy is expected to create millions of direct, indirect and induced jobs in the long run and to have a variety of associated co-benefits (UNEP et al, 2008).

Construction of greener buildings will make a contribution to this, which will be particularly beneficial in providing employment to large numbers of lower skilled workers. UNEP in its Green Economy report estimates that investments in improved energy efficiency in buildings could generate an additional 3.5 million green jobs in Europe and the US alone. If the demand for new buildings that exists in developing countries is considered, the potential is much higher (UNEP, 2011).

2.2.8 Comfort

Aside from improving energy efficiency and sustainability, green building projects mostly have the effect of improving comfort. Achieving a higher standard of liveability in buildings is an explicit objective for most approaches to green building, and in energy efficient buildings the cost of maintaining comfortable temperatures year round is much lower than in more traditional structures. This is one of the major attractions to householders and businesses of retrofitting buildings for improved energy efficiency.

Other benefits to comfort can include lower levels of noise and improvements in indoor air quality. Building envelope improvements intended to reduce the transit of heat also typically reduces the transit of noise.

2.2.9 Opportunities for enterprises

Green building is generating substantial business opportunities, not just for construction businesses and for construction professionals, but also for businesses supplying the technologies, materials and services required. These opportunities are driving entrepreneurship, and are giving existing businesses scope to diversify and expand. In turn, their efforts to innovate, commercialize and market are improving the capability of green building technologies and techniques to deliver benefits, and to do so cost-effectively. They are also raising consciousness of green building among businesses and individuals.

An illustrative example can be found in Japan, where large construction companies got involved in green building in anticipation to legislation related to the country's commitments under the Kyoto Protocol. These companies now have an advantage in complying with stricter building codes and standards, with more building projects in the country incorporating green technologies and solutions (Beasley et al, 2007). The business opportunities presented by green building are also attracting interest from other stakeholders that benefit from business success; from government agencies working to develop their local industrial base to investors in search of high potential businesses to fund.

2.2.10 Quality of building stock

Given the slow turnover of the building stock in most developed countries, the greatest opportunity for carbon and energy use savings in the building sector in these countries is considered to be in retrofitting and in switching to more energy-efficient appliances (WBCSD, 2009).Because the energy efficiency of the existing building stock has a big impact on the scale of the benefits that can be derived from retrofitting, the scale of this opportunity varies depending on the quality of a country's building stock. The extent of the benefits arising from relatively costly investments such as exterior wall insulation varies depending on the context.

In Germany, for example, which has a relatively old stock of buildings, the energy saving potential of most buildings built between 1950-80 is about 50 per cent; 75 per cent of all 40 million residential single units were built before 1979.[7]

In other developed countries where the majority of buildings were built since the energy crises of the 1970s, the opportunities to reduce energy consumption through installing more insulation are typically less.

[7] Federal Ministry of Transport, Building and Urban Development for Germany; www.bmvbs.de

This analysis, however, applies much less to developing countries where new buildings with poor thermal qualities have continued to be built, and where more of the opportunity for improvement lies in better construction of new buildings yet to be built.

2.2.11 Ecological sanitation

Health and environmental problems associated with deficient sanitation systems are at once a centuries-old and present-day harm. Although poor sanitation is mainly a problem in rural areas worldwide, urban centres are also under pressure as urban populations are growing fast and increasing the burden on existing systems. Green sanitation is driven by water scarcity, sustainability and health concerns, improving living standards and demand for comfort. At the same time, the need for green sanitation drives greener building solutions. Almost 40 per cent of the world's population (about 2.6 billion people) live without access to improved sanitation, mainly in Asia and Sub-Saharan Africa.

If the environmental burden and impacts of buildings are to be reduced, new and greener sanitation systems must also be considered as an alternative to conventional flush and pit toilets.

However, implementing green toilets in refurbishment projects can be more complex than in new developments where systems are integrated from the design phase. Availability of space to install collectors and treatment facilities may be an issue, along with the willingness of households to convert their working systems while not necessarily being the direct beneficiaries. In these cases, incentive or regulatory policies will be necessary to support change, while an external system will be required to collect, transport, treat and distribute the end-products.

2.3 Barriers

2.3.1 Overview

The previous section highlighted numerous benefits coupled with green buildings and associated behavioural, economic and political changes underlying the green building push. Still, a number of barriers and negative incentive structures persist that seem to be holding hold back a wider adoption of technologies and practices for greening the construction sector. Based on the classification suggested by The

Table 2.1. Barriers to energy efficiency uptake in the construction sector

Category	Definition	Barriers
Financial cost- benefit	Ratio of investment cost to value of energy savings	• Up front equipment costs • Deficient financing opportunities • Energy subsidies • Marginal costs (environment, health) not internalized in price
Hidden cost-benefit/ transaction costs	Cost or risks (real or perceived) that are associated to change and not captured in standard cost-benefit analysis	• Possible costs and risks associated with incompatibility, performance and other transaction costs • Costs or risks of not changing: obsolescence, change in consumption patterns, new legislation
Market imperfections	Market structures and constraints which prevent the consistent trade-off between energy-efficient investment and the societal energy-saving benefits	• Principal agent dilemma • Fragmented market structure • Regulatory failures • Imperfect information
Behaviour	Behavioural characteristics of individuals and organizations	• Business as usual behaviour and lifestyle • Lack of awareness • Corruption

Source: Carbon Trust (2005) and Levine, Ürge-Vorsatz et al (2007)

Carbon Trust (2005) and further adapted by Levine, Ürge-Vorsatz et al (2007). Table 2.1 summarizes the main impediments for energy-efficiency measures, which are equally valid for water efficiency.

The research for this report highlighted a number of the barriers listed by Ürge-Vorsatz et al. The paragraphs that follow will focus on these.

2.3.2 Up-front costs

In considering up-front costs, it is necessary to make a distinction between construction of new buildings and retrofitting of existing buildings.

- With good design and easy access to green building materials and technologies, buildings much more energy efficient than their conventional equivalents do not have to cost significantly more. Particular design features or the addition of renewable energy technologies can increase the cost, but these can

be avoided if the up-front cost is critical to the decision to invest. However, country level research showed that in many developing and emerging economies easy access to good design and to green building materials and technologies is not yet a reality, making upfront costs a serious barrier to the construction of new green buildings in these countries.

- In retrofitting of existing buildings, all costs are incremental, so the upfront cost and the payback period are important to householders and businesses. There are retrofitting measures that cost relatively little to implement and typically have a short payback period, making them easy to justify, such as improved draftproofing and improved heating controls. However, the upfront cost of measures such as double and triple glazing, building envelope insulation and renewable energy systems is much more substantial (when installed as a retrofit), and under most climatic and building conditions has long payback periods that make them more difficult to justify on purely economic grounds. This has been identified by the WBCSD as a substantial barrier to comprehensive retrofitting that requires significant policy interventions to be overcome.

2.3.3 Energy subsidies

Many countries operate energy subsidies to ensure access to energy for low income households and for other social and economic objectives. In some countries this is a major barrier to the adoption of green building approaches. Energy is so cheap to users that there is little incentive to invest in energy efficiency. In the country level research undertaken, Egypt was identified as a country where cheap energy poses a particularly important barrier to investing in retrofitting existing buildings, and where even new buildings are frequently designed with conspicuously little regard for energy efficiency.

There is a substantial policy literature arguing for the removal of energy subsidies, and for other measures to be substituted where they currently serve a valid policy need (Saunders and Schneider, 2000).This is important from a skills policy perspective, as countries maintaining high energy subsidies are unlikely to develop a substantial requirement for green building skills unless they put in place strong countervailing measures to favour energy efficient buildings.

2.3.4 Information asymmetries, principal-agent issues and split incentives

There are significant principal-agent issues in green building, where the client (principal) cannot be sure that those providing green building services (agents) will act in the client's best interests.

Clients for green building projects often do not themselves have enough information or understanding of what is involved to be able to make a well informed assessment of whether what they are being offered makes sense and is good value, and do not themselves have the knowledge and skills required to assess whether what has been delivered is what they need. If builders and providers of services provide substandard advice or do substandard work, this may never be caught by the client. In the absence of mechanisms to check on builders and service providers, this poses two major problems for green building:

- the work may not be well designed or up to standard, compromising the environmental and economic benefits; and
- clients uncertain that they will get what they think they are paying for may decide not to invest.

In some countries there is a significant issue with retrofitting for energy efficiency in rented accommodation, where the landlord has to pay for energy efficiency measures but the tenant receives the benefit in terms of lower energy costs and improved comfort. This dissociation between the decision maker/investor and the customer/user, known in the literature as a misplaced or split-incentive barrier (Golove and Eto, 1996) creates a disincentive for investments in energy efficiency, and is a significant barrier.

A property developer may place less emphasis on green building features than a prospective buyer or tenant for similar reasons.

2.3.5 Multi-dwelling housing

Multi-dwelling buildings pose challenges to green building refurbishment because they require collective decision making. Some owners or tenants may not be willing, or may not have the financial resources, to support improvement measures for the whole building.

Some countries have developed solutions. In Austria, for example, special rules are applied to apartments in multi-dwelling buildings that undergo thermal

refurbishment. If no collective decision is taken, individual units can still apply for governmental reimbursement of investment costs for partial renovations such as improved glazing. In other countries, low income families in multi-dwelling buildings that undergo major refurbishment may be fully subsidized by the state.

Another type of barrier appears when resource use and related bills are shared among all households, providing no incentive for unit-based efficiency practices. In Brazil, where multi-dwelling buildings typically share one single water meter, this is often the case. By implementing smart and individualized water meters in residential buildings, the city of São Paulo is proving that reduction of water consumption can be attained through simple measures such as issuing individualized water bills.

2.3.6 Skills and training

Deficiencies in the supply of skills and training for green building can function as an important barrier to the development of green building. Report findings confirming this are elaborated in Section 5.

2.4 Policy levers as drivers of green building activity

2.4.1 Introduction

Green building is shaped not just by underlying drivers of change and barriers to change, but by the policy levers that governments use to influence behaviour. As these have a major determining influence on green building activity in each country, it is appropriate to address them in the part of this report that addresses drivers. In this section, policy levers are grouped under four broad categories:

- control and regulatory type of instruments;
- fiscal and financial types of incentives and instruments;
- market-based types of instruments; and
- information and opportunity creation.

This section concludes with Table 2.2, which illustrates the four types of policy lever with country-based examples drawn from the research. It is important to stress that the research was not designed to identify comprehensive lists of

countries using each type of measure, so the examples mentioned should be understood as being representative of practices in a wider range of countries.

2.4.2 Control and regulatory type of instruments

This type of regulatory mechanism specifies the minimum standards or performance levels that buildings or particular components must attain. They are mandatory, and subject to enforcement and compliance, and have the advantage of guaranteeing outcomes and being straightforward to communicate. However, there are significant costs associated with monitoring and enforcement. Moreover, established standards that are not regularly updated according to new cost-effective solutions might hinder innovation or improvements beyond the baseline.

a) Building codes and building regulations

Originally dealing with safety and minimum quality assurance, building codes have evolved to also address energy efficiency of buildings.

Building codes normally apply to all new building (although often with different standards across commercial, residential and industrial categories) but they increasingly also target existing building that undergo renovation. The European Directive on the Energy Performance of Buildings (EPBD) from 2002 (2002/91/EC), for example, was recently recast (2010/31/EU), and this version seeks stricter standards for buildings undergoing renovation.

b) Mandatory building labelling/certification or information disclosure measures

Mandatory schemes to measure and certify characteristics of buildings complement more rigorous building codes. These provide the buyer or tenant with reliable and meaningful information about a building's energy efficiency performance to support informed decision making. They can take this information in account when negotiating price and contractual conditions.

This practice is associated with the EPBD, which requires an energy performance certificate (EPC) to be issued whenever a new building is constructed or an existing one is rented or sold. EPBD recast from 2010 extended requirements to make it compulsory to display the EPC performance indicator when the building or unit is advertised and to include within the certificate indicators for comparison of buildings, recommendations for the cost-effective improvement of the building and an estimate of investment payback (European Commission, 2008).

Australia established a similar scheme for commercial buildings from 2010, under which building owners are required to disclose a Building Energy Efficiency Certificate (BEEC) when selling or leasing a unit of 2000 square meters or more (GBCA, 2010b).

c) Appliances and other (water, waste, acoustics and air quality) standards

Standards applied to specific building systems or associated systems such as appliances can improve energy efficiency in buildings, and may be a first move towards more encompassing regulations.

Waste, water, noise and emissions are closely regulated in many countries during the construction phase, when environmental impacts can cause considerable on-site and off-site disturbance.

Although appliance standards are only indirectly related to building energy efficiency, they are considered particularly cost-effective in reducing energy requirements.

2.4.3 Fiscal and financial types of incentives and instruments

Fiscal and financial instruments are used worldwide to complement environmental regulation. The most common working principle is a price-based mechanism, which endeavours to incorporate external environmental costs and benefits arising from production and consumption activities into services and products prices by means of taxes, charges, subsidies, rebates and preferential loans.

a) Subsidies and tax reductions

Investment subsidies for the end-consumer and, to a lesser extent, tax concessions, are among the financial measures most commonly used worldwide to leverage green building investment.

Some countries surveyed under this research project provide subsidies for residential investment in improved insulation (wall, roof and glazing), improvement or replacement of heating or cooling installations and installation of renewable energy-based systems for water heating or electricity generation. Energy audits may also be subsidized. Subsidies for commercial buildings also exist (such as in Austria) as well as funding for local public authorities willing to implement energy savings improvements in public buildings (such as in the Czech Republic). Subsidies are administrated either under public established funds (such as in

Estonia, Slovenia and Lithuania) or through specific designed programmes and plans (such as in the Czech Republic and Austria).

Tax reductions for green building improvements also exist. In Italy, a 55 per cent tax deduction has been in place since 2007 for expenses related to products and services when retrofitting existing buildings, including replacement of inefficient heating plants and installation of solar thermal systems. Republic of Korea also employs rebates, but on property taxes. Local government allows a five per cent to 15 per cent reduction on purchase and registration taxes, depending on the building's green certification category.

b) Energy and carbon taxes

While taxes on energy and carbon have some impact on the economics of investing in green building projects, research has shown that it is not sufficient to have a major impact (UNEP, 2011). There are two issues:

- the elasticity of investment in retrofitting with respect to energy prices is generally low, so demand does not rise substantially unless energy prices are increased by more than typical carbon tax levels; and
- typical carbon taxes are not high enough to have a major impact on the economics of installing building envelope insulation.

c) Financing

Provision of financing for green building projects addresses up-front cost issues. Many instruments are in place such as referential or soft loans, for example, that have been used in Slovenia and Lithuania.

Grants are also applied in a number of countries. In Japan, the "Eco-Point" scheme is a gift-certificate or pre-paid card made available to promote both the purchase of energy saving home appliances and to increase energy efficiency in new build and renovation projects. The country is also implementing a domestic feed-in tariff programme allowing householders to sell surplus home-generated solar energy for (initially) twice the market price.

2.4.4 Energy efficiency obligations and certificate trading schemes

Certificate trading schemes usually operate under a quantity-based approach, where an acceptable damage threshold is established, for instance for carbon

emissions, and a market is created in which actors involved may trade or exchange the limited number of permits or quotas available (Bräuer et al, 2006). There are some innovative instruments in place aiming at improved energy efficiency which are also applied to the building sector, such as White Certificates and carbon trading.

An example of a market based instrument is the White Certificate in Italy, where an annual energy efficiency target (expressed in tonnes of oil equivalent) is shared between large scale energy distributors supplying 100,000 or more and end-users. Savings have to be confirmed and then a White Certificate is issued, which can be traded among distributors, underpinned by mechanisms established under the country's liberalization of its electricity and gas markets.

A variation on the same theme is an energy efficiency obligation on energy businesses to achieve energy efficiencies among their customers, without the presence of an associated trading mechanism.

2.4.5 Opportunity creation

a) Increasing information and confidence

Diverse initiatives address the imperfect information barrier described earlier. These include:

- information campaigns, conferences, publications and web sites (such as the online BUILD UP platform, aimed at supporting the implementation of the Energy Performance of Buildings Directive (EPBD));[8]
- energy advisery services for building professionals, government and consumers;
- Independent Quality Assurance (QA) services; and
- Voluntary Labelling or Certification schemes.

b) Public procurement

Worldwide, the public sector is a major source of demand; in Europe, public purchases of goods and services are estimated to amount to 16 per cent of the EU's annual GDP (Commission of the European Communities, 2008). The public sector has the potential to influence market changes towards green building by the means of incorporating stricter sustainability criteria just through its own building projects and related procurement and financing.

[8] http://www.buildup.eu/

For example, the city of Vienna, has established an eco-purchasing programme named "Ökokauf Wien" in support of its climate programme to reduce greenhouse gas emissions. It is a compulsory programme involving all departments of the city specifying environmentally sound delivery of products, services and construction.

As noted earlier, the US Government has announced that it will require new federal buildings to be compliant with LEED green building standards in future.

c) Research & development (R&D)

Research and development is important in generating business opportunities that attract a commercial impetus to drive green building forward, and improve the effectiveness and/or cost of green building practices.

Differences in institutional support and corporate structures appear to be behind the variations in success between countries in building industry innovation. A study looking at European countries concludes that three factors are important at the firm level (Miozzo and Dewick, 2002): the structure of ownership and management of contractors; the capacity that firms have to diffuse innovation within their own structures; and the quality of relations between firms and external sources of knowledge such as universities and research centres. It illustrates how in Germany, for example, contractors have supportive institutions such as banks and workers that allow them to engage in long-term research in regard to construction materials. German building firms are also active in promoting the diffusion of innovation through structures such as "competence centres" and are, at the same time, partnering with other firms and research centres to enable learning and knowledge exchange.

Government financial and non-financial support to research and development is also important. For example in Republic of Korea, the development of low energy and environmentally-friendly technologies for the construction sector is an important part of the country's green development plan. Although investment in R&D is still considered low and country reliance in external-generated technology high, advances have been made in new construction materials such as aerogel insulation.

Table 2.2. Examples of policy measures leveraging green building

Policy Measure	Examples of Countries	Examples of Policies
Control and regulatory type of instruments		
Building codes and building regulations	EU countries, Australia, Austria, China, Findland, Germany, India, Singapore, the UK	EU: National legislation in response to EU Directive on Energy Performance of Buildings; unequal levels of implementation Australia: Energy efficiency measures were introduced into the national building code in 2003 allowing for either a performance-based approach compared to a reference building or a prescriptive approach based on requirements for specific subsystems or components Austria: Additional energy efficiency standards and legislation are issued by States and differ from one another China: Building codes and obligatory standards for new building are differentiated by climate zones, over 50 per cent more energy efficiency than standards set in the 1980s; additional provincial and local regulation Finland: Land Use and Building Act of 2000 issues provisions concerning energy efficiency and indoor air quality of buildings Germany: ENEV – Energieeinsparverordnung für Gebäude (Energy saving regulation for new and old buildings) was updated in 2009, sets standards for all buildings (new build and existing buildings if planned retrofitting project includes parts relevant for energy efficiency) as well as standards for low-energy houses, also includes regulation about energy pass for buildings; ENEV is based on ENEG, the energy saving law for buildings India: Voluntary Energy Conservation Building Code established in 2007 will most likely to become mandatory; minimum requirements for building envelope, heating, ventilation and air conditioning (HVAC) and lighting systems Singapore: Code for Environmental Sustainability of Buildings UK: Code for Sustainable Homes 2006 (England and Wales); the Homes and Communities Agency standards (England); Zero Carbon Target from 2016

Policy Measure	Examples of Countries	Examples of Policies
Mandatory labelling/ certification or information disclosure measures	EU countries; Australia, China, Republic of Korea, Singapore	EU: Energy performance certificate (EPC) requirement under the EU Directive on Energy Performance of Buildings Australia: Mandatory Disclosure of Commercial Office Energy Efficiency Scheme, providing the buyer or tenant of a commercial unit of over 2000 square meters with a Building Energy Efficiency Certificate (BEEC) China: The National Energy Building Standard requires new residential building to indicate the energy consumption index and insulation warranty within building documentation Republic of Korea: Mandatory green building certification for new public building and, by 2013; obligatory record of annual energy usage Singapore: Water Efficiency Labeling Scheme (WELS); Singapore Energy Labelling Scheme for air-conditioning
Appliances and other (water, waste and air quality) standards	Australia, Belgium, Brazil, China, Germany, India, Philippines, Republic of Korea	Australia: The Equipment Energy Efficiency Program (E3) Belgium: Standards for boilers and stoves in relation to pollutant emission and yield Brazil: National Programme for Electricity Conservation (PROCEL); ABNT Technical norms for waste management in the construction sector China: Technical standard for the employment of solar water heater systems; Technical standard for the operation and management of air conditioning and ventilation systems Germany: Erneuerbare-Energien-Wärmegesetz (Renewable Energy heating regulation) stipulates that until 2020, 14 per cent of heating needs to come from renewable sources India: Energy labeling for appliances has been wide spread since 2006; in 2008 it was made mandatory for some appliances Philippines: Philippines Efficient Lighting Market Transformation Project (PELMATP), developing standards, policies and guidelines on energy efficient lighting Republic of Korea: The objective is to strengthen standards for window insulation efficiency by 2012

Policy Measure	Examples of Countries	Examples of Policies
Fiscal and financial types of incentives and instruments		
Subsidies and tax reductions	Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Italy, Lithuania, Republic of Korea, Slovenia	Austria: The better the energy efficiency gained through refurbishment, the higher the level of subsidization; additional subsidies available for commercial buildings improving heating systems (installment of heat recovery plants and thermal solar plants, replacement with biomass systems etc) Belgium: Federal tax reduction for energy efficiency improvements and for the installation of renewable energy systems; tax reduction for passive houses (850 euro/year/for 10 years); Flemish region: reduction of advance levy on income derived from real state for low-energy buildings (up to 40 per cent during ten years if the house meets an energy level of E40 at most) Czech Republic: Green Saving Programme, subsidies for residential investment in improved insulation, renewable energy and efficient heating installations; Operation Programme Environment (OPE), subsidies for municipalities to implement energy savings programes in public buildings, sewage and waste management plans Denmark: Establishment of a fund to subsidize refurbishment resulting in increased energy efficiency Estonia: Credit and Export Guarantee Fund (KredEx), subsidies for energy audits France: Subsidies for lowest income groups (in order to combat energy insecurity) Germany: CO_2-Gebäudesanierungsprogramm (programme on CO_2 renovation of buildings), subsidized credits and direct subsidies to investment in energy-efficient renovation, funded by KfW (German Bank of Reconstruction and Development). In 2007 the Bank spent 1,9 Mrd. € on credit subsidies for refurbishing of ca. 83.000 houses/ flats plus investment subsidies for another 5000 flats . It dropped in 2009 to 2,1 Mrd. €, in 2010 to: 1,35 Mrd. €. Italy: Tax deduction of 55 per cent from taxes expenses with regard to selected green building improvements

Policy Measure	Examples of Countries	Examples of Policies
Subsidies and tax reductions (cont.)	Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Italy, Lithuania, Republic of Korea, Slovenia (cont.)	Lithuania: Law on State Aid for the acquisition or rent of housing and renovation, supports renovation work and EE improvements in multi-dweling building; 50 per cent coverage of applicant expenses in producing necessary documentation to apply for governmental loans for renovation if the building is to attain a minimum class of "D" at EE performance
		Republic of Korea: Local government entitles five per cent to 15 per cent reduction on purchase and registration taxes depending on which green certification category the building fits into; under the Green Home 2 million project, subsidies are available to renewable energy equipment purchase for new building and retrofitting
		Slovenia: Eco Fund, energy efficiency and renewable energy investment subsidy for multi-dwelling houses
Energy and Carbon taxes		
Financing	Spain, Estonia, Lithuania, Austria, Bulgaria, Japan, Canada	Austria: Renovation Cheque Action Plan 2011, grants for private individuals undergoing selected building refurbishment measures (costs with acquiring the energy certificate – which is a necessary document for eligibility – are also covered)
		Bulgaria: Ministerial financial assistance for small municipalities for energy efficiency refurbishment of educational institutions infrastructure in 178 municipalities
		Canada: EcoEnergy Retrofit Programme, grants of up to US$ 5.000 to offset the costs of energy-efficiency related improvements
		Estonia: Credit and Export Guarantee Fund (KredEx), co-finance loans for renovation
		Japan: Grants (gift-certificate or pre-paid card) and feed in tariff
		Lithuania: Low interest (up to three per cent annually) and long-term loans (20 years repayment) for renovation in multi-dwelling buildings
		Slovenia: Eco Fund, soft loans, grants and guarantees for green building investments
		Spain: SOLCASA and GEOTCASA Programmes, financing, respectively, solar thermal and geothermal installations

Policy Measure	Examples of Countries	Examples of Policies
Market-based types of instruments		
White Certificates	Italy	Italy: annual energy efficiency target shared among large scale energy distributors
Kyoto Protocol flexible mechanisms (Clean Development Mechanism – CDM, Joint Implementation – JI and International Emissions Trading – IET)	Czech Republic, Japan, Latvia	Czech Republic: IET, emissions trading funding its Green Savings Programme Japan: Tokyo Emissions Trading Scheme Latvia: IET emissions trading funding its Climate Change Financial Instrument
Opportunity creation		
Increasing information and confidence	EU countries, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Czech Republic, Estonia, Finland, Germany, India, Philippines, Singapore, Slovenia	EU countries : BUILD UP initiative to support EU Member in implementing the Energy Performance of Buildings Directive (EPBD) Australia: Green Star Rating Austria: "Klima:aktiv renewable heat" initiative, technical assistance for consumers in evaluating feasibility of solar heat, biomass, heat pumps or a combination of these systems; overall energy advisery services (Lower and Upper Austria); Vienna's building rating system is based on a criteria of social-sustainability, architecture, ecology and economy Belgium: Diverse informative websites and awareness campaigns; development of a life cycle environmental impact assessment system for construction products and materials Brazil: PROCEL Edification voluntary label; Aqua label Bulgaria: Bulgarian Construction Chamber, raise awareness among member companies, elaboration of manual for energy efficiency in renovation of buildings; seminars on energy efficiency Canada: "Green construction in Canada" section within the Construction Sector Council webpage, provides a resource library, discussion forum, best practices directory and information on standards and regulations

Policy Measure	Examples of Countries	Examples of Policies
Increasing information and confidence (cont.)	EU countries, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Czech Republic, Estonia, Finland, Germany, India, Philippines, Singapore, Slovenia (cont.)	China: China Green Building Star Rating System Czech Republic: Low-energy house national competition Czech Republic/ Association of Building Entrepreneurs: International Sustainable Construction Seminary; Sustainable Construction Forum; advisery programmes for energy savings Estonia: Energy Efficiency Consulting Centre; Estonian-Latvian project "Active Through Passive" to increase population awareness on energy efficiency in buildings Finland: As part of its Climate and Energy Strategy, the Ministry of Education has the aim to include energy efficiency in the curricula of educational institutions at all levels by the end of 2011; in partnership with the Ministry of Employment and the Economy, they also aim at ensuring the integration of energy efficiency and energy conservation skills in vocational additional and supplementary training in various fields Germany: Information campaigns funded by Ministry of Education and Research, or Ministry of Environment, for consumers, practitioners, craftspeople, research, policy makers etc. India: LEED-India; Green Rating for Integrated Habitat Assessment (GRIHA), tuned to climatic zones and traditional green techniques within the country Philippines: BERDE (Building for Ecologically Responsive Design Excellence) Singapore: Singapore Green Labelling Scheme (SGLS) Slovenia: Eco Fund tri-monthly green building informative bulletin, technical advice

Policy Measure	Examples of Countries	Examples of Policies
Sustainable public procurement	Austria/Vienna, Finland, Latvia, Slovenia	Austria/Vienna: "action plan for promoting sustainable public procurement" (Ökokauf Wien) Finland: As part of its climate and energy strategy plan for 2010-2020, energy efficiency will be introduced as a central criterion in public procurement by Ministry of Employment and the Economy. Latvia: Environmental criteria in public procurement through which the state and municipalities are able to support green building Slovenia: Green public procurement programme aiming at energy rehabilitation in hospitals and schools
R&D	Germany, Republic of Korea, China	China: Innovation in energy saving technologies is supported by the National 11th Five-Year Plan (the country already leads photovoltaic and wind technologies); ESCOs are also establishing in-house research Germany: Contractor engagement in long-term research of construction materials facilitated by supportive institutions (banks and workers); cultural and supportive institutions allowing for innovation diffusion and partnering for learning and knowledge exchange purposes. Republic of Korea: Direct government investment in R&D and environmentally-friendly technologies for the construction sector (Green Growth Initiative); Green technology portal (GTNET), technology forecast and monitoring

Observation: Elaborated based on primary information generated by the project (constituent survey country responses and case studies). Country examples are illustrative of practices in a wider range of countries.

Source: Authors.

Section
3
Occupations and Skills

3.1 Introduction

New skill needs related to energy efficiency, water management and renewable energies in buildings have already emerged. Many existing occupations will have to be upgraded in terms of skills content. Workers transitioning from traditional construction and from declining sectors will need to be retrained. New emerging occupations will appear in green building.

Early identification of skill needs for green building, and the timely and adequate provision of skills for the future demand, can make an important contribution to the transition to a sustainable economy. Skills shortages and deficiencies are considered a bottleneck constraining the development of green building.

This section identifies and analyses the core occupations in green building. Skill needs associated with these core occupations are also discussed. The findings presented in this section draw on both country level studies in green building undertaken for the research, and a survey of ILO constituents – governments, employers' organizations and worker's organizations.

These core occupations are grouped in six clusters as follows:

- Conceiving, planning, designing and advising occupations;
- Construction, installation, maintenance occupations;
- Controlling occupations;
- Enabling occupations;
- Manufacturing and distribution occupations; and
- Green building clients.

Table 3.1. Core occupations in green building

CONCEIVING, PLANNING, DESIGNING and ADVISING	Construction company managers and business functions		
	Architects and civil/structural/ environmental engineers		
	Architectural technicians and technical drawing specialists		
	HVAC, electrical, mechanical, sanitary, renewable energy and building services engineers/designers		
	Surveyors		
	Energy, water efficiency and waste management analysts, consultants and advisers		
CONSTRUCTION, INSTALLATION, MAINTENANCE	Building site supervisors, site engineers/architects		
	Conservation	Insulation/ weatherization	Bricklayers, carpenters, plasterers, glaziers, masons, foofers, painters/ decorators, as well as semi-skilled occupations that assist.
		Efficient heating & cooling	Plumbers and heating installers/maintainers
			HVAC installers
			Electricians and IT technicians
		Conservation of electric power (other than electric heating & cooling)	Electricians and installers of energy management systems (At domestic level, mostly responsible for helping individual householders to choose energy efficient appliances and lighting technologies)
		Water conservation	Plumbers

CONSTRUCTION, INSTALLATION, MAINTENANCE (cont.)	Building level renewable energy (and high efficiency energy) systems	Heating/cooling	Installers/maintainers of solar thermal systems
			Installers/maintainers of wood pellet and other biomass Heating Systems
			Installers/maintainers of mass heating (large building or district) and combined heat and power (CHP) systems
			Heat pump installers/maintainers
		Electricity	Installers/maintainers of solar photovoltaics (PV)
			Installers/maintainers of small scale wind energy Systems
CONTROLLING	Energy auditors		
	Inspectors, certifiers and quality controllers		
ENABLING	Policy makers		
	Urban planners		
	Financing		
	Educators and information providers		
	Researchers		
MANUFACTURING & DISTRIBUTION	Manufacturers and distributors of green building materials and products		
	IT & system technicians		
GREEN BUILDING CLIENTS	Developers		
	Energy managers, facilities managers and building managers		
	Public servants working in procurement and management of buildings		
	Householders and tenants		

Source: Authors.

The main types of occupation in each cluster are described in Table 3.1. The boundaries between the occupational groups are not rigid. Advice may, for example, also come from people who install a technology or from people in controlling occupations. Construction company managers who are classified as being in the controlling/planning/advising/controlling cluster will often also be involved in project delivery.

3.2 Occupations in conceiving, planning, designing and advising

3.2.1 Introduction

The main types of occupation included under this occupational group are:

- Construction company managers and business functions
- Architects and civil/structural/ environmental engineers
- Architectural technicians/technical drawing specialists
- Building services, HVAC, electrical, mechanical, sanitary, and renewable energy engineers/designers
- Surveyors
- Energy and water efficiency and waste management analysts/consultants/advisers

The activities of conceiving green building projects, planning them, designing them and advising on them are all closely connected and share much in the skills they require. In many cases, they are carried out by the same people. For example, a construction company manager, architect or energy efficiency consultant may work with a client to work out conceptually what will be involved in retrofitting their home or business premises. They may then design the project on their behalf, or advise them on the options, on what the energy savings are most likely to be, and on how to go about hiring a construction company to do the work.

These occupations may also get involved at other points in projects, for example in project management and in quality control.

3.2.2 Construction company managers and business functions

Construction company managers and business functions (such as sustainable procurement managers and sales representatives) play an important role in conceiving

and advising on green building projects. The transformation of the current building sector towards a more sustainable one implies new business opportunities in new areas, where the financial, technical and legal aspects of green building are still unknown by construction company managers.

Whilst the mainstreaming of green building will not increase demand for these professional services, they are important in moving the building sector towards green building. Competencies such as risk management of green building projects, interdisciplinary knowledge, leadership and innovation are essential for them. Understanding market needs with regard to green building will also be crucial for these professionals.

Some existing occupations will need to incorporate green aspects in their content. One clear example comes from Spain where procurement managers/technicians who are responsible for the purchase of products are now facing difficulties in buying environmentally friendly, efficient and recycled products due to a lack of knowledge of life cycle analysis, energy efficiency and recycled materials. Another example of business functions relevant to green building is the sales representative in India who requires a general knowledge of green building and its benefits to be able to convince potential buyers.

3.2.3 Architects and civil/structural/environmental engineers

A set of people likely to benefit in terms of employment are professionals like engineers and architects involved in designing green buildings (UNEP, 2011). The architectural profession has a pivotal role to play in determining how green new buildings will be. Much of the domestic building stock and almost all of the non-domestic stock is planned and designed by architects and civil/structural engineers, with the support of environmental engineers where required. Sometimes they are also involved in the retrofitting of existing buildings.

Country level research shows that architecture is a key occupation in green building and one of the most difficult in which to fill positions with people who have the right skills and knowledge for green building. Development of green building projects will require that architects learn passive design techniques to maximize energy efficiency, such as:

- orientation and layout of the building to reduce/maximize (depending on the weather conditions in the area) the absorption of heat from the sun;
- space allocation to enhance the inflow of daylight;
- the design of the roof to provide overhangs;

- the provision of sun shading devices;
- ventilation; and, more recently,
- wall greenery.

These techniques are especially relevant in emerging economies where large numbers of new buildings are being constructed. Passive techniques, often combined with traditional architecture, that may be well adapted to conditions in the country (in terms of weather, culture, local materials, among other factors), can maximize the efficiency of the building. Typical principles that draw on traditional architecture include climate-responsive design, use of local and sustainable materials, and water harvesting methods.

Architects, civil/structural/environmental engineers should be aware of regulatory frameworks/schemes and certifications for green building.
They should be able to:

- choose materials and building systems based on their environmental and energy cost over the life cycle of the building;
- design systems and facilities of high energy efficiency and renewable energy systems for thermal conditioning and lighting;
- design efficient water management systems (including water harvesting, grey water); and
- estimate the economics of renewable energy projects, including calculating major financial indicators, such as return periods.

Environmental engineers should be able to determine the ecological impact of construction sites, planning green spaces, wildlife corridors and waste management measures in the construction phase of the building.

In some countries with changing weather and climatic patterns, architects will need to introduce innovative solutions more resistant to local conditions. An example is the case of New Orleans in the US, where smart houses have been built that are designed to float if the city floods again (Strietska-Ilina et al, 2011). With regard to soft skills, country level research in some countries, such as India and China, shows a need to strengthen cooperation between architects and engineers. Communication skills, innovation, strategic thinking, leadership, interdisciplinary competences and languages are important for architects and civil / structural engineers.

3.2.4 Architectural technicians/technical srawing specialists

Architectural technicians/technical drawing specialists play an important role in supporting architects and engineers. Skill needs in green building are mostly a subset of the ones that architects require, with more emphasis on preparing detailed plans for green building projects.

In some countries, architectural technicians may also be in charge of managing construction works on site (see building site supervisor/site engineers and architects in Section 3.3).

3.2.5 Building services, HVAC, electrical, mechanical, sanitary, and renewable energy engineers/designers

As a core responsibility for engineers involved in building services is to ensure the efficiency of these, their roles and skills are already generally well aligned with green building objectives. Engineers from a range of professional backgrounds may be involved in building services, including building services engineers, HVAC engineers, electrical engineers, mechanical engineers, sanitary engineers and renewable energy engineers.

Building services, HVAC, electrical, mechanical, sanitary, and renewable energy engineers/designers can have a major impact in reducing energy needs of buildings in the specification and design of a heating and cooling plant, lighting and in the installation of such additions as heat pumps, small-scale combined heat and power system (CHP), solar water heating and photovoltaic systems. Sanitary engineers can also be involved in specifying and designing solar water heating systems and in specifying 'sustainable sanitation' (or 'ecosan') toilet and building water management systems. They are knowledgeable about lifecycle performance of individual components and of the combined installations and therefore able to make calculations and simulations for different combined systems.

In China, for example, the importance of mastering green building software and simulation tools such as Equest, EnergyPlus, ECOTect, is well recognized as they are required to understand green building rating systems and regulations. In some cases, such as in Spain, these professionals are in charge of disseminating the green building knowledge to other colleagues working on the building site.

3.2.6 Surveyor professions

There are a number of different surveyor professions, which vary in role and skills content, and between countries. In most countries, surveyors are concerned with the cost of buildings (such as quantity surveyors in Malaysia, budget analysts in China and cost estimators in India). In many countries, they are also responsible, as 'para-architects', for designing less complex buildings where no architect is involved.

While the roles and skills content associated with these occupations vary, in many cases their skills can be an important factor in enabling green building. For example, a quantity surveyor may be well positioned to advise other construction professionals on how to minimize or eliminate any cost premium associated with a green building project. A surveyor involved in building design will have as much impact on the sustainability of the building as any other building designer. There is, therefore, a need for members of these professions to develop their skills and knowledge of green building technologies, techniques and design approaches.

3.2.7 Energy and water efficiency and waste management analysts, consultants and advisers

Another group of occupations relevant to the conceiving, planning and designing phase of green buildings is energy/water efficiency and waste management analysts/consultants/advisers.

Energy efficiency analyst/assessor is a new occupation for most countries covered by the research. It is particularly important in developed countries with significant retrofitting activity, but is also significant for green building in developing ones.

For example, the private sector in Malaysia has developed the green building index (GBI) specifically for the Malaysian tropical climate and socio-economic context. It is a benchmark for energy efficiency, indoor environmental quality, sustainable site planning and managing, materials, resources and water efficiency and innovation in buildings. A new occupation has been created, the GBI facilitator, whose role is to assemble data and advise the design teams on what should be done for a building to attain a green rating (Ofori et al, forthcoming).

In the developed world, recovery packages, such as the American Recovery and Reinvestment Act (ARRA) of 2009 in the US, have included significant allocations for the weatherization or insulation of existing buildings. Plans such as this generate construction-related jobs, including a requirement for energy efficiency analysts. They measure and assess the current energy performance of

existing buildings. Once the evaluation has been produced, they make suggestions for improvements to energy efficiency including identifying cost-effective energy saving improvements appropriate to the building. They assess the feasibility of introducing renewable energy systems. They also advise design teams on what should be done to comply with current regulations or to achieve a green or energy efficiency rating/certification for a building. Analytical skills and good written and oral communication skills are important. A good understanding of regulations, certifications and schemes designed to support green building is also necessary. Some examples of technical skills required are:

- understanding heating, ventilation, and air conditioning systems;
- knowledge of installation and maintenance of solar thermal/photovoltaic settings;
- energy efficiency of facilities and materials; and
- energy control systems, among others.

In Spain, these analysts and advisers also deal with water efficiency. In some cases, they also assist auditors/inspectors in certifying green buildings and also prepare the necessary paper work for public tenders. In all cases, mathematical skills are important.

Waste management consultants are mainly involved in the design of new buildings, advising design teams on waste management techniques and technologies.

Energy, water efficiency and waste management analysts/consultants/advisers require interdisciplinary skills to work effectively with people in other occupations concerned with green building.

Energy consultants are also referred to as domestic energy assessors (in the UK), energy performance experts (in France) or consumer advisers (in Germany) (Strietska-Ilina et al, 2011).

3.3 Occupations in construction, installation and maintenance

3.3.1 Introduction

Once a green building project is approved for construction work to begin, people with appropriate skills are required to implement it. Green building brings new technologies and techniques to construction. These change the skills required,

although most roles can still be filled by skilled construction trades workers from existing occupations with only a limited amount of additional training.

3.3.2 Building site supervisors/site engineers and architects

Building site supervisors/site engineers and architects are responsible for the management of a building site, where the project is big enough to justify this. Because they have an intimate knowledge of project specifications and are the ones who are present on site, they provide the main bridge between plan and execution. They supervise construction workers and the quality of their work, control the flow of products and materials and communicate with the architects and/or engineers responsible for the project.

Different countries appear to have different qualification and educational requirements for this type of position. Some employ professionals trained as architects and engineers, while others such as Brazil may utilize professionals with no certification but a good practical knowledge of products and processes in the construction phase. For the latter, long-term experience in the building site appears to be a requirement.

The building site or construction supervisor should be capable of overseeing workers in undertaking green building works such as installation of insulation, installing greywater systems, installing efficient heating and air conditioning systems, installing renewable energy systems and the management and recycling of waste materials.

As with many other occupations in green building, interdisciplinary skills are important.

3.3.3 Insulation and weatherization

Insulation and weatherization is an important area of activity in retrofitting of existing buildings for energy efficiency. Occupations involved in installing insulation vary by country. In some, such as the Czech Republic, a new occupation has emerged. There are other countries where insulation work is undertaken by a specific existing occupation, such as in Germany where external insulation work is undertaken by painters. In other countries again, there is no fixed connection between insulation and a specific occupation, but the work is done by people from any of a number of occupations with some additional training. Examples of trades involved in insulation include masons, bricklayers and plasterers.

Some of the insulation-related occupations are described in more detail below:

- *Bricklayers* – In many countries where most housing is built with bricks or blocks, increasing activity in retrofitting will lead to a higher demand for this occupation. The basic activity of bricklaying will not change, but bricklayers may become involved in installing insulation requiring some additional training. A possible exception to the increase in demand is illustrated by the case of the UK where the NHBC is predicting an increase in factory production of house components, which is expected to reduce demand for bricklayers to work on new buildings.

- *Roofers* – The effectiveness of roof or attic insulation is a major contributor to high energy conservation standards in houses (and all buildings of one or two stories). Whilst it is generally in the competence of roofers to install insulation as an integral part of the roof, they may not be skilled in applying advanced technologies such as new insulation products, green roofs, or roof structures capable of carrying solar panels. Increased activity in green building will require that roofers develop skills in areas such as these. Attic insulation work may be undertaken by people from a range of occupational backgrounds.

- *Glaziers* – Windows make a substantial difference to heat gain and loss from buildings, and the choice of windows can make a significant difference to a building's energy efficiency. It is important that glaziers should be able to advise on window choice, and be skilled in installing energy efficient glazing solutions.

- *Insulation installers, dry wall installers and plasterers* – Installing insulation on external walls is one of the main activities in retrofitting of buildings for energy efficiency. In some places, as seen earlier, the work is done by people from a specific occupation, or it is a specific occupation in its own right. In others, it may be done by people from a range of occupations. Dry wall installers may be required to move panels and walls to improve ventilation according to plans. They may also get involved in installing insulation on the interior of a building as an alternative to external wall insulation. Plasterers have a role in finishing insulation work, and in some areas get involved in installing insulation themselves.

  In countries where uninsulated cavity walls or walls constructed from hollow blocks are common, there may be significant activity in installing cavity insulation. As the main content of this work is operating machinery to pump foam or other insulating material into the cavity, the volume of work

required to insulate a building is much less than that for installing insulation on either surface of external walls. As the work does not interfere significantly with existing wall finishes (except for the need to repair holes drilled for access to the cavity), the level of manual skill required is much less than for other forms of wall insulation.

- *Woodworkers* – Increased timber use in building will not of itself improve energy efficiency or improve sustainability of construction. However, depending on the insulation technology used, woodworkers may be involved in activities such as rebuilding fitted furniture or refitting kitchens following the installation of new insulation, or making changes to exterior wooden fittings.
- *Painters and Decorators* – Painters and decorators are frequently involved in retrofitting projects, as many insulation solutions need to be painted. In Germany, painters and decorators install insulation.
- *Electricians, plumber and installers/maintainers of heating and HVAC systems* may also be required to move fixtures.

3.3.4 Plumbers and heating installers/maintainers

The broad area of 'green plumbing' encompasses the occupations of plumbers and heating installers/maintainers. It focuses particularly on installing efficient heating systems, making existing heating systems more efficient, using water more efficiently and installing solar water heating systems. This can be extended to cover rainwater harvesting, the use of grey water (any household wastewater with the exception of toilet water), the installation of heat pumps using geothermal or inertial ground temperature, and biomass heating systems.

Ecological or green sanitation comprises well-controlled sanitation systems with multiple objectives: reducing water use, improving health and environmental quality and promoting nutrient recycling. It is based on four building blocks: source-separation, containment, sanitization and recycling. Urine and faeces can be separately collected and stored to make the most out of nutrient recycling. These sanitation systems are of two main types: dehydration (chemical) or decomposition (biological). Faeces containing a high organic content will decompose can be used as humus to improve soil. Urine, which is rich in nitrogen, phosphorus and potassium, can be a valuable plant fertilizer.

All of these are important advances in green building. In terms of skills and competences, however, they have only diffused to a small percentage of the plumbing workforce across the countries studied.

Green plumbing initiatives have emerged in Australia (with these extending to New Zealand and North America), China and the US where accreditation schemes have been established. The plumbing trade needs to be sensitized to green advances in plumbing with the upgrading of skills. Should there be increasing demand for such green technologies as solar water heaters and heat pumps an increase in the number of plumbers required is likely.

Separate trades may emerge (most probably in some countries where weather and natural conditions are favourable) focusing on installation of each of the following new technologies: installer/maintainer of solar thermal systems (in countries like Spain, the US, Brazil, Slovenia, Cyprus, India, Singapore, Republic of Korea, Italy), heat pump installers/maintainers (in countries like Slovenia or Japan) and biomass heating systems installers/maintainers.

3.3.5 HVAC installers

HVAC (heating, ventilation and air conditioning) installers need backgrounds in electrics, in plumbing, and in installation of ducting. Specialized knowledge includes an understanding of temperature and humidity, and the ability to make relevant measurements. The installer should be able to perform load calculations, measure airflow, and do full commissioning and maintenance work following installation.

These occupations install the whole HVAC system which, owing to technology differences may require different skills set from the ones of heating systems installers in houses. A good example is in the US, where HVAC installers are trained to install systems in big commercial centres. In New York, HVAC apprentice technicians are crucial to retrofit work because the upgrading and replacement of these systems is often the centrepiece of a retrofit project and makes the greatest contribution to reducing energy use. Knowledge of energy efficiency standards for equipment and green building standards (such as LEED and others) is valuable.

3.3.6 Electricians and IT technicians

Electricians have important roles in green building, having the main responsibility for installing a range of new technologies, and being involved in installing the supplies of electric power and the control systems required for others.

There are many innovations that can be applied through specification and the installation of new electrical technologies, ranging from choice of light

bulbs to motion-sensor light switching, and other electricity-saving devices to smart meters.

Electricians may also be required to install the electrical parts of plumbing systems (electric water heating, heat pumps, small-scale CHP (combined heat and power) systems) including controls. In the case of larger buildings, controls can be complex and require specialist IT technicians to install them.

There is evidence of a new occupation in installation and maintenance of photovoltaic systems emerging in several countries, which undertakes both structural work and electrical work associated with the installation, as noted later.

The term 'green electrician' has not achieved currency similar to that of 'green plumber' but has been applied to electricians involved in installing solar photovoltaic systems.

3.3.7 Installers/maintainers of solar thermal systems

The installer/maintainer of solar thermal systems is responsible for the installation and maintenance of solar thermal systems of hot water production, mainly in buildings and swimming pools. Demand for these occupations is higher in countries where weather conditions are good enough, and latitudes are low enough to make the technology a reasonably reliable source of heat.

Examples include Australia, Spain and Brazil, which have policies favouring the installation of solar thermal systems. The installer of solar thermal technologies is responsible for placing the structure of the panels in the right place and at the correct angle to maximize solar gain throughout the year. This implies a basic understanding of mathematics and physics to make the necessary calculations.

Once the structure is fixed to the exterior of the building, these workers make the necessary connections with the interior plumbing system. A base of skills in plumbing is therefore also essential. In some cases, they also have to install circuits and electrical equipment including controls for solar heating, which requires electrical knowledge. Alternatively, electricians with an understanding of solar thermal systems can do this part of the installation.

Installers may also be responsible of the maintenance of the system, but in some cases, optimizing solar thermal systems to maximize efficiency requires additional training. The importance of preventive maintenance was raised by experts interviewed in Spain. The aim is to reduce potential problems that will appear while using the technology. The client should be instructed on efficient and safe use of the system. Good communication skills are therefore necessary.

Counselling and marketing skills are also very relevant for this occupation. These workers should be able to advise the client on the best solution, and in some cases sell particular products.

3.3.8 Installers/maintainers of wood pellet and other biomass heating systems

Skills for installers/maintainers of wood pellet and other biomass heating systems are centred on traditional plumbing skills, and supplemented by knowledge of the characteristics of biofuels, the ability to calculate heat loads, and an understanding of relevant legislation and regulations. For example, it is very important for them to understand and determine moisture content, calorific value, bulk density and energy potential of biofuels. It is also important to have knowledge of locally available fuel supplies, including types of fuel, suppliers and pricing.[9]

3.3.9 Heat pump installers/maintainers

Heat pumps are a technology that draws heat from geothermal sources. They can be used in most locations, but are most effective at geothermal hotspots. Heat pump installers/maintainers require a background in plumbing, drilling, geology and basic construction, with some knowledge of electrics. Specific knowledge includes understanding of the available technologies and their various ratings schemes, knowledge of under floor heating, soil classification, rock classification as related to thermal conductivity, drawing site plans, copper pipe work, above ground pressure pipe work, plus commissioning, testing, and maintenance.[10]

3.3.10 Installers/maintainers of mass heating (large building or district) and combined heat and Power (CHP) systems

While many green building skills requirements are quite generic, the main capital equipment in mass heating and combined heat and power systems is typically

[9] From industry associations , university course lists, vocational institutes, job postings, and biomass heating system firms.

[10] From the EU Certified Heat Pump Installer programme, private industry, and vocational institute course listings.

installed by the supplier, which can take responsibility for developing the specific skills required.

Installation of these systems also requires people skilled in plumbing and/or heating installation, who may need some additional training.

3.3.11 Installers and maintainers of photovoltaic solar systems

Installers and maintainers of photovoltaic solar systems need a foundation in electrical systems as well as basic construction and mechanical skills to do their work. The installer is responsible for identifying a suitable location for solar photovoltaic panels, installing the m at the place chosen, and making the necessary indoor connections. They perform the maintenance of the installation according to code requirements for photovoltaic installations. They also take responsibility for preventive maintenance.

Skills in health and safety at work are important for these workers, since much of their work is done on roofs. As in the case of solar thermal, photovoltaic installers/maintainers need to explain the operation of the installation, and how to ensure the best performance and basic maintenance to the user.

If there is a smart meter present that will allow surplus electricity to be fed to the grid, the installer needs an understanding of what is required to connect to it, even if the final connection may be made by someone else.

3.3.12 Installers/maintainers of small-scale wind energy systems

Installers/maintainers of small-scale wind energy systems should have a background in electrics and general construction. Skills specific to a wind energy system installer include: understanding of wind turbine placement, wind speeds, turbulence, and knowledge of any regulations on wind turbine design or construction. For example there is a need for these workers to be able to read topographic maps and aerial photographs, and select appropriate anchor types based on soil type. It is also important that they should be computer literate, understand wind speed calculators, be able to estimate electrical load and energy use, and be able to make the necessary connections using appropriate standards appropriate to the electrical tension (NABCEP, 2010).

If there is a smart meter present that will allow surplus electricity to be fed to the grid, the installer needs an understanding of what is required to connect to it, even if the final connection may be made by someone else.

3.3.13 Installers/maintainers of complex systems for buildings

There is a considerable amount of innovation underway in technological systems to improve the energy efficiency of buildings. Much of this technology is proprietary, and optimal installation of a particular type of system requires skills and knowledge that are specific to the technology. In many cases, only people employed by the supplier and by approved distribution partners have access to the training required to undertake the installation to a reliably high standard and to provide reliable ongoing maintenance services. Access to approved training in these skills is in many cases effectively restricted to those working in distribution channels approved and overseen by the supplier of the technology.

Such proprietary technologies with limits on skill diffusion are particularly an issue for larger buildings, whether commercial or multi-unit residential; smaller buildings with less complex building management challenges are more likely to be suited to mass-market solutions for which suppliers have an interest in diffusing skills as widely as possible. However, the issue is not limited to large buildings, access to training in some of the skills required for larger-scale installations at domestic level, in areas such as solar heating and ground pumps, may also be controlled by the supplier of the technology.

Workers involved in installing and maintaining these systems may acquire all the relevant skills wholly through the supplier of the technology. However, in most countries, they are more likely to acquire skills in installing simpler systems (in areas such as plumbing, electrics and controls) through apprenticeships or vocational education and training, and to layer specialist skills on top of those basic skills through training provided or approved by the supplier of the technology.

As building systems become more complex, the extent to which technology suppliers control access to the training required to work on installing and maintaining building systems technology appears to be increasing.

3.3.14 Issue cross-cutting across occupations

One consequence of the emergence of jobs focused on the installation of specific technologies is that in many cases people in these roles acquire skills that cross traditional occupational boundaries. Rather than needing to deploy people from several different occupations on a job, as well as deploy someone to coordinate their work, the work may be done by teams whose members have multiple skills, or by multiskilled individuals.

3.4 Occupations in Controlling

3.4.1 Introduction

Occupations in controlling are important to the development of green building. It is necessary that householders, businesses, governments providing finance and others with an interest in the energy efficiency and sustainability of a building should be able to be confident that the information they have on energy performance is accurate, that green building measures proposed make sense, and that they are carried out to a high standard. If they do not have this confidence, they are much less likely to invest or make informed decisions.

3.4.2 Energy auditors

As in the case of energy efficient analyst/consultants, this is a relatively new profession concerned with identifying building energy consumption profiles. The occupation is usually associated with an audit process that leads to the issuance of an energy consumption certificate.

In many European countries, activity in energy auditing is associated with building energy sating systems implemented in response to EU directives such as 2002/91/EU and 2006/32/EU and to national energy saving plans. In some countries specific occupations might be associated with the same or a similar assignment, such as home energy raters in the US and chimney sweepers in Germany.

The latter occupation is responsible for verifying emissions and keeping an appropriate level of energy consumption of heating and ventilation systems through the cleaning and monitoring of chimneys. They usually carry out energy measurements themselves or supervise subcontracted workers. They also suggest ways to optimize existing systems, and identify measures for efficient energy use. Knowledge of thermodynamics and heating installations is important.

Energy auditors need the skills to make technical and economic comparisons across conventional and green solutions and between different green solutions. They need to understand energy certification schemes in their countries, and master the procedures for obtaining certification.

The workforce composed of energy consultants or auditors is mostly drawn from established occupations at professional and skilled manual levels, such as civil engineers, architects, and craftspeople including: carpenters, masons, plumbers, building surveyors, heating installers, roofers, electricians and others, combined with long experience of building construction (Strietska-Ilina et al, 2011).

3.4.3 Inspectors, certifiers and quality controllers

Inspectors, certifiers and quality controllers in green building check that that works are carried out in conformance with standards, regulations and/or project specifications. Depending on their specific role, they may issue certifications.

For example, Green Star Assessors in Australia certify projects as per industry and government regulations. A good grasp of legislation at the international, national, regional and local level is fundamental.

People in these occupations may work for local and regional governments (directly or through a contracted service) or for independent green building certification schemes (such as BREEAM or LEED). They may also work for other types of organization involved in promoting green building, such as Energy Services Companies (ESCOs), or energy supply businesses that get involved because they are subject to energy efficiency obligations. ESCOs contract to carry out energy efficiency works for other organizations, in return for a share of the resulting energy savings.

3.5 Enabling occupations

3.5.1 Introduction

Occupations in education, research, financing and policy making are grouped together as enabling occupations that play important roles in supporting the development of green building.

3.5.2 Policy makers

Policy makers at all levels (local, regional, national and international level) are key actors in driving green building forward, sometimes through government-led initiatives, and other times through public-private partnerships.

As seen earlier, the design of a policy is a major factor affecting the adoption of green building. Choices and trade-offs to be made are complex. It is important that policy makers involved in making them should have a very good understanding of the environmental, social, behavioural and economic issues involved, and should have the analytic capabilities required to develop, and advise, governments on coherent and effective policies.

As many of the important policy choices to be made in developed countries are about financing of retrofitting projects, it is also important that they have a good understanding of relevant aspects of finance.

3.5.3 Urban planners

Urban planners design, promote and administer government plans and policies affecting land use, zoning, public utilities, community facilities, housing, and transportation. Land development can be regulated through planning guidelines and through factors relevant to green building, such as spatial form, density, building types, and so on.

In many cases, urban planners are also involved in enforcement of planning and building regulations and decisions. Where there are policies favouring green building, they may be in a position to guide people working in conceiving planning and designing new buildings and building renovations.

Country level research, from example for China, reports that these interventions are important in ensuring that building development meets the required standards for green building.

Urban planners should assess the feasibility of proposals and identify necessary changes according to the initially planned project or regulations that might incorporate green building criteria. To do this, urban planners must be well informed about economic and legal issues involved in zoning codes, building codes, and environmental regulations with regard to green building. General green building knowledge and interdisciplinary skills are very relevant as they also coordinate work with economic consultants and architects as plans are formulated and buildings are designed.

3.5.4 Educators

Educators (from university professors and teachers in TVET, to professional associations and private training providers) and people involved in disseminating information and raising awareness are important occupations for fostering green building.

Providing training for trainers in energy and other resources efficiency and renewable energies in buildings is considered a key measure in countries such as France for a smooth transition to a low carbon economy.

For example:

- The INES (Institute of Solar Energy) in France prepares trainers for the use of solar energy;
- Some training centres, such as CENIFER in Spain, have developed training programmes on energy efficiency and energy management in buildings

In some cases construction company managers and policy makers are involved in providing training in business schools.

At universities, professors involved in research on green building or professors being members of green building associations are the ones providing the training. Personal interest, environmental awareness, innovation and leadership are some of their most important soft skills.

In many cases, engineers and energy efficient analysts train construction teams (such as electricians, bricklayers, plumbers, HVAC technicians) before starting green building works.

Environmental awareness and information about availability of green solutions, financing options and environmental as well as economic benefits of implementing them is very important. There is a general deficiency in understanding of sustainable building, from developers to final consumers.

Awareness and information campaigns play an important role in addressing this challenge.

3.5.5 Researchers

There is still much to be done in the area of research for green building. Technologies that give higher performance at lower costs, sustainable building materials, the most favourable technologies depending on climatic conditions, and new passive techniques combined with traditional architecture are some of the areas where researchers will need to continue to make progress. There is a great need for researchers to work in these and other areas. Many of the key questions in green building require skills and knowledge from several disciplines, such as engineering, economics, materials science and business, and so effective research requires interdisciplinary skills or joint efforts of research teams with different backgrounds.

3.5.6 Financing related occupations

People in finance related occupations may be involved in the granting of loans for retrofitting or the construction of new green buildings. These people have a

financial background but, in many cases, have an inadequate understanding of economic and financial evaluation aspects of green building projects. For example, in Brazil, financial agencies funding building construction are expected in the future to have sustainability experts among its staff who understand about sustainable materials and procedures in green building.

People with financial skills are also required to inform policy making on retrofitting, much of which focuses on choices between alternative models to provide finance for householders to undertake retrofitting projects.

3.6 Occupations in manufacture and distribution of green building materials and products

While the manufacture of green building materials and products is an important part of green building, the types of manufacture are so diverse that there is little if any cross-cutting consistency in their skills requirements.

There is more consistency in the case of distribution of green building materials and products, where customer facing employees need skills in advising on the application of green building products and materials.

3.7 Green building clients

3.7.1 Introduction

The skills of clients (and potential clients) are among the key factors impacting on the uptake of green building projects.

3.7.2 Developers

The Developers of green building projects include managers and other decision-makers both in the private sector (more important for housing and commercial buildings) and in government (more important for public buildings) who take decisions with respect to how new buildings are built and how renovations of existing buildings are designed. Whilst this may involve green skills in the sense of knowing what is and is not green, what is more important is that

it requires developers to have skills to orient architects and contractors towards greener building. They need a good understanding of the value of green building, including understanding the value of energy and water savings, and of any benefits that green construction may have in rental returns and resale value.

Whilst it is unlikely that there will be increased demand for their services because of mainstreaming green building, developers are important in determining what green skills will be required downstream.

The UK National House-Building Council has a model whereby developers can be sensitized in green building and encouraged to specify green buildings when engaging architects and their own internal designers.

3.7.3 Energy/facilities/building managers

Energy efficiency is becoming a higher priority, both as a means of cutting costs, and as a response to environmental priorities.

Energy management has emerged as a new management specialization, with energy managers being employed by many businesses whose spenditure on energy is large enough to justify this.

Facilities management and building management are existing occupations that are also concerned with the efficient operation of buildings. As efficiency in buildings becomes more important as a business issue, in many cases their roles are growing from being concerned mainly with day to day building operations and maintenance, to also taking a significant role in improving energy efficiency and reducing operating costs.

These changing roles require higher levels of skill and knowledge than have traditionally been required in these occupations, so that facilities managers and building managers can pursue the "quick wins" on energy efficiency that are available in many large buildings with very limited investment, as well as propose and champion larger scale investments with greater paybacks in reduced energy consumption and improved building utility.

3.7.4 Public servants working in procurement and management of buildings

Many governments are seeking to provide an example to their society by introducing green concepts into public buildings. Governments giving priority to sustainability in public buildings drive green building forward, and generate

opportunities for businesses focussed on green building. This is in the context that many governments also have broader green procurement initiatives, designed to limit the environmental impact of their purchases of goods and services.

Doing this effectively requires that public servants working in procurement of green buildings require skills and expertise in specifying green building requirements, evaluating bids made against these, and assessing works and buildings provided against these bids. They should also be able to carry out economic and environmental evaluations of green building projects and purchases. While they may be able to delegate much of the technical work to professional specialists, they will still require significant skills and expertise.

Partly as a means of supporting green procurement, and partly in support of broader sustainability initiatives, significant numbers of public servants are likely to require skills in carbon accounting.

3.7.5 Householders and tenants

Householders and tenants are important as clients for green building services and as operators of residential property whose actions affect how sustainable the building is in operation. In many countries, little information on the cost of renewable and energy efficient technologies is available to householders. Information on financial mechanisms that aim to foster the implementation of green building technologies may also be difficult to access. Many consumers think that sustainable buildings are more expensive, and in some cases not as attractive, as regular ones. An understanding of green building makes it more likely that a householder will consider retrofitting, or that a tenant will encourage their landlord to retrofit or even undertake basic retrofitting works themselves.

Knowledge of green building also reduces the information asymmetries between householders and providers of retrofitting services, reducing the scope of principal-agent barriers to adoption. A householder that can understand and evaluate a retrofitting design, and can contribute to supervising the works, is more likely to be confident in commissioning retrofitting works. They may also be more confident in buying a new home built to a sustainability standard.

Just as energy managers, building managers and facilities managers influence building sustainability through the operational choices they make, householders and tenants also affect building sustainability through their building management decisions.

Very sophisticated technologies are being developed for householders and tenants to better monitor and report their own electricity usage, being able to

increase or decrease the usage by remote control. Many machines have timers and can already be manually programmed to run during off-peak hours (Yudelson and Breunig, 2011). These appliances may be complicated to understand and manage. It is therefore important that householders and tenants understand how to use them, how to avoid maintenance problems and how to make the most of the technologies.

Energy performance certificates are a fast emerging trend in Europe and the US. When property is sold, new owners and tenants are entitled to information about building energy performance (Yudelson and Breunig, 2011). Access to this information will allow potential buyers and tenants to compare better compare properties and to make informed decisions on their new acquisition, including energy consumption as a new criterion.

Many landlords consider only the initial price of retrofitting work, and are not concerned with savings on energy bills, or with improving comfort. The split incentives issue between landlords and tenants, on who pays for the retrofit and who benefits from lower energy bills, makes this issue more difficult. The landlord needs to have an understanding of the impact of a retrofit on the value of the property and on rental returns.

3.8 The downside of skills weaknesses

In green building, as in every other area of economic activity, strong skills are important to the ability of businesses and workers to carry out their work effectively and efficiently. It appears from the research that it is not unusual for things to go badly wrong on a green building project because of skills deficiencies.

It seems helpful to describe some of the problems seen from the research, both so as to caution about specific hazards to be avoided, and so as to reinforce the more general point that well designed investments in skills for green building are likely to provide a good social return on investment.

3.8.1 Poor quality installation

Evidence from the research shows that problems with poor quality installation of green building technologies are not unusual. If the problem is found in time, the main consequences are a significant cost to the installer who is required to rectify it, and perhaps a delay to the overall project while the rework is undertaken.

If the problem is not found in time, or is not found at all, the consequence may be that the technology underperforms badly. Some examples are:

- problems with insulation may lead to higher heating and cooling costs than planned, higher carbon emissions and lower comfort;
- problems with renewable energy systems can result in a lower energy yield of useful energy than planned, this makes the technology less economically viable, reduces its impact on carbon emissions, and may shift the lifecycle impact on carbon emissions against the technology; and
- problems with the design of heating and cooling systems, and with building environmental controls, can cause them to consume more energy than necessary, resulting in higher carbon emissions than necessary, while at the same time compromising comfort.

In general, the root causes of these problems are deficiencies in skills and deficiencies in the quality assurance processes that are required to ensure that workers on green building projects apply their skills to their best advantage.

There is not much quantitative evidence as to the scale of these problems, but they appear as such a frequent theme in the literature and among people interviewed for the study that it is evident that they must be widespread.

3.8.2 Health and safety hazards among green building workers

Building is a relatively dangerous industry, and for this reason most developed and developing countries place a heavy emphasis on training for health and safety. In some countries, it is illegal to employ people to work in construction who do not have the required training in this area. Problems with health and safety tend to be greater where there is a significant informal construction sector, where workers may have missed out on training required to work in the formal sector.

However, even where health and safety training is obligatory, green building work can expose workers to hazards that are unfamiliar, and for which they are not well prepared. There is a particular issue with workers moving to a very different area of construction – such as from large well supervised building sites to retrofitting work on residential property.

Examples of hazards include:

- installers of solar panels (photovoltaic or heating) working on roofs at risk of falling;

- installers of various types of insulation working on ladders or scaffolding at risk of falling;
- fixing insulation to walls, rafters or other structures that may carry electric cabling, risking electrocution; and
- exposure to extremes of heat in attic spaces in hot countries causing a risk of heat exhaustion.

3.8.3 Home Insulation Programme (Australia)

The Australian Home Insulation Programme provides a useful cautionary example which has been documented well. As many of the issues that the implementation of the programme raised have a much wider relevance for green building globally and particularly for retrofitting, we should be grateful to the Australian government for enabling others to learn from its experiences. The description here is based on the Hawke Report commissioned by the government (Hawke, 2010).

The Home Insulation Programme focused on providing subsidies for the installation of ceiling insulation, which is estimated to cut household energy bills by an average of 40 per cent in the Australian context.

It was already known that there were risks with insulation. Working in attic spaces has inherent work safety hazards. Inspection of 1,000 earlier installations of foil insulation in the state of Queensland had found electrical safety issues in 20 per cent of cases. Over 80 fires per year in Australia were associated with insulation before the start of the programme.[11]

As the programme was intended both as a stimulus measure and as a means to improve energy efficiency, it was rolled out quickly. Take up was much faster than anticipated, peaking at almost 180,000 installations per month. Oversight of quality was largely left to state level regulators.

The programme was launched in July 2009 and largely delivered on its objectives in terms of economic stimulus and improving energy efficiency. However, it was discontinued (after a number of interim changes) in February 2010. During its operation, three installers died of electrocution (or suspected electrocution) and one of heat exhaustion.[12] A number of fires were also reported. Aside from safety issues, other questions were raised that cast doubt on the energy saving

[11] For context, installing the insulation typically involved stapling insulation panels in place. The staples could go through electric wires running through the attic space if due care was not taken, which could result in foil insulation being electrically live.

[12] The report does not attribute responsibility for these deaths.

effectiveness of the installations of insulation at many homes. A post-HIP inspection regime was expected to cover 50,000 houses with foil insulation and 150,000 with non-foil insulation. A very substantial volume of rework was expected to be required, including measures to ensure the safety of all installations of foil insulation that could include removal of insulation or the installation of a safety switch.

Initially, to register to take part in the programme, businesses had to declare that job supervisors had formal trade competencies or long-term experience in the sector. Individual workers were required to have completed occupational health and safety training. A national training package for insulation was developed and provided to registered contractors, but training in installing insulation was only due to become a requirement for all installers as of February 2010, when the programme was shut down.

While deficiencies in regulation, rapid growth in activity and noncompliance by some contractors were among the key problems with the operation of the programme, on the job these were reflected in inadequate training and skills deficiencies. A great many of those working in installing insulation had limited skills and training, and little or no prior construction industry experience.

Section

4 Skills Response

4.1 Introduction

The economic crisis that started around 2008 severely hit the construction sector over much of the world, and has led to high levels of unemployment in this sector in many countries.

At the same time, demand for workers in retrofitting and new green construction is increasing. This demand should continue to grow over the coming years, as governments seek to bring emissions of greenhouse gasses under control, as green building technologies and techniques mature, and indeed as many governments seek to boost employment in construction.

Governments are establishing policies, financial incentives, regulations, and schemes to move the green building sector forward, but in most cases these initiatives lack a training component. Lack of skills is considered a bottleneck for sector growth, so adequacy of training provision is vital for success. A well trained workforce is needed in green building, as well as a general understanding of green building concepts in the society as a whole. In Section 3, we saw that there are many areas of new skill needs, across many occupations and in different degrees, associated with green building. Training systems in countries have already started to react to these needs, although there is still a long way to go.

This section describes the current training response in green building. It explains the main skills responses for each occupational cluster identified in Section 3 (see Table 4.1) and illustrates what countries are doing with examples. Some training programmes do not target only one group of occupations, but rather have a cross cutting effect. These have been included in the most relevant section.

Finally, this section highlights some aspects of institutional set-ups in providing training for green building.

Table 4.1. Main skills responses in green building

Clusters of Occupations in Green Building	Main Skills Responses
Conceiving, planning, designing and advising	University degrees
	Specialized masters and other forms of continuing training in energy efficiency, building codes and energy certification
	Training offered by professional associations
	Continuing Professional Development (CDP) requirements Professional CPD requirements
	In company training
	Certification institutions
Construction, installation and maintenance	Adaptation of TVET courses/new TVET courses
	Formal apprenticeship system
	Continuing training ... offered by industry associations and workers' organizations
	In company training
	Active labour market training policies for unemployed
	Entry-level training by not-for-profit organizations
Controlling	University courses (degrees and continuing training)
	Technical education complemented by certified working experience
	Training and examination related to certification
Enabling proccupations	Training for teachers
	Higher education for urban planners
	Training for policy makers and finance professionals
Manufacturing and distribution	Same experiences as in manufacturing for other sectors
Green building clients	Courses in green procurement
	Information campaigns
	Higher education in energy management

Source: Authors.

4.2 Skills responses in conceiving, planning and designing

4.2.1 University degrees

Traditional academic curricula at university level, in general, have not covered green building. However, universities all over the world are gradually adapting their curricula to meet the increasing demand for professionals in green building. Universities such as Riga Technical University in Latvia have integrated principles of green building into the basic courses for architects and engineers.

Some other universities have opted for the creation of new modules, subjects and electives.

- In Italy, environmental design is now compulsory in some colleges of architecture in the first years.
- In Slovenia, technical modules such as energy efficiency have been introduced in the energy industry subject of mechanical engineering.
- In Brazil, electives such as Sustainable Construction and Thermal Performance of Buildings have been made available for students of civil engineering.

Some universities have gone further and consider that the combination of a number of electives or other mechanisms can lead to a specialization in green building. In Denmark for example, bachelors students in Architectural Technology and Construction Management can specialize in Energy Efficient Sustainable Design and Construction through their studies by means of accomplishing around 70 European Credit Transfer and Accumulation System (ECTS) credits in elective topics related to green building, during their compulsory company internship or by choosing a dissertation topic related to green building.

Although some degrees exist, specializations in green building are rather rare and green building aspects are generally not embedded in the content of all relevant university degrees and diplomas. Survey responses from some countries say that these developments in green building are important, but that available training is sometimes too general and not technical enough for graduates to apply the knowledge acquired in their professional life. Students wanting to develop their careers in green building have to supplement their diplomas with specialized master's degrees, post-graduate degrees or other types of continuing training.

Intelligent Energy Europe has supported a review of the state of the art in environmental sustainability in academic architecture courses (EDUCATE, 2010b), as well as the development of a Framework on Curriculum Development focused on integrating sustainability into architecture courses (EDUCATE,

2010). The review is based on a detailed analysis of courses in architecture at 52 universities in 22 EU countries and ten courses in seven countries from outside the EU.

4.2.2 Specialized masters and other forms of continuing training in energy efficiency, building codes and energy certification

There is an increasingly wide (but still in development) range of specialized masters, post-graduate training programmes and continuing education courses in high demand by professionals of the industry and university students that want to specialize in green building. The length of these courses is variable and depends on the degree of specialization that is aimed to be achieved. The topics are numerous and the target groups and teaching techniques also vary (see table 4.2).

Some post-university courses target graduates in architecture and engineering without professional experience. An example is the National University of Singapore that has two masters courses relevant to green building: the Building Performance and Sustainability programme and the Integrated Sustainable Design programme. In other cases, courses are designed for professionals already working in the construction sector, such as with masters courses in management of green building companies that are emerging in Europe and Latin America. At least three years of professional experience is typically required for entry. The main objective of these programmes is to provide directors and managers with a global strategic vision of companies' management in green building. The students will be able to contribute to the necessary transformation of the current model of construction with a new approach towards a more sustainable and efficient model of running construction firms and undertaking green building projects.

Technical and management programmes and masters are not restricted to developed economies. Emerging economies also provide some: in India, for example; the TERI University offers M.B.A. programmes in infrastructure and in business sustainability. Also in India, a short-term course on IT for Intelligent and Green Building Design introduces various aspects of intelligent building and energy efficient building design. In Brazil, the post-graduate course in Sustainable Construction Management, offered by the Catholic University of Salvador (UCSAL) in Bahia, targets engineers, architects, designers and planners. It aims to improve design skills, with a focus on sustainability issues. Also in Brazil, masters in architecture, design and environment, offered by the post-graduate programme in Architecture and Urbanism from the Federal University of Rio

Grande do Norte (UFRN) aims to enhance skills related to sustainability, environmental comfort, energy efficiency, accessibility and safety of buildings.

Some training courses are provided by private training centres (for example in Cyprus) focused on updating the knowledge of new building technologies and techniques among higher level occupations in green building such as architects and civil and mechanical engineers.

Learning techniques are comparable to those used in other disciplines. They combine on-line and classroom learning. Regarding contents, some courses include a first foundation block on topics such as electrical engineering, automation and electronics, environmental aspects, economic analysis, fuels and processes, and thermodynamics. This kind of introductory material on cross cutting subjects provides the student with a multidisciplinary education and a better understanding of green building.

Many public and private institutions provide specific training for architects, engineers and other professionals on building codes, certifications and rating systems of green buildings. These are typically courses of short duration. The common objective is to give the professional the tools and knowledge required to be able to achieve a better energy performance of the building in compliance with regulations.

Green building councils (GBCs) all over the world are playing an important role in this area. In the Philippines, the PHILGBC) trained the first set of Building for Ecologically Responsive Design Excellence (BERDE) qualified professionals and assessors in early 2011. In Australia, the Green Building Council Australia through its Green Star Retail Centre and Green Star Multi Unit Residential courses informs professionals about Green Star certification, how it is applied to retail centres and multi unit residential facilities, and how to achieve the targeted Green Star rating. In Japan, the JaGBC provides training to Comprehensive Assessment System for Built Enviornment Efficiency (CASBEE) assessors, as well as training to "specialist engineers" who plan to use CASBEE in their projects. In Spain, the GBCe offers a certified evaluator course that covers energy certification tools used in buildings such as BERDE and LEED. Similar courses exist for the various other GBCs. These training courses appear successful, as the number of certified assessors, professionals, and associates across countries continues to grow. However, as skilled manual occupations are not in amongst those mainly targeted by these training programmes, the courses mostly impact professional and management occupational levels.

Other councils have expanded their offer and have also created management studies such as the MBA in Sustainable Construction offered by the Brazilian Green Building Council. The GBCe in Spain is now developing curricula for green building practitioners.

Table 4.2. Examples of masters and other post university level programmes

Name	Country	Training provider	Duration	Contents	Target group
Masters in Integration of renewable energy in architecture	Spain	Polytechnic University of Catalonia (UPC)	450 hours	• Energy and comfort in buildings • Urban environment and energy • Urban environment information and new technologies • Renewable energy in architecture • Energy control in architecture	Architects and engineers who wish to obtain a higher degree of specialization in the application of renewable energies in architecture.
Executive MBA in Construction and infrastructure. towards green building	Spain	EOI Business School	720 hours	• Business management administration • Risk management, quality and environment • Sustainability, efficiency of materials and new business opportunities • Urban planning • Technical, financial and legal aspects of the operation of infrastructures • Environmental services management	Directors and managers of construction companies
International German-Malaysian Master in Green building energy & management	Germany and Malaysia	University of Applied Sciences Rosenheim and Universiti Kuala Lumpur	4 semesters	• Mathematics & science • Materials & construction • General scientific studies • Building physics • Building services engineering • Design of green buildings • Monitoring green buildings • Leadership for entrepreneurs • Business administration • Building management and law	Graduates in engineering, science or technology, preferably with relevant working experience

Name	Country	Training provider	Duration	Contents	Target group
MSc Sustainable building technology	UK	The University of Nottingham, Faculty of Engineering	1 to 2 years	• Modelling environmental performance • Renewable energy technology • Ventilation design • Sustainable research project • Research methodologies • Optional modules: energy efficient systems, air conditioning technologies, advanced topics of heat transfer; Energy conversion and utilisation; cooling technologies & applications; modelling and materials and building physics; building design in different climates; solar architecture in different regions	Graduates in building services, architectural environmental engineering, architecture and other related disciplines.
Master of Planning with specialization in environmental planning	India	School of Planning and Architecture of New Delhi	2 years	• Environmental planning and design • Techniques of measurement of water, soil, air and noise pollution • Environmental management • Environmental impact assessment • Auditing and risk assessment • Environmental economics • Environmental legislation	Architects and engineers who wish to obtain a higher degree of specialization in environmental planning applied to building and urban planning.

Name	Country	Training provider	Duration	Contents	Target group
PhD in Energy and environment with focus on green Building	India	TERI University, Department of Energy and Environment	2 to 5 years	• The Department is engaged in research in the broad area of clean technologies to achieve energy efficiency and minimize adverse environmental impacts. Green building, solar thermal and solar photovoltaic are examples of broad areas where students can pursue research leading to a PhD.	Bachelors in engineering or equivalent and a masters in a relevant field who wish to obtain a higher degree of specialization in green building.
Post-graduation course in Energy efficiency	Brazil	SENAI Faculty of Technology	380 hours	• Energy efficiency • Electrical technology • Thermal fluid technology • Scientific methodology • Energy assessments and diagnostics • Quality of electricity • Power management • Economic engineering • Renewable Energy, environment and sustainable development	Graduates in electronics, management, environmental sciences and sustainable development

Source: Authors.

Box 4.1 Urban planning for green sanitation

Sweden has long-term experience with ecological sanitation and shows it can also work for multi-dwelling buildings in peri-urban and urban areas. The Gebers collective housing project outside Stockolm, a 32 apartment building, is a showcase example of a closed-loop system for toilet and organic waste. Urine is diverted and flushed into collectors which are emptied twice a year and used as agriculture fertilizer in the nearby fields after treatment. Faeces are dry collected and composted together with organic waste. The resulting humus is also used in agriculture. The country is currently cooperating with others worldwide which are interested in the system such as Mexico, El Salvador, Uganda and Vietnam.

In China, a more audacious joint-project involved the planning and implementation of a whole eco-town in the municipality of Erdos, Inner Mongolia autonomous region, where the principle of eco-sanitation was used in all its housing buildings (825 apartments), in a nursery school and in its commercial centre. The first construction phase was finalized in 2006 and included an on-site treatment system, also for grey water.

Source: www.ecosanres.org, www.ccb.se.

Some GBCs act through associated training institutions. For example, GBC India is working with the Bureau of Energy Efficiency (BEE) to introduce specialized green building courses.

4.2.3 Professional associations

Professional associations are important training providers for the conceiving, planning and designing stage of green building. Associations organize conferences, seminars or short training courses on emerging techniques, technologies and regulations for green building to keep their members up to date. The knowledge provided may be general or very specific. They target mainly association members at higher skilled levels. This training helps promote industry-wide standards and best practices.

Examples of providers include associations such as the Latvia Association of Architects that in 2010 started a project called "Energy-saving building in Latvia". The aim of this project was to develop an action plan on energy saving in buildings in Latvia and provide training for professionals.

The Association of Industrial Engineers in Madrid (Colegio Oficial de Ingenieros Industriales de Madrid) provides training to its members and to industrial engineering students on energy certification. The course's duration is

40 hours and the only prerequisite to attend the course is to have knowledge of thermodynamics.[13]

In Australia, the Australian Institute of Architects provides courses based on successful experiences such as the Making Refurbishments Greener programme. This course uses the new Australian Ethical Investment headquarters as a case study. The building received six stars from the Green Building Council of Australia. Lecturers show step-by-step how environmental measures were incorporated into the building, and describe the (often ingenious) recycling of materials. This course was developed with the support of the Department of Environment and Water Resources.[14]

The Estonian Society of Heating and Ventilation Engineers, aimed at maintaining high professional standards among its associates, provides regularly lectures, seminars, meeting and publications to contribute to the continuing education of its members.

4.2.4 Continuing professional development (CPD) requirements

Continuing professional development (CPD) is the process whereby professionals acquire, maintain, update and broaden their knowledge and skills over the course of their careers.[15]

Some professions in particular countries or regions have compulsory CPD requirements. In the case of architects in Germany, for example, the Federal Chamber of Architects obliges its members to take short courses on a regular basis in order to maintain an up to date knowledge of the field. These courses are increasingly introducing green building content to ensure that architects are aware of new technologies and techniques.

In China, certified architects have to participate in a continuing training course (about 40 hours over a three-day programme) every two years, in order to retain their professional certification. In 2007-2008, the training focused on green building. The contents covered a number of green building related topics, such as the concept of green building, energy efficiency, renewable energy use, technology, and best practices. These courses, also aimed at certified engineers,

[13] Available at: http://www.coiim.es/Formacion/Biblioteca%20de%20documentos/DocumentacionCursos/Lider%20calener%20VyP%20y%20GT_1110.pdf

[14] Australian Institute of Architects – Available at http://www.continuum.com.au/raia/courses.php?o=list&c=18

[15] From ILO Glossary of key terms on learning and training for work

were provided mainly in Beijing and Shanghai by the Ministry of Housing and Urban-Rural Development (MOHURD) or higher education institutions.

The inclusion of green building concepts in compulsory CPD requirements is a practical way to spread knowledge about the sector among professionals, and to raise environmental awareness. However, as courses are usually short, they risk being very general and not sufficiently specific in terms of content and practice.

4.2.5 In company training

Training in green building or energy efficiency also takes place within large firms, in construction, professional services and other sectors active in green building. In China and in other parts of the world, managers and professionals are sent to forums or promotion events. These events are organized by suppliers of technology or by public bodies that promote green buildings.

Formal on-the-job training for professionals in the conceiving, planning and designing category occurs more rarely, although informal learning is significant. Managers and professionals may be allowed to take a paid educational leave to undertake specific training programmes on renewable energy technologies, sustainable design in construction, passive techniques in architecture or other studies in green building.

Within most small construction companies, other than those specialising in green building services, very little attention is paid to green building training.

4.3 Skills responses in installation, maintenance and construction

4.3.1 Adaptation of TVET courses/new TVET courses

The content of many Technical Vocational Education and Training (TVET) courses has been modified to introduce green building content. Most alterations and changes in curricula seen in the research undertaken have been recent, in the last five years. Developed countries seem more advanced in including modules in traditional TVET curricula on new sustainable materials, energy certification notions, energy use/efficiency, water use, environmental health, resources, adequacy of space, efficient installations, solar thermal installations, among others.

Many examples can be found all over the world. In Slovenia, secondary vocational education programmes for chimney sweeperss, erectors of prefabricated buildings, tile setters, floor-coverings setters, carpenters and masons include an obligatory insulation module covering thermal and acoustic insulation. In Spain, heating installers and plumbing courses now cover a new topic on the installation and maintenance of solar thermal systems, and courses to become an electrician include the installation and maintenance of solar photovoltaic systems. In Denmark, training for trades such as for plumbers or electricians has been updated to address green standards and technologies. In Brazil, curricula incorporate sustainability-related topics such as environmental impact, sustainable materials, water use, recycling and green technologies.

If course contents are changing, so is the number of places made available for young people. In France, the Comité de filière du Plan Bâtiment du Grenelle de l'Environnement has calculated that around 20,000 people need TVET training in green building per year. This means an additional class of 20 students per TVET School. They also indicated in a report on building occupations, "*Métiers du bâtiment*"(2009), that new curricula incorporating energy effiency should be devised and existing curricula modified according to the needs of the Grenelle.

In some countries, high demand for specialized workers in green building has led to the creation of new training programmes specialized in green building. Table 4.3 is an example of a new curriculum developed in Spain in 2010.

The curriculum includes current issues such as business ethics and social responsibility, and entrepreneurship, that are very useful for the student in his/her working life. These issues are specifically relevant to green building because of the trust it often demands from clients and because entrepreneurship has an important role to play in progressing the development of green building. Some modules can be taught in English in order to foster geographical mobility which will enhance the graduates' employability in the future. The course contains 400 hours of training in companies (besides 1600 hours at the training centre) which provides the students with the opportunity to acquire practical experience during their course.

In few of the developing countries covered by the research is there much green building training activity at TVET level, with the exception of tailor-made courses for particular initiatives. An example is the 'Minha Casa Minha Vida' (My House, My Life) programme in Brazil, that aims to increase solar thermal energy use in low-income housing. A matching initiative led by the ILO was created to train people on the installation and maintenance of solar panels. Despite the limited availability of TVET courses, country level research undertaken for this project indicated a high level of demand for such courses over the next five years.

Table 4.3. Spanish curriculum for "advanced technical degree in energy efficiency and solar thermal energy", 2010

Level	Higher Vocational Education	
Duration	2000 hours (2 years)	
Modules and number of hours per module	Thermal equipment and facilities	230
	Energy efficiency of facilities	130
	Installation and maintenance management of solar thermal systems	135
	Promote the efficient use of energy and water	90
	Energy certification of buildings	195
	Training and job guidance	90
	Hours reserved for the module taught in English	90
	Assembly process of installations	230
	Graphic representation of installations	90
	Solar thermal settings	110
	Water efficiency management in buildings	70
	Enterprise and entrepreneurship	60
	Hours reserved for the module taught in English	40
	Training in companies	400
	Dissertation in solar energy and energy efficiency	40
Examples of generic skills included	English language, communication skills (oral and written), empathy, punctuality, order, cleanliness, responsibility, security, collaboration, entrepreneurship, planning, sales techniques, among others.	
Most relevant occupations and jobs	• Energy efficiency of buildings technician • Assistant of energy certification of buildings process • Solar installations salesman • Responsible for installation of solar thermal systems • Responsible for maintenance of solar thermal systems • Energy manager • Promoter of energy efficiency programmes	

Source: Instituto Nacional de Cualificaciones (INCUAL) in Spain.

4.3.2 Apprenticeship Systems

Formal apprenticeship systems are gaining support because they provide hands-on initial training based on workplace learning, usually coupled with structured learning in schools or training centres.

- In the US, the California Apprenticeship Council (CAC) recently approved the integration of environmental components into minimum industry training

criteria for building construction trades apprenticeship programmes, with full support from the construction industry.[16]

- The dual apprenticeship system in Germany has already started to include green building in its training content.
- In New York (US) construction trade workers employed on large-scale municipal retrofit project sites must usually be certified by a New York State-recognized apprenticeship training programme. It is generally believed that a construction worker who has been through a certified apprenticeship programme has the fundamental occupational skills that underlie energy efficient practices.
- In some other countries, such as Australia, more apprenticeship opportunities are being made available. There are special programmes such as the Australian Apprenticeships Access Program targeting insulation apprenticeships to turn these short-term jobs into long-term careers. As part of it, the Access Program will train 2000 insulation installers. This training and support aims to open up genuine pathways for low skilled and disadvantaged insulation installation workers to gain longer-term employment and to boost their skills by undertaking further training through apprenticeship.[17]

Although empirical evidence is limited, it can be assumed that an important part of green building training occurs on the job or through 'informal apprenticeships',[18] especially in countries where informal construction is common practice. Informal practices risk leading to divergent standards and practices, risking poor quality in green building construction.

4.3.3 Continuing training

Continuing training in green building allows individuals to complete or update knowledge and skills in green building. For this type of training, providers and themes are very variable, and course durations are usually short. For instance, the

[16] Available at: http://sg.finance.yahoo.com/news/Green-Technology-Training-prnews-3371482449.html?x=0

[17] Australian Government – Department of Education, Employment and Workplace Relations – Climate Change and Skills for Sustainability – http://www.deewr.gov.au/Skills/Programs/WorkDevelop/ClimateChangeSustainability/Pages/QuestionsandAnswers.aspx#s32

[18] 'Informal apprenticeship' refers to the system by which a young learner (the apprentice) acquires the skills for a trade or craft in a micro or small enterprise learning and working side by side with an experienced craftsperson. Apprentice and master craftsperson conclude a training agreement that is embedded in local norms and traditions of a society.

FEE Bat intiative in France (Formation aux Economies d'Energie des entreprises et artisans du Bâtiment)[19] is a partnership between public organizations, professional associations, small and medium-sized enterprise (SME) associations and large energy companies. It's objective is to train a total of 120,000 people by 2020 and mainly targets workers in retrofitting. The programme aims at including a systematic consideration of the energy and environmental dimension in the renovation of existing buildings, ensure quality of work and enhance understanding of green retrofitting among businesses and craftspersons.

The practical training has three modules and is delivered by training organizations authorized by the steering committee of the FEE Bat:

- Module 1: Identify the key elements of retrofitting (two days)
- Module 2: Master the tools to implement retrofitting actions (two days)
- Module 3: Understand, control and implement the technology to improve energy performance of buildings (one or two day(s) depending on the technology and the training organization. Module 1 and/or 2 is a prerequisite)

The Australian Institute of Refrigeration, Air conditioning and Heating (AIRAH), belonging to a professional association, has created the Vocational Graduate Certificate in Energy Efficient HVAC Design. Candidates begin by gaining a strong grounding in the compliance requirements of energy efficient HVAC design and industry best practice. Building on this, the second unit provides knowledge on the energy use implications of operational HVAC systems. The final unit applies the knowledge gained in previous units to develop skills for the design of energy efficient HVAC systems.[20]

The same centre in Australia offers the Sustainable Building Operations course. This course provides facility managers, building operators and technicians with the necessary tools to turn their existing building into a "beacon of sustainability". Upon completion, participants will be able to describe the issues of climate change and its effect on Australian buildings, explain how to operate a sustainable building and engage with stakeholders to achieve these objectives.[21]

Also in Australia, the Technical and Further Education (TAFE) system created courses in solar panel and grid connector installation and design. It targets

[19] www.feebat.org

[20] Australian Instiute of Refrigeration, Airconditioning and Heating – http://www.airah.org.au/Content/NavigationMenu/ProfessionalDevelopment/GraduateCertificate/EnergyEfficientHVACDesign/default.htm

[21] Australian Institute of Refrigeration, Airconditioning and Heating – http://www.airah.org.au/Content/NavigationMenu/ProfessionalDevelopment/TrainingCourses/SustainableBuildingOperations/default.htm

licensed electricians that seek to expand their business by becoming a certified installer of photovoltaic systems. This course includes: "technical standards, regulations and codes for general electrical installations, electricity distributors, supply requirements, electrical metering arrangements, occupational health and safety principles, electrical safe working practice and grid connected inverters".[22]

Sectoral skills institutions such as Sector Skills Councils in the UK (for example, ConstructionSkills),[23] Industry Skills Councils in Australia, Eco Construction Skillnet in Ireland or the Building & Construction Authority (BCA) Academy in Singapore also provide continuing training. These institutions generally provide training courses, both to individuals or companies, on a variety of skills and technologies. Examples of courses provided at BCA Academy in Singapore include "solar modelling, energy efficient air-conditioning for commercial buildings, or passive building designs for natural ventilation."[24] These training institutions represent a source of centralized knowledge and best practices within the industry, and can provide standardized training across a variety of firms.

In most of the countries studied, some suppliers of technology (e.g. thermal solar water heating systems) provide short training courses of a few days to their clients; targeting plumbers, insulation installers and workers of other manual skilled occupations in order to make them familiar with their new products. Specialized firms sometimes train their own insulation installers, especially those companies with a patented product. In some cases, new construction technologies require official certification, which may include a requirement that installers undergo a specified programme of training.

In some cases, manufacturers' associations organize this kind of training in collaboration with partner companies.

E-learning initiatives can also be a good means for providing continuing training, provided that the design and targeting of each initiative takes account of its limitations. One of the technologies most used for spreading knowledge is the internet. Many green building promoters also believe that the internet is a good tool for upgrading people's skills and increasing understanding of green building sector among workers and the society as a whole.

These are just a few examples of continuing training. Industry associations, non-for-profit organisations and companies also provide continuing training courses for workers. As all of them have an important role to play in the training provision of green building concepts we will discuss them separately.

[22] SkillsTech Australia: course list – http://coursesearch.skillstech.tafe.qld.gov.au/detail.aspx?sid=80a2e5ac-35a1-40dd-812e-4d35793e730b)

[23] http://www.cskills.org/

[24] BCA Academy course list – http://www.bca.gov.sg/academy/courses_tests.aspx

Box 4.2 France encourages e-learning initiatives: e-nergieBAT

The association CAH (Club d'Amélioration de l'Habitat) groups around 50 members involved in retrofitting in France; including professional associations, construction companies, energy suppliers, banks, manufacturers, distributors and estate agencies. In collaboration with ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie), CAH has launched e-nergieBAT which targets all actors involved in retrofitting existing buildings: professional, workers and society.

The website recognizes that actors have to face new changes with regard to green building: new regulation, new construction techniques, new materials, new fiscal aids, changing clients' preferences and needs. This tool is not a standalone training programme for workers but rather a complement to other training in new environmental topics in retrofitting. It also aims at providing the necessary knowledge for workers to be able to provide advice and inform their clients on new technologies available that suit them best. Teachers and clients can also benefit from the information provided on the website.

Information in retrofitting is divided into 32 modules. Some examples are: regulation, water harvesting, solar thermal and photovoltaic, electric heating, insulating materials, among others. In addition, 12 complete programmes with questions, simulations, visuals, animations, videos are tailored-made for 12 occupations including plumbers, electricians, painters. It claims to be adapted to the needs in terms of timing of workers and is periodically updated.

Source: www.energiebat.fr

… offered by industry associations and workers' organizations

Industry associations are among the main training providers for green building in many of the countries studied. They are particularly involved in upgrading workers' skills through continuing training programmes. Trade unions, professional associations, company associations and a combination of these play an important role in green building. These associations design specific training courses for their affiliates and in some cases award green building related certificates.

In Brazil, construction-related chambers, councils and unions also develop manuals and brochures to communicate sustainability issues within the sector, and occasionally organize events such as conferences and "information days" that bring together specialists on the topic to interact with their members.

Many labour unions in the US are also incorporating specific training on green materials and techniques into their programmes.

In Australia, the Plumbing Industry Association of South Australia has created the Eco-Smart Plumber course, and certifies plumbers in green plumbing. The purpose is to increase the plumbing industry's awareness of its responsibilities towards developing environmentally sustainable work practices. The content of

the new course includes: introduction to sustainability, government departments and authorities standards & guidelines, water conservation, energy efficiency, waste water systems, work practices, and communication.[25]

Responding to its members needs, the Chamber of Commerce of Malta designed and ran the first green technicians course in 2008.

The Czech Building Academy's Department for Building Craft, working within the Architecture and Building Foundation (which is an industry association) has opened winter term 2010/2011 courses addressing reduction of heating energy, heat cladding systems and their components: assembly, weaknesses of heat cladding systems, possibilities for energy savings concerning heating and warm water preparation.

In some cases, governments provide funding for industry associations to develop training programmes for their affiliates. For example, in China a number of provinces have provided funding to industry associations to develop green plumbing initiatives, and train and certify plumbers in household water and energy efficiency.

In Spain, the Labour Foundation for Construction (Fundación Laboral de la Construcción), whose members are the most relevant trade unions and associations of employers in the Spanish construction sector,[26] offers courses for workers and the unemployed. For the last five years, it has been introducing green concepts in its curricula (see table 4.4).

The Bulgarian Construction Chamber is engaged in raising awareness for green building among its member companies. It has developed a manual for energy efficient renovation in buildings, organized seminars on energy efficiency and is now implementing, with the support of the EU Leonardo da Vinci Programme, a three-year training project focused on entrepreneurs and managers of the building industry called "*Development of Innovation, Energy Efficiency in the Building Sector: a Sustainable Future*". The aim is to establish an e-learning platform offering courses related to EU standards and regulations in green building, simulation exercises and examples of cases and practices in emissions reduction, improved comfort and access to financing, among others. The programme also aims at analysing gaps in the current training system concerning energy efficiency in buildings.

[25] Plumbing Industry Association of South Australia: Eco-Smart Plumber -http://www.piasa.com.au/?/m/ecosmart-plumber

[26] FLC membership: Confederación Nacional de la Construcción (CNC), Federación Estatal de Construcción, Madera y Afines de CC.OO. (Fecoma-CC.OO.) and Metal, Construcción y Afines de UGT (MCA-UGT).

Table 4.4. Examples of courses offered by the Spanish Fundación Laboral de la Construcción

Core occupations	Examples of courses offered by the FLC
Architects and civil/ structural/ environmental engineers	• CTE and energy efficiency • Design and installation of renewable energy projects applied to building • Preparation of waste studies and waste management plans • Sustainability, resource management and renewable energy • Retrofitting I: Management • Retrofitting II: Construction • Sustainability in building
Energy and water efficiency and waste management analysts, consultants and advisers or energy auditors	• Environmental Management in the construction sector • Energy specialist in building • Sustainability, resource management and renewable energy • Energy efficiency audit and certification
Building site supervisors	• Rethink solar thermal • Rethink and operation of solar photovoltaic • Technical building code • Implications of technical building code in the field of tiles and bricks • Management of construction and demolition waste • Retrofitting
Installer and maintainer of solar thermal systems	• Maintenance of solar thermal systems • Installation of solar thermal systems • Installation and maintenance of solar thermal • Organization and mechanical and hydraulic assembly of solar thermal • Prevention and safety in the process of mechanical and hydraulic assembly of solar thermal systems • Commissioning and operation of solar thermal systems • Rethink and operation of solar thermal installations
Installer and maintainer of solar photovoltaic systems	• Maintenance of solar photovoltaic • Electrical and electronic installation of solar photovoltaic • Mechanical Assembly of solar photovoltaic • Installation and maintenance of solar photovoltaic • Rethink and operation of solar photovoltaic installations
Insulation installer	• Techniques of thermal and acoustic insulation

Source: www.fundacionlaboral.org

In Republic of Korea, professional organizations are also providing training. The Korean Institute of Registered Architects (KIRA) and the Construction and Economy Research Institute of Republic of Korea (CERIK), a research institute supported by the Construction Association of Korea, are the two institutions selected by the Korean Minstry of Land, Transportation, and Maritime to run a US$ 900,000 five year programme (2009 to 2013) to promote the education of green building human resources. Table 4.5 provides examples of courses offered.

Table 4.5. Examples of courses offered by CERIK and KIRA, Republic of Korea

CERIK, through the KICTE (Korea Institute of Construction Technology Education)	
Course area	Examples of short term modules of approximately 2 hours each
Sustainable building design	• Global sustainability and change of construction paradigm • Policy for green building • Ecological city planning • Low carbon building design • Natural lighting • Passive design technique • Energy saving building design • Creative design and green building certification
Sustainable environment technology and building equipment	• Construction plan for energy saving and integration of construction plan • Eco-friendly heating and cooling and cogeneration system technology • Green construction air duct design and construction • Eco-friendly water supply system technology in skyscrapers • Design and management of rainwater utilization facilities • Solar heating energy technology; • Building Integrated Photovoltaic (BIPV) technology and design • Energy saving technology of electricity equipment • Energy saving lighting system design • Hybrid lighting technology in skyscrapers • Emergency equipment in skyscrapers • Energy management technology in buildings • Diagnosis, evaluation, simulation of energy efficiency
Sustainable construction technology and resources	• Green building construction technology and construction examples • Long life building and remodeling construction • Low carbon green concrete and examples • Resources cycling waste disposal and utilization • Low carbon construction technology • Evaluation of efficiency of low energy green materials • Eco friendly steel construction technology

Course area	Examples of short term modules of approximately 2 hours each
Sustainable construction technology and resources (cont.)	• Crack control technology of sustainable concrete structure • Systematic management of construction process at field • High power insulation equipment and prevention technology, condensation in external wall • Resources saving top-down construction examples • Evaluation of environment burden and LCC of green building • Sustainable construction technology of skyscrapers • New technology of skyscrapers construction and examples
KIRA, through the Future Green Building Design Academy (FGBDA)	
Course area	Short term modules of 2 to 4 hours each
Theory and policy	• Sustainable city and construction • Concept of green building • City and building plan for sustainability • Sustainable city remodeling examples • Green construction policy • Korean traditional building and ecological environment • Integrative design for green buildings • Energy circulation of urban and rural areas • Green building certification • Prospect of green buildings in Korea
Sustainable urban planning	• Sustainable village planning and examples • Sustainable urban planning and examples • Analysis and utilization plan of microclimate of land • Eco-friendly land usage and design process • Sustainable community plan and practice I, II • Green exterior space planning • Low carbon/renewable energy utilization plan • Eco-friendly water circulation planning • Ecological landscaping and design
Green materials	• Green materials • Recycling materials and resources • Dry process system • Natural lighting and simulation • Recycling of buildings: renovation practice • Interior air quality and natural ventilation • Life cycle costs/maintenance and management • Application of green materials, woods • Application of green materials, soil • Green building construction practice

Source: Country study, Republic of Korea.

4.3.4 In company training

Enterprise-based training of employees represents another form of training.

This is common in Japan where workers in construction firms are directly trained by their employer on a specific proprietary technology or method.[27]

In Singapore some firms such as Building System and Diagnostics Pte Ltd (BSD), or City Developments Ltd provide in-house training following their own annual identification of skill needs among their employees. The companies incur the cost, and retention rates of workers are usually high due to the highly specialized skills they acquired.

In contrast, in the Republic of Korea, companies in sectors that make use of confidential proprietary technology (e.g. LED lighting systems) are reported to be reluctant to conduct in-house training due to the high mobility of workers.

In France, the Comité de filière du Plan Bâtiment du Grenelle de l'Environnement, in its report "*Métiers du bâtiment*", considers that the initial training efforts must go hand in hand with a company to offer young workers continuing education in green building and retain them in their speciality.

4.3.5 Active labour market training policies/programmes for unemployed

In refocusing the building sector towards greater sustainability, the role of public employment services and other governmental institutions is important. They play a role in retraining unemployed individuals and workers from disadvantaged groups, as well as in identifying and anticipating skill needs for green building.

Public employment services in Spain provide training at regional level to the unemployed, e.g. on the Balearic Islands.
Two examples of courses are the following:[28]

- Installation of renewable energy in buildings – the objective of this training programme is to train unemployed individuals to be able to perform installations, maintenance and repair of renewable energy, including:
  1. wind facilities (80 hours); and
  2. installations of photovoltaic solar energy in buildings (120 hours).

[27] Tokyo Metropolitan Government, "Tokyo Climate Change Strategy: Progress Report and Future Vision" http://www.kankyo.metro.tokyo.jp/en/attachement/tokyo_climate_change_strategy_progress_report_03312010.pdf

[28] Available at www.sepe.es

- Technician in green building – the objective of this training programme is to train unemployed individuals to design, plan and execute green buildings and traditional construction and renovate historic buildings made of stone and adobe. It combines traditional recovery techniques with the latest technologies, while taking sustainability and energy efficiency into consideration. The contents are:
  1. green and traditional construction I foundations (30 hours);
  2. green and traditional construction II profession (90 hours);
  3. green and traditional construction III techniques (200 hours);
  4. architectural and sculptural stone sculpting (240 hours); and
  5. market and sustainability (40 hours).

At local level there are a number of initiatives such as one in La Orotava in Santa Cruz de Tenerife (Canary Islands) where the local employment service of the city council trains 22 unemployed individuals in the installation and maintenance of solar panels in sports halls and public buildings.[29]

4.3.6 Entry-level training by not-for-profit organizations

Many local not-for-profit organizations perform retrofits under the Weatherization Assistance Program (WAP) in New York (US). They train entry-level workers on the job, and familiarize them with construction skills and retrofit technologies. With greater and more specialized training these workers can go on to pursue energy analysis certifications and auditor jobs.

Also in the US, HVAC Excellence, a not-for-profit organization focused on providing ongoing training for experienced HVAC workers, has started to include green content in its curricula. Workers can obtain certifications they need to perform more complex work. Certifications cover topics such as: residential air conditioning, light commercial refrigeration, heat pump installation, green awareness, and combustion analysis.

4.3.7 Training by suppliers of green building products and materials

Suppliers of green building products and materials are important providers of training. In many cases, the ability to install a green building product effectively

[29] Available at: http://webcache.googleusercontent.com/search?q=cache:WDndRX8a1FkJ:www.villadelaorotava.org/empleo.php%3Fop2%3D48+formacion+parados+instalacion+de+paneles+solares+edificios&cd=2&hl=es&ct=clnk&gl=es

requires not just general skills in installing that broad class of product, but also skills relating to the specific product. These skills are, in many cases, imparted through training provided or approved by the supplier of the product.

In some cases, the practical need for this training is reinforced by regulatory requirements. For example, in Ireland a new wall insulation system must be certified by the Irish Agrément Board, and installers are obliged to undertake training for installing the system approved by the supplier. The training is typically provided either by the manufacturer itself or by approved agents and distributors. Similar arrangements exist in many other countries.

For many types of green building systems, the extent to which additional training of workers who already have the general skills is required is limited. In the case of a new insulation system, it may be as little as a couple of days. For more complex systems, such as systems that involve complex controls and major installations of hardware such as combined heat and power, active shading, renewable energy and sophisticated environmental controls, and which require significant integration between technologies, the additional training can be very substantial. Developing capabilities in these areas, and keeping them up to date, can require major initial and ongoing investments in training by businesses engaged in installing these technologies. The training is typically only available from the supplier of the technology and its agents and distributors, and may be difficult for an installation business to access because of the scale of the investment required, or because they do not have an established business relationship with the supplier of the technology.

4.4 Skills responses in controlling

Building energy auditors, assessors and inspectors, certifiers and systems inspectors tend to be independently certified experts, certified by national authorities or under voluntary certification schemes to conduct controlling work. Training for this occupation occurs in different formats, depending on the degree of specialization required. In a report available at the EU Energy Performance of Buildings Directive (EPBD) Buildings platform (Olloqui and Hartless, 2009), case studies from member states show that individual European countries are following different training paths as EPBD does not specify qualification requirements for these experts apart from the certification requirement. The availability of a training initiative appears to be linked to the extent to which regulatory measures have been implemented. In countries where specific inspection procedures have

not yet been developed qualification needs are also still unclear and training requirements are thus not yet defined. This is, for example, the case for inspectors of air-conditioning systems in Italy under the EPBD.

4.4.1 University courses (degrees and continuing training)

Some countries provide training for architects, engineers and related high-qualified professionals to perform energy auditing in buildings. Universities generally introduce elective courses which allow students to specialize, for example, in energy management or energy efficiency.

Denmark will implement 'energy specialization' courses from 2012 onwards, to be offered to architecture, building engineering and mechanical engineering students. Students can choose a series of electives during their last semesters (around 65 ECTS credits) and obtain the title of Specialists in Energy within their fields.

In Singapore, engineers can sign up for continuing training to become energy auditors and managers through the Singapore Certified Energy Manager Training, provided by a governmental training agency.

In Spain, a 45-hour course on technical building codes is being offered for engineers and architects and other experts involved in the design, construction, certification and auditing of buildings. The content covers existing regulations and standards, energy certification procedures and possibilities to reduce building energy demand, among other topics.

4.4.2 Technical education complemented by certified work experience

Besides tertiary education requirements, some countries also accept energy auditors and systems inspectors and certifiers with a technical education degree complemented by attested work experience.

In Bulgaria, for example, training in energy audit is offered in six technical universities. In addition, professionals must prove at least three years of practice.

Slovenia has defined obligatory qualifications for energy assessors which include either a tertiary education degree in engineering or a technical education degree plus a minimum of five years work experience (Olloqui and Hartless, 2009).

The same applies in the Czech Republic, where energy auditors may be engineers or architects with specific additional certification, or alternatively workers

in the construction industry, such as craftspersons with no tertiary education, but with five years of experience in the field.[30]

4.4.3 Training and examination related to certification

Continuing training is often felt to be under-regulated, at least in some areas. It can be difficult for those not closely familiar with courses to know exactly what competences people should acquire from pursuing them.

Some countries consider that introducing standardized certifications can help tackle the problem. The process is most commonly coordinated by government bodies, or in the case of voluntary certification schemes by private or non-governmental organizations.

In the green building context, this approach has been taken in parts of the US, including New York. Participating contractors in the New York State Energy Research and Development Authority (NYSERDA) building efficiency programmes required staff members to be certified by the private not-for-profit organization Building Performance Institute (BPI), "a national standards development organization for residential energy efficiency and weatherization retrofit work".[31] NYSERDA reimburses the cost of BPI training and certification. Relevant BPI certifications include:

- Building analyst (for auditors of one- to four-unit residential buildings); training includes an overview of building science fundamentals, analysis of diagnostic equipment, and assessment of building tightness.
- Multifamily building analyst (for auditors of larger residential buildings); training for experienced energy auditors and building analysts to perform energy audit work in multifamily buildings.
- Building envelope specialist; training includes building analyst courses, health and safety, indoor air quality, and advanced blower door applications and other topics related to building envelope efficiency.

Some of the institutions offering BPI certifications are: the Association for Energy Affordability, the City University of New York Center for Sustainable Energy, and the Thomas Shortman Fund.

[30] http://www.buildup.eu/fr/publications/1309
[31] http://www.bpi.org/

It is common that certification processes are accompanied by compulsory training such as in the case of Bulgaria. Applicants, besides being eligible in terms of required qualifications, must also complete a training course on building auditing and certification before receiving a professional certificate by the national responsible body. In Slovenia, the amended Energy Act (11/2006) also established training and examination as a precondition to obtain the state license for energy assessor. Japan, as part of its Comprehensive Assessment System for Building Environmental Efficiency (CASBEE), also ensures that candidates wanting to become an energy assessor attend a training course before examination and certification can take place by one of the five recognized certification bodies.[32]

In many countries, the same certification valid for energy efficiency analysts is also valid for auditors or inspectors. In other countries, such as in Spain, energy efficiency analysts do not need to be university graduates, and a new TVET course has recently been devised for them (see *Adaptation of TVET courses/new TVET courses* in Section 4.3.1). In other countries, continuing training for construction trades with professional experience is being provided for energy analysis.

There are also interesting examples of courses to train people working in the construction industry in providing advice on building energy efficiency. For example, a widely available German course offered by trade chambers which targets skilled construction trades workers leads to a qualification in advising on energy efficiency.

4.5 Skills Responses in Education, Research, Financing and Policy Making

4.5.1 Training for teachers and trainers

Preparation for trainers in energy and other resources efficiency, and renewable energies in buildings is considered a key measure for a smooth transition to a low carbon economy in countries such as France. One proposal from the Comité de filière du Plan Bâtiment du Grenelle de l'Environnement in its report "*Métiers du bâtiment*" is to create a post-graduate masters in universities. It would be a course for teachers of TVET on green building. It would extend over a period of five years, including three years of university education and two years of training

[32] Japan Green Building Council/Japan Sustainable Building Consortium – Comprehensive Assessment System for Building Environmental Efficiency (CASBEE): http://www.ibec.or.jp/CASBEE/english/document/CASBEE_brochure.pdf.

in company. Another proposal regarding continuing education for teachers is to create on-line training linked to the initiatives of the Grenelle. It would also help information providers, researchers, policy makers and professionals dealing with finance, as does the previously mentioned Energie BAT on-line tool.

In Spain, the National Spanish Centre and Foundation for Training in Renewable Energies,of the Navarre Government in Spain (FFER-CENIFER) offers technical education in renewable energies not only for young people, workers and unemployed individuals but also for teachers at the local, regional and national level. The energy efficiency and energy management in housing training programme for teachers covers regulations at the national and European level, energy tools, energy audits and certification, among other topics.

4.5.2 Higher education for urban planners

Emerging economies have already started to introduce green building concepts into urban planning education. In Brazil, the post-graduate course in planning and management of sustainable buildings, at the Industrial Engineering Faculty in São Paulo (FEI), aims to equip engineers, architects and urban planners with skills to meet new sustainability requirements in the building sector, based on efficiency, innovation and rationalization of available resources.

Some of the disciplines are: certification systems of buildings, law applied to construction industry, building materials, sustainable building retrofit, sustainable building technologies, sustainable neighbourhoods, risk management, evaluation of the enterprise life cycle and building materials, and sustainability indicators in building and environmental assessment of buildings.

In India, country level research shows that training in sustainability for urban planners is increasingly being made available at masters and PhD levels.

4.5.3 Training for policy makers

Countries are enhancing the awareness and knowledge of policy makers in many ways. In China, for example, training programmes have been developed which aim to upgrade strategic skills of governors and city officials who are responsible for urban development and construction, with a focus on green building and sustainable development. These training courses are characterized by a mix of lecture topics including: introduction to building design regulations, energy-efficiency building regulations, renewable energy and the concept of green building, among

others. Most of these courses are short, ranging from one day to four or five days at maximum, and no certification is provided.

4.5.4 Finance Related Training

In Slovenia, the Environmental Public Fund (EcoFund) has organized courses for public employees on tendering with regard to subsidies for the construction of low energy and passive class houses. In 2008, when the first public tender came out, EcoFund provided cost-free counselling for design of low energy and passive class houses and counselling about the application procedure for the tender, that were aimed to help investors and their designers. The effect of counselling and training becomes visible in the reduced numbers of design errors, more informed investors and fewer problems with the application procedures for the grant of subsidies that EcoFund provides for passive class houses.

In Australia, the Green Star Associate programme targets "people who are in design professions, trades, manufacturing, finance, policy development, sales/communication/marketing, or HR and need some understanding of Green Star and green building practices."[33]

4.6 Skills Responses in manufacturing and distribution

It is difficult to generalize across all manufacturers of materials, components and technologies for green building as this covers a multitude of different skills responses ranging from low-skilled labourers to highly trained engineers/designers.

However, the skills response for these workers is not different from that provided in manufacturing in other sectors. Country level research into responses specific to green building skill needs found almost none that were focused specifically on manufacture of green building products.

There is, however, a need for skills development among customer-facing employees in distributors of products and materials for green building. Employees of building businesses often rely on these for advice and some basic training, so it is important that they should be well trained in the features and applications of the products they sell. The box below describes examples of this sort of training from Brazil.

[33] Green Building Council Australia: http://www.gbca.org.au/education-courses/continuing-professional-development/green-star-associate/3487.htm

Box 4.3 Alternative training response coming from green building product suppliers in Brazil

According to market research, 52 per cent of the Brazilian consumers are willing to buy products from manufacturers that do not harm the environment, even if they are more expensive, and 73 per cent are planning to increase their spending on green products and services. Two of the major suppliers of building materials in Brazil (Leroy Merlin and Casa & Construção), for instance, are rapidly increasing their offers in sustainable and green products. To match these changes in consumer preferences and product supply, suppliers realize that there is an increasing need for training focusing in particular on sales people, who need to provide accurate information to customers and sometimes assume the role of adviser. Along with differentiated communication and display strategies that green products receive in supply stores, such as special tags, training is being provided for employees both by the supply stores such as Leroy Merlin and Casa & Construção and by green building products manufacturers. Training focuses on aspects of sustainability in the construction sector in general but also on more technical contents relating to energy efficiency and material lifecycle. Supergreen, a supply store specialized in green building products located in the city of São Paulo, offers training for installers in the region to encourage the uptake of green technologies such as rain water harvesting systems.

Source: Elaborated based on the article from Guerreiro and Ariane (2010). Sim, é possível. Revista Anamaco, julo de 2010, Ano XIX (n.208), Editora Grau 10.

The demand for training is growing all over the world. In some countries such as the Philippines, the training of manufacturers in greener manufacturing practices is essential for construction companies to obtain third party certifications.

4.7 Skills Responses for Green Building Clients

4.7.1 Continuing education in green procurement

Purchasing green building products and environmentally friendly materials for green building is an important area of skills need. Some companies /public institutions train their procurement specialists in house. In Latvia, for example, the Ministry of the Environment set out recommendations for environmentally friendly buildings in 2008. These recommendations target procurement processes required for design, construction, exploitation and dismantling phases of building work.

4.7.2 Information campaigns

A lack of understanding of the green building sector among society in general and potential clients in particular is holding back developments in green building. Many countries have recognized this and have introduced information campaigns as a response. Belgium, for example, has created provincial advisery centres for sustainable living and building. These centres target individuals, the building industry and the local government, lending support and advice to municipalities on integrating sustainable building practices in complex projects at the level of buildings or neighbourhoods. They aim to organize coordinated campaigns, offer training and building advice, etc. The Vlaamse Confederatie Bouw (VCB) is a federation of building sector companies. One of its activities is to encourage member companies and their clients towards energy saving investments through information campaigns.

The Czech Federation of Technical Contractors for Building Industry not only organizes international seminars and forums on sustainable construction for the country, but has also established a special programme to advise householders on energy savings through its Building Advisery and Information Centre.

The Internet is commonly used to make information on green building widely available. In Germany, a number of campaigns offer online energy saving calculations for private householders, information on subsidized loans, and search functions to identify suitable professionals (www.klima-sucht-schutz.de, www.heizspiegel.de, www.energiesparclub.de, www.sanieren-profitieren.de).

In Belgium, two awareness campaigns have been created using websites: indoor air pollution (www.airinterieur.be) and sustainable construction (www.underecoconstruction.be). The first summarizes basic technical principles and problems of air pollution in buildings, while the latter contains information on premiums and subsidies, how to save energy in every part of the construction process, energy labels and related topics. The website www.energivores.be contains modules on energy intensive products (lighting, boilers, appliances), but also products for saving energy (roof insulation, glazing). It aims to provide an interactive, hands-on support to citizens and to guide their consumer choices. A media campaign regularly draws attention to the existence of this site.

4.7.3 Higher education in energy management

Professionals trained in energy management may take on a wide range of roles in green building, including: conceiving, planning and designing roles, controlling

roles and green building client roles in businesses concerned with managing their energy usage.

An example of a course in energy management is the energy management course at the Polytechnic University in Madrid (UPM) aimed at graduates, architects, engineers and related technical degrees. The course includes the following subjects: energy efficiency and energy management, energy law, energy and environment, renewable energy and energy markets, energy planning models, energy systems, and energy and environmental efficiency techniques.

4.8 Institutional set-up and channels for delivery of skills responses

Countries have already started to adapt qualifications and curricula (either modifying existing courses or creating new ones) in their education and training systems to the current demand for green building. Since national systems are often slow in responding to changing demands, a wide range of more flexible, short-term, private or public-and-private initiatives are filling the gap. The major patterns for the institutional set-up are the following:

4.8.1 Involvement of social partners in design and implementation of skills responses

Tri-partite education and training systems provide an institutional involvement of industry and workers' organizations in decision-making about training delivery. New industry skill needs are taken into account and feed-back is provided on a constant basis.

In Demark, curricula for academic professional programmes at universities are designed in collaboration with social partners to ensure appropriate competence profiles of the graduates, which is then approved by the Danish Ministry of Education. In Germany, green building concepts are being introduced in apprenticeship programmes whose content is determined in tripartite bodies. In Australia, tripartite dialogue led to an increase in training numbers. More places for apprenticeships are being made available in companies dealing with green building issues.

In countries where social dialogue on training is less institutionalized, partnerships between industry and training providers ensure that skill needs expressed by businesses are reflected in training programmes. In Malaysia, the founders of

the Green Building Index (GBI)[34] have successfully influenced some of the top universities to include GBI in the curricula of their engineering and architecture programmes. In India, Sir JJ college of Architecture in Mumbai is collaborating with the industry to create courses and programmes that could potentially bridge the skills gap in green building and provide interdisciplinary education in this field. Another example is the Green Campus programme in China, established in May 2010 under the China Green Building Council at 18 universities in China, in order to promote the concept of green building in campuses, organizes training and knowledge exchange activities.

The Belgian Walloon region is developing an "Alliance Employment-Environment" for the building sector, within its socio-economic and sustainable development plan ("green Marshall Plan"). The Alliance is coordinated by the Walloon Minister of Energy and Housing and each working group (including the one on training) is composed of regional and local government representatives, business associations, trade unions, researchers, education and training providers, and non-governmental organizations (NGOs).

The plan includes a comprehensive skills development component for the building workforce, and is implemented by multiple stakeholders. It spans from improved vocational guidance and information on training provision, to strengthening synergies between the social partners and education/training providers, developing courses for jobseekers and practical training for students at secondary and tertiary education, enhancing continuing training opportunities in green building for the existing workforce by granting training vouchers, enabling recognition of qualification, and promoting clusters.

Industry associations and workers' organizations also provide training in green building for their members, in some instances these are supported by public funds. Examples covered in this section include the Spanish foundation of trade unions and employers in the construction sector, green building councils all over the world, labour unions in the US, and construction chambers in Bulgaria. Green building councils play a particular role in providing skills upgrading for different types of occupations and are present in many countries.

[34] The private sector in Malaysia has developed the green building index (GBI) specifically for the Malaysian-tropical climate and socio-economic context. It is a benchmark for energy efficiency, indoor environmental quality, sustainable site planning and managing, materials, resources and water efficiency and innovation. For more information see: http://www.greenbuildingindex.org/how-GBI-works2.html#Classification.

4.8.2 Government – driven training initiatives

Governments are either providing skills development through formal education and training systems, or have set up new institutions such as authorities, funds, commissions or working groups to respond to the specific skill challenges related to green building.

Singapore's Building and Construction Authority (BCA), an agency under the Ministry of National Development, set up a training academy (BCA Academy) focusing on improving skills and capacities for the construction sector in 1984. It offers a wide range of courses for new-entrants and workers from all education levels, from skilled workers with no certification to university graduates, including technical workers, as well as executive programmes for professionals. Courses related to green building vary from short add-on courses such as two-day Sustainable Acoustics courses to a complete Master of Science programme on sustainable design. It also launched innovative initiatives such as the BCA-Industry Built Environment Scholarship, through which leading construction firms can sponsor the studies of outstanding students in engineering, architecture, and other relevant subjects.

In China, the government is expected to lead training in green building and, for that reason, the private sector has not been active nor engaged in training provision.

In Australia, a number of training programmes are subsidized by both national and state governments, including the Green Skills Agreement, Queensland Green Building Skills Fund, Skills for the Carbon Challenge, and the Jobs Fund. These funds and initiatives generally encourage either (i) initial training/apprenticeship of job-entrants into an existing trade, incorporating green methods and technologies,[35] or (ii) the up-skilling of construction workers with green skills.[36]

In France, the government called for a review of training needs in the green building sector, and established a working group for this purpose, the Comité de filière du Plan Bâtiment du Grenelle de l'Environnement. The commission's report "*Métiers du bâtiment*" promotes innovative e-learning initiatives in green building in partnership with ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie).

[35] Council of Australian Governments, "Green Skills Agreement" http://www.deewr.gov.au/Skills/Programs/WorkDevelop/ClimateChangeSustainability/Documents/GreenSkillsAgreement.pdf

[36] Queensland Government, "ClimateQ: toward a greener Queensland" http://www.climatechange.qld.gov.au/pdf/factsheets/3planbuild-e2-greenbuildingskillsfund.pdf

In Spain, the Training and Green Building in TVET working groups funded by the Ministry of Education was created to facilitate the geographical mobility of students. This initiative, first at the national level but now also at international level, aims at consolidating a network of TVET centers to improve the green content in curricula in relation to 'Building and Civil Works'. It is run by TVET teachers. Specific objectives of the initiative are:

- compare TVET curricula in "Building and civil Works" in the different regions of Spain
- compare the construction methods in other regions of Spain and other countries that are potential sources of employment for TVET graduates
- evaluate other training mechanisms: continuing education, distance, e-learning…
- understand enterprises' needs
- offer training that includes alternatives to the current construction model

4.8.3 The role of public agencies to create active labour market programmes (ALMP) to train unemployed

After the crisis, levels of unemployment in the construction sector rose tremendously. Some countries such as Ireland faced employment levels in construction that dropped by 60 per cent from 2007 to 2010. Active labour market policies to retrain unemployed workers (often through public employment services or other public and/or private institutions) also aimed to meet companies' recruitment needs in the area of green building. In Belgium, within the Work and Investment Plan framework, the Flemish government and it's social partners urged the Flemish Public Employment Services (VDAB) to organize 135 training pathways for 'green jobs' and 'jobs for the future' in 2010-2011. In response to this objective, and as part of the recovery package, the VDAB launched training courses for sustainable construction practices, energy efficiency, ecology, insulation and burner technologies among other topics.

4.8.4 Private non-profit certification

Particularly in countries without national qualification systems, such as the US, private not-for-profit organizations set standards for green building. The US Building Performance Institute (BPI), for example, accredits contractors and provides certification for professionals and skilled construction trades workers,

and partners with training affiliates. It works in partnership with New York State Energy Research and Development Authority (NYSERDA) for energy efficiency in buildings, in such a way that NYSERDA reimburses the cost of BPI training and certification to the contractors participating in these programmes of energy efficiency in buildings.

4.9 Conclusions

Training offered in green building has increased notably over the past few years. However, employers still face difficulties finding qualified people to perform certain jobs.

The training response in green building has been mainly based on: the creation of new and the adaptation of existing TVET courses, the creation of new qualifications in apprenticeships, specialization courses outside the workplace by industry associations, green building councils and skills councils, in-house training in companies, electives and postgraduate degrees offered by universities and business schools, and training programmes developed by public administrations or partnerships of the public and private sector. Some of the training providers often act in partnership with ministries or the private sector.

Section
5

Skills Gaps and Labour Shortages

5.1 Introduction

This section addresses skills gaps and labour shortages identified and expected to emerge across the countries surveyed. It therefore sheds light onto two fundamental dimensions of the labour market dynamics: changes in skills and competencies needs for existing or new occupations (content), and changes in the number of professionals required (volume).[37]

Mismatches may occur because education and training actors and/or mechanisms are insufficiently effective in responding to market demands. Changes in skills needs may be too fast, or too unpredictable and they may not be well monitored. On the other hand, the industry may not be effective in communicating its needs to those responsible for developing adequate skills responses.

This section illustrates its findings by highlighting issues from some of the countries covered by the research. These should be seen as representative of wider issues that are present across many countries, rather than being specific to the countries mentioned.

[37] The term 'skills shortage' refers to both quantitative (labour shortages) and qualitative (skill gaps) lack of skills. 'Skills shortage' is defined as "a genuine lack of adequately skilled individuals available in the accessible labour market with the type of skill being sought and which leads to a difficulty in recruitment. A skill shortage characterizes the situation where employers are unable to recruit staff with the skills they are looking for at the going rate of pay. This could result from basic lack of people (when unemployment levels are very low), significant geographical imbalances in supply (sufficient skilled people in the labour market but not easily accessible to available jobs), or a genuine shortfall in the number of appropriately skilled individuals – either at new entrant level, or for higher level skilled occupations," (Strietska-Ilina et al., 2008).

5.2 Labour shortages and green building practice

Labour shortages can come about because:

- there are not enough people interested in working in an area with the underlying abilities required to do the job well;
- there are deficiencies in training and education arrangements that make it difficult for suitable people to develop the skills required; or
- requirements change so that the supply of skills that was broadly satisfactory in the past no longer meets requirements, and systems of skills anticipation, careers counselling and provision of training and education fail to keep up with change.

In the case of green building, the skills shortages that have appeared are primarily of the third type, although deficiencies in the education and training systems that service the construction sector also contribute in some countries and to a large extent in developing countries, and there are some countries, mainly developed countries, in which career opportunities in manual occupations in the construction sector are seen as unattractive by young people.

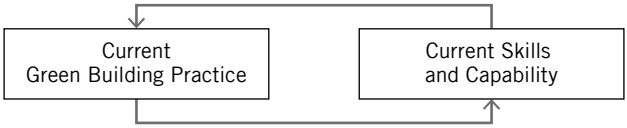
In most countries there are enough people interested in working in the building sector, and existing education and training systems are capable of delivering the interventions required once they know what is needed. In these countries, skills gaps are mainly a consequence of rapid greening of building activity and ongoing advances in green building techniques and technologies changing skill requirements faster than the education and training systems have responded.

This contrasts with experience during the information and communication technology (ICT) skills crisis around the turn of the millennium. Initiatives in many developed countries to increase the supply of suitably qualified people were stalled by insufficient interest from suitable applicants for higher education in computing and other ICT disciplines.

In green building, it is possible to think of skills as being part of a dynamic system in which available skills, and the capabilities they underpin, interact with current green building practice.

- If green building practice changes, either in content or in scale, this opens up a skills gap unless the change has been well anticipated and a response is in place ahead of time. This creates pressure at industry and enterprise level to put in place measures to ensure that skills and capabilities catch up.
- The corollary is also true; investing in skills and capabilities for green building can open up a gap where current green building practice lags behind what the

Figure 5.1. Dynamic relationship between green building practice and skills



Source: Authors.

building industry is capable of delivering. This creates space to raise standards of energy efficiency and sustainability, and drives the creation of more sophisticated green building services as people seek commercial outlets for their new skills (see figure 5.1). Later in the report, it is argued that skills-led strategies based on developing skills and capabilities ahead of current practice have a useful contribution to make to driving green building forward.

5.3 Skills gaps and labour shortages

5.3.1 Introduction

This overview of skills gaps and labour shortages follows the framework for analysis of occupations in green building presented earlier.

- Conceiving, planning, designing and advising occupations
- Construction, installation and maintenance occupations
- Controlling pccupations
- Education, research, financing and policy making cccupations
- Manufacturing and distribution occupations
- Green building clients

In covering a wide range of countries, both developed and developing, and from a wide range of geographical locations and climatic conditions, this overview identifies themes that are common, as well as highlighting issues that relate to a narrower range of conditions.

Even among developed countries, there is considerable variation in the extent to which they have engaged with green building so far. As a consequence, some countries have already made good progress towards tackling skills gaps identified here while others have barely started.

There are few good estimates of the total scale of the gap between what is needed now, and what will be required in the future. However, France has estimated additional annual recruitment needs of 20,000 people; 15,000 due to the increase of construction and renovation activities, and 5,000 related to new requirements for renewable energies in construction. This means an average of an additional class of 20 students for each TVET school.

5.3.2 Conceiving, planning, designing and advising occupations

This is one of the main areas where country level research has identified deficiencies in skills. The main issues that come out of the research are as follows:

- In many countries, architects are not sufficiently knowledgeable about green building approaches.
  - The central issue is that there are still a great many architects who do not pay adequate attention to the fundamentals of energy and resource efficiency that should now be a basic part of mainstream architectural practice. This is partly a matter of skills, and partly of priorities. One practical example from the research in Cyprus is of architects who do not understand the practicalities of avoiding thermal bridges when designing insulation, which compromises the performance of the insulation.
  - Another issue is that there is a need for more architects specializing in green building with the skills to push mainstream architectural practice on sustainability forward.

  Broad areas where better skills are required are in passive techniques (such as, for example, building orientation or window size), integration of heating and air conditioning systems, integrating renewable energy systems into buildings, water conservation, design of insulation, and integration of control systems from basic temperature control to more sophisticated building control systems. There is also a need for architects to be better able to communicate the benefits of sustainability to their clients, and to explain the trade-offs involved.

  Research in a number of countries (the Philippines and China, for example) found that deficiencies in this area are partly related to inadequate coverage of energy efficiency and sustainability in the curricula of universities, and to inadequate links from what is learned to what is put into practice.

- In some countries there is a shortage of civil engineers with the skills to work in green building; this was highlighted in the research for a number of core

EU countries. The issue is partly a more general shortage of civil engineers, and partly due to many lacking skills and interest in sustainability.

- In a number of emerging economies, including China, shortcomings in the skills of engineers working in building services were identified, with a need for stronger skills in integrating intelligent building and renewable energy technologies into buildings. Issues with skills in integrating buildings with municipal services including water and electricity were also noted in the Chinese research. On a more global view, however, the research showed building services engineers to be better aligned with the objectives of sustainability than other professions because designing for energy and resource efficiency is core to their role.

- There is a major issue with skills in conceiving, planning, designing and advising on green building retrofitting projects. In developed countries, the greatest opportunity for energy savings and improved sustainability in buildings lies in retrofitting existing buildings because large improvements are possible, because most of the existing building stock is likely to remain in use, and because in most cases levels of new construction are low relative to the size existing building stock.[38]

  Deficiencies in skills in this area among construction professionals are a significant problem. However, they are not the only people to whom householders and businesses look for advice on retrofitting. They also look to businesses providing retrofitting services for advice and to skilled construction trades workers doing work in the area. Where available they may look to public advisery services or to specialist energy efficiency professionals. The research evidence is that across many countries businesses providing retrofitting services do not consistently provide optimal advice, whether because their skills are deficient, because they prefer to sell the specific services they can provide themselves, or for some combination of these. Similarly, unless they have undergone specialist training in advise on energy efficiency, skilled construction trades workers are seldom well prepared to give comprehensive advice.

  This issue was raised in connection with so many countries that it is probably close to universal among developed countries, though countries with public advisery services (such as France) may be partial exceptions. Arising from its major study on energy efficiency in buildings, the WBCSD has identified the need for better advice as one of the key factors constraining the greening of the building stock.

[38] Japan is a notable exception because it has a much greater propensity to replace existing buildings than most other countries (the average life span of a home is approximately 26 years).

- One specific area of skills deficiency for construction professionals and their support staff that was identified in a number of countries (Spain, for example) was a lack of knowledge of lifecycle analysis of building materials and products, which makes it difficult for them to make well founded choices on the selection of environmentally friendly and recycled materials.

5.3.3 Construction, installation and maintenance occupations

The research shows that there are significant shortages and deficiencies in the skills required for green building at the operational level, such as that of constructing green buildings, and of installing and maintaining green building technologies.

Some developed countries (Czech Republic and Sweden, for example) report a lack of young people interested in doing construction work, which is cutting the number of people entering the construction trades and is either causing shortages now or is causing them to anticipate shortages in the future.

Research for Austria highlighted the high average age of construction workers as being a barrier to the development of the skills required for green building.

The research found a significant number of cases where there are deficiencies or shortages of skills at skilled manual level in various countries. Examples include installers of building envelope insulation in Cyprus, people to work on central heating and domestic renewable energy in Belgium,[39] and installers of HVAC (heating, ventilation and air conditioning) and sanitation systems in Germany. In some emerging economies, initiatives to install solar thermal systems in a large numbers of homes have tackled the need for installation skills but have left a deficiency on maintenance skills.

A study in Los Angeles found 53 per cent of businesses having at least some difficulty in recruiting HVAC mechanics/technicians/installers, 54 per cent having difficulty with building controls systems technicians, and 60 per cent having difficulty recruiting project managers for construction and design.

However, while problems similar to these are not uncommon, the overall picture that comes through the research is that training and education providers and businesses are responding to skills needs once they become apparent. Where

[39] In an earlier skills needs study carried out in 2008, the Belgium capital Brussels found that approximately 30 per cent of vacancies in companies engaged in green building were not being fulfilled because of problems related to training, knowledge and skills among the applicants. Occupations where skills gaps appeared to be more critical were masons, carpenters, heating workers, architects and consultants in general. (EcoRES, 2008).

the base of existing construction skills is strong, as it is in most developed countries, the amount of additional training required for a skilled construction trades worker to work on green building projects is quite modest. It typically takes between less than a week and a few weeks to acquire skills in an area related to existing skills such as solar photovoltaic panels (for an electrician) or the installation of wall insulation (for various occupations, depending on the country).

A significant exception to this among developed countries is in countries such as Australia that have introduced "eco" versions of existing occupations that have skills in a range of new green building techniques and technologies. Examples include "eco-smart electricians" (adept in solar panel installation, lighting efficiency, and energy efficiency for pumps and fans, amongst things) and "eco-plumbers" (knowledgeable in greywater systems, solar hot water, rainwater capture, and in some cases heating efficiency). Existing electricians and plumbers require more extensive reskilling for these roles.

In developing countries with a large informal construction industry, and in countries where there is a large migrant component to the construction workforce, there is often a more general issue with low construction industry skills. Where this is the case, the amount of additional training required to do green building work is greater, making the gap to be bridged when green building activity increases more substantial.

Retrofitting projects are less common in developing countries than in developed countries, and where substantial initiatives exist they most often focus on a single technology such as solar photovoltaic to provide electricity for the building, or solar thermal to provide hot water.

Much of the country level research undertaken for this study showed gaps between the skills available now, and those that will be required in the future. Many of these identified a growing need for skills in installing insulation. While expectations of future skills needs varied by country, all of the main occupations in this construction, such as installation and maintenance groups, were highlighted as growth areas for at least some countries.

Skills deficiencies in construction extend to management level. In many cases, green building works are more complex than traditional approaches, so effective project management and coordination are particularly important. Deficiencies in these areas affecting green building were highlighted in country level research for several countries, among them Germany, Singapore and the UK, in areas including coordination, leadership, project management and team work among experts.

5.3.4 Controlling occupations

Controlling occupations are important to the success of green building, and require substantial skills specific to green building, on top of more general construction sector skills at around the professional and technician levels. Country level research has shown a growing requirement for skills in this area, and shortages of sufficiently skilled and experienced people in some cases.
Growth in requirements exists across a range of areas:

- assessment of works against planning requirements and building regulations, which increasingly emphasize energy efficiency and sustainability;
- assuring that specific technologies have been installed properly, such as efficient HVAC systems or solar thermal systems;
- assuring that more broad-based retrofitting projects have been carried out both in accordance with building regulations and in accordance with the project plan and design; and
- assessing new and retrofitted buildings against green building standards such as BREEAM and LEED.

However, as building activity is depressed in many developed countries at present, the practical requirement in skills relevant to planning and building regulations for these countries (first bullet above) is to develop people already working in planning more than to recruit new people with skills relevant to green building as planners. Examples of areas of growing skills needs identified in the research include:

- Emerging need of inspectors for HVAC systems (Cyprus);
- Emerging demand for energy auditors and building inspectors, as well as for experts in quality assurance to work in energy efficiency (Slovenia);
- Shortage of green building professionals and assessors with auditing skills, and to perform green certification (Philippines);
- Rapid spread of China Green Building Standard rating system expected to drive an increased need for certifiers, auditors and appraisers over the next five years (China);
- Projections for the period 2009 to 2018 indicate an expected shortage of construction inspectors (Canada);
- Around 500,000 professionals will need to be trained by 2013 to respond to the increasing need for energy efficiency audits, control of energy performance and building regulatory compliance (France);

- In a Los Angeles survey, 74 per cent of respondents identified at least some difficulty in recruiting compliance specialists and energy regulation specialists (US).

5.3.5 Education, research, financing and policy making cccupations

The need to develop the skills of the educators and trainers in green building is a major theme of the country level research undertaken.
For example:

- The research for Denmark highlighted a need for updating among educators and instructors to ensure the newest knowledge on green technologies and processes are passed on to students of all occupational levels. It was noted that, carpenters and bricklayers, for example, are still trained without reference to green technologies and processes.
- The research for Belgium highlighted an urgent need to establish retraining measures for educators and trainers so that training provision can meet the growing demand for training in the green building area.
- The research for China highlighted a shortage of training professionals, and perceived a knowledge gap in green building among current training professionals.
- The research for Canada highlighted the rapid evolution of increasingly complex, interdependent and high tech building systems, and indicated that this is resulting in training gaps.
- The research for Slovenia highlighted the need for educators to in future have expert and interdisciplinary knowledge about new technologies to increase energy efficiency and to integrate renewable energy resources in buildings.

The need for skills in research, financing and policy making came through the country level research more sporadically, although this reflects the relatively small numbers required in each country rather than a lack of importance.

Many of the countries studied have significant construction research activities, and these require people with significant knowledge of green building. The research on Demark, for example, highlighted the need for continuous research and development in more efficient and cost-effective green building technologies. More generally, research is also required in areas including design and techniques for green building, the energy performance and sustainability of the

existing building stock, strategies to improve energy efficiency and sustainability of buildings, and progress in the greening of buildings. Suitably skilled people are required to undertake this research, at both researcher and research support (technician) levels. Research at country level is important because conditions vary between countries in important ways: construction practices and materials, past and present, climate and regulatory conditions, among others.

Improved skills are also required at the policymaking level, a need which has been highlighted more generally in the *Skills for Green Jobs* report undertaken by Cedefop and the ILO. It has also been highlighted by others, notably by Comhar SDC in Ireland (Comhar SDC, 2010).

In the context of green building, a significant part of the policy focus is on financing, particularly financing of retrofitting projects. This makes the development of skills useful in the design of financing instruments increasingly important for policymakers.

5.3.6 Manufacturing and distribution occupations

Manufacturing and distribution occupations are too diverse to identify cross-cutting consistency in their skills requirements. A comprehensive cross-country analysis of skills gaps and deficiencies for these enterprises would be likely to find a very diverse range of issues, most of them specific to particular manufacturing sectors and to some ICT services sectors, particular countries, or to both.

The clearest message on the manufacture of green building materials and products that came through the research is that this is likely to be a growth area across many countries in years to come, particularly in developing countries. While improved distribution of imported products will overcome many current country level deficiencies in the supply of products and materials for green building, lower logistics costs for heavy and bulky products, and products that are better adapted to local conditions, will favour local suppliers in many cases.

In the case of distribution of green building materials and products, a much clearer message emerges from the research. Distributors play an important role in advising builders and construction professionals, and in some cases provide training in the installation of products. Country level research has pointed towards a need to upskill customer-facing staff at distributors of building products so that they will be better equipped to provide advice.

5.3.7 Green building clients

The skills of clients (and potential clients) are among the key factors impacting on the uptake of green building projects. This is an area where needs are developing rapidly. The skills gaps that exist arise because the skills were mostly not needed in the past.

Based on the research, the following are key areas where there is a need to develop skills:

- *Green procurement* – In many governments and large enterprises there is a trend towards introducing green procurement principles. This can extend to procurement of buildings, as with the decision of the US government (referenced earlier) that new federal buildings should comply with LEED standards. Moving to green procurement of buildings creates a need for procurement staff and staff involved in developing specifications who are familiar with green building techniques, technologies and standards, and how these are applied in procurement. It also creates a need for auditing staff to assure compliance with standards.

  In some cases, the need is for new staff. In other cases, the need is to develop the skills of existing staff. For example, the country level research in Italy pointed towards a need for skills and knowledge related to the energy efficiency of buildings directive for those involved in public procurement.

  Estonia pointed towards a lack of experience in dealing with sustainable procurement among state bodies, and also resistance towards sustainable criteria that do not necessarily favour the lowest priced bid.

- *Energy management* – In both enterprises and governments, energy efficiency is becoming a higher priority; both as a means of cutting costs, and as a response to environmental priorities. To respond effectively, they need to gain the expertise in energy management required to manage energy efficiently. This is partly a matter of appointing energy management specialists and partly a matter of training people in relevant existing roles, including facilities management and operations management, in energy management.

  In a number of the countries reviewed, there are now higher education courses in energy management available that are suitable for developing the specialist skills required.

- *Householders and Building Owners* – Lack of sufficient knowledge about energy efficiency and retrofitting among householders and building owners is a significant factor limiting investment in retrofitting projects in many countries. It is also a factor in decisions about incorporating energy efficiency, water

efficiency and other sustainability features in the design of new buildings, both in developed and developing countries.

For example, interviews in Brazil found that, "there is a consensus that green building is not being pushed vigorously enough by entrepreneurs and managers inside their own companies or among their peers in chambers meetings or other types of employer's organizations. Lack of knowledge and prioritization of sustainable construction practices are the main reason for that."

5.4 Issues with core skills[40]

In addition to skills needs relating to specific occupations and groups of occupations, the country level research undertaken identified a range of areas where there is a need for stronger core skills for employability.
The key areas highlighted were:

- *Capability to adapt to change* – This is broadly in terms of being ready to adapt to green building approaches, and more specifically in terms of the ability to quickly adapt to changing conditions and introduce new technologies, techniques and materials.
- *Environmental awareness* – Lack of environmental awareness among those involved in developing building projects, whether as building occupiers, property developers or building professionals, and indeed among those working in building construction, is a significant factor constraining green building. Issues with environmental awareness among urban planners are significant in some countries.
- *Interdisciplinary* skills – Green building calls for a combinations of skills that cross traditional occupational and disciplinary boundaries. The interdisciplinary skills that are required are of two types. The core skill that is needed is that of being able to work effectively with people from other disciplines and occupations. The other type of interdisciplinary skill is that of individuals having a combinations of skills that cross traditional occupational and disciplinary boundaries.

[40] 'Core skills/core employability skills' refers to non-vocational/non-technical skills or competencies that are needed to perform at work and in society. They apply to work in general, rather than being specific to an occupation or industry. 'Core employability skills' include: the ability to work with others and in teams, the ability to solve problems and use technology, communications skills and learning-to-learn skills. 'Core skills' are also called generic skills, key competencies, key skills, portable skills, soft skills and transferable skills. (ILO: Glossary of key terms on learning and training for work, 2006).

For example, the 2004 Egan Review of Skills for Sustainable Communities report in the UK found that a lack of understanding across the professions and occupations involved in the planning, designing, creating and maintaining the built environment was a key factor restricting effective delivery.

Country level research in China found that because green building is slowly moving from isolated solutions for energy efficiency to "integral green building", the integration of skills across trades is seen as crucial yet still very underdeveloped. Courses and programmes integrating various skills areas are very rare.

- *Teamworking, coordination and leadership* – These are important core skills in all sectors, but are of particularly great importance in building projects which require well coordinated work involving people from many specialisms who may not have worked together previously. Country level research from a number of countries highlights deficiencies in this area.

  For example, country level research in Brazil found that among professionals, weak communication skills resulted in a difficult collaboration between engineers, architects and designers .

- *Interpersonal skills and negotiation* – These are also important core skills in all sectors, and are particularly important in building projects. Again, country level research from a number of countries highlights deficiencies in this area.

- *Problem solving and critical thinking* – These are also identified by some countries as areas of deficiency.

- *Business and marketing skills* – These have been identified as important, particularly in emerging economies including China and the Philippines, as there is a major need to communicate the benefits of green building more widely. They have also been identified as important in a range of developed countries including Denmark and Ireland.

- *Foreign languages* – Country level research in a small number of countries, including Austria and China, identified a need for skills in foreign languages to improve access to information on green building that is being mainly produced elsewhere. It is particularly important in the context of joint venture projects with foreign partners.

A specific issue that emerged from the research is that in many cases people working in construction are moving from working on large building sites to working on retrofitting projects in peoples' homes where acceptable standards of behaviour may be quite different, and where they may be in almost constant

contact with the client. There is a need for training to prepare construction workers moving into work on residential and small commercial retrofitting projects to adapt to this different environment.

5.5 Identification and anticipation of skills for green building

Based on the country level research, research on identifying and anticipating skills for green building at country level follows at least one of the following tracks and, in some cases, several.

- A considerable amount of skills research in green building is undertaken through existing sectoral skills anticipation mechanisms for the construction sector.
- A substantial amount of skills research in green building is undertaken as part of wider initiatives to map and anticipate skills for green jobs.
- Some skills research in green building is undertaken in support of specific policy proposals for initiatives to promote and develop green building.
- A very substantial amount of skills anticipation relating to green building has been taking place at the micro level. Many professional bodies for construction related professions have identified green building as an important issue, and have developed and provided training based on what they perceive the needs to be. Many education and training institutions going through established institutional processes to update and renew their courses in building construction and related areas have identified a need for green building content; either to prepare trainees and students to comply with more demanding building regulations, or to develop deeper and more extensive skills relating to green building.
- In cases where curricula is designed centrally, as is the case with some national qualification systems, and in cases where a major organization, such as Serviço Nacional de Aprendizagem Industrial (SENAI) in Brazil or Foras Áiseanna Saothair (FÁS) in Ireland, has a leading role in shaping training nationally, there are usually processes in place to update courses and identify new areas of skill where training is required. These typically draw on consultations with businesses, workers' representatives and providers of education and training.
- Some skills research relating to green building appears as an outcome of more general enquiry into emerging skills needs.

Examples from the country level research include:

- In the Czech Republic, the National Qualification System has had an important role in identifying emerging skills needs in green building.
- Estonia's Energy Saving Action Plan 2007-2013 identified a lack of adequate training as one of the main gaps. The government is reported to intervening as a result through:
  - Identifying occupations, mapping training needs and formulation of training principles;
  - Mapping actors and mechanisms of training response; and
  - Developing state support strategies and schemes for training provision, including material provision.
- Since 1998, the Chinese government has been guiding skills development, including skills for the construction sector, through a National Plan for Vocational Skills Development. The plan is built around a mechanism to match skills demand and supply according to state development priorities and market needs, and is well responding to the transition to the low-carbon economy directives.
- In Canada, the Human Resources and Skills Development office (HRSD), Environmental Careers Organization of Canada (ECO) and Construction Sector Council (CSC) will soon be releasing two studies focused on skills for green building. The studies will investigate the impact of current and future industry trends on the construction workforce, identify key gaps and elaborate strategies to anticipate and address these gaps.
- Austria's Public Employment Office has established a committee to identify skills needs across the changing economic sectors and labour markets, including the building industry. With the participation of social partners, it also aims at (re)elaborating occupational profiles which will further inform training measures.
- The Construction Sector Skills Council in the UK is responsible for setting occupational standards for the UK. It has established standards for a range of areas of skill related to green building including energy advisers (domestic and non-domestic) and thermal insulation amongst others.

5.6 Effectiveness of training provision: actors and mechanisms

The effectiveness of training provision for green building varies considerably between countries. The broad picture that emerges from country level research in developed countries is that training provision for the construction industries is well developed. Gaps in provision relating to green building are mainly temporary; arising because demand for skills is changing and while provision is moving in the right direction it has not yet caught up. In some cases this is because requirements are changing faster than provision can match. In others, systems have been slower to reallocate resources towards green building than would be ideal. However, there are effective mechanisms in place to at least identify, and, in many cases anticipate, skill needs, and these inform the development of training provision.

There are more substantial challenges in many of the emerging economies reviewed, where training for the construction industries is less well developed, and this more general challenge impacts on skills development for green building. The general challenge is compounded by the fact that the need for green building approaches is less widely recognized than in most developed countries.
Findings in this area from country level research include the following:

- In China, the government is trying to overcome weaknesses in training for integrated green building design by partnering with the US and Western European countries through international cooperation programmes. However, these mainly focus on technology transfer or exchange, with only limited development content. Attending and hosting international green building conferences is another strategy used.
- According to the country level research, the training response in the Philippines is currently weak and insufficient to address requirements. Most of the training provision is only available in Metro-Manila and not in other regions of the country. Skilled and semi-skilled workers lack access to technical training on more complex green building related work (such as solar technology, HVAC, and energy management) at a reasonable cost. According to the research, the Technical Education and Skills Development Authority (TESDA),[41] a government institution to develop technical and vocational skills in the Philippines, does not have a training or retraining effort focused on greening the construction sector.
- Brazil is undergoing a construction boom, and much of the labour requirement is being supplied by an inflow of people from other sectors,

[41] http://www.tesda.gov.ph

notably agriculture. The skills profile of most new entrants to construction is low. As a consequence, there is a major need for upskilling in the sector in well established skills, as well as in skills specifically relevant to green building. The mobility of construction workers and the reluctance of many to attend training off-site makes it difficult to service their training needs with traditional off-site training provision, and there are now initiatives to provide training on-site at the workplace. The first priorities in such provision are training in safety and in quality, but there is scope to provide training in skills for green building too.

- In India, 82 per cent of the workforce employed by the construction sector consists of unskilled workers without any formal education. By and large, skills development of this workforce category takes place through informal channels such as family occupations and on the job /working. For masons, for example, there is no formal training at educational institutions.

- Brazil and India are not the only emerging economies that have issues with low skills in construction. These issues are common across many developing economies where, even if skills in the formal construction sector are broadly adequate, there is often a large informal construction sector in which low skills are an important feature. The lack of adequate training initiatives to tackle these skills deficiencies will make it difficult to develop skills for green building across large parts of the construction sectors of countries that account for a large share of the new building work being undertaken globally.

Section
6
Skills Anticipation

6.1 Introduction

Where the report has focused on qualitative aspects of skills anticipation in green building up to this point, this section addresses the application of quantitative methods.

It will also look at skills anticipation for green building in action, highlighting the fact that governments, employer organizations, workers' organizations, providers of education and training, professional bodies and civil society organizations all play an active role in skills anticipation for green building.

6.2 Quantitative methods in skills anticipation for green building

6.2.1 Introduction

While policy makers and policy researchers in many countries have undertaken research into the skills requirements associated with green building, relatively few have studied the requirements quantitatively. The research undertaken for this project identified a number of cases where this has been done.

6.2.2 Examples of national level quantitative research

The research project reviewed research from a number of sources that addressed employment and skills requirements for aspects of green building at national level.

- The Centre for Climate Change and Sustainable Energy Policy (3CSEP) at the Central European University in Budapest, Hungary, undertook the most detailed and apparently rigorous national level study on the employment impacts of retrofitting that was reviewed focusing on Hungary (Ürge-Vorsatz et al, 2010). It set out five scenarios based on three different types of retrofitting approach (business as usual, suboptimal and deep) and a range of different rates at which retrofitting progresses (from 60,000 to 250,000 dwellings per annum). The study focused on residential and public buildings, and excluded commercial buildings. It classified residential buildings into 6 types: historical and protected buildings, pre-1960 traditional multi-family homes, multifamily homes pre- and post-1992 and single family homes pre- and post-1992.

  The study used two main methodologies to estimate employment impacts under each scenario.

  - Case studies were undertaken to identify actual employment associated with retrofitting projects, disaggregated between different levels of skill. The quantitative findings of these case studies were scaled up, based on the levels of activity assumed under each scenario, to estimate the direct employment impact of retrofitting activity under each scenario.
  - Input-output (I-O) modelling was undertaken to analyse wider employment impacts, including indirect and induced impacts. Assumptions about the labour intensity of retrofitting construction outputs were based on the most current available data. Costs were assumed to be constant for baseline and suboptimal retrofits, but it was assumed that they would fall for deep retrofits as the technology matured.

  Peak employment under the different scenarios varied from approximately 120,000 full time equivalent (FTE) workers under the fastest deep retrofit scenario to being maintained at less than 10,000 under the business as usual baseline scenario. Employment projections under each scenario were disaggregated between three skill levels: unskilled, skilled and professional.

- The Political Economy Research Institute (PERI) of the University of Massachusetts, Amherst in the US has undertaken research into the employment impact of retrofitting as a part of its work on assessing the employment

impacts of green elements of the ARRA stimulus package, which has supported "weatherization" work and other green activities. Its approach is broadly similar to that adopted by the Hungarian study described above, using a combination of case studies and input-output analysis, and indeed it is referenced prominently in the Hungarian report.

- Two published analyses (Comhar SDC, 2010; IIEA, 2009) of the employment potential of a national retrofitting initiative have been undertaken in Ireland, using broadly similar methodologies. In each case, the approach taken has been to start by estimating the number of homes of various types, each requiring a number of important retrofitting interventions. Key distinctions in classifying buildings are age, which substantially indicates the standard of energy efficiency to which each building was constructed, and whether the building is a single or multi-unit dwelling.

  The estimates are converted into the number of job years of work to be done by estimating the average cost of each intervention and the share of this cost that will be accounted for by labour, and then dividing the resulting estimate of expenditure on labour by average construction sector labour costs. The analyses each put forward various scenarios as to the amount of work to be done in practice and the rate at which these will be accomplished, and thereby generating scenarios for employment.

  All of the calculations are in current prices, with the implicit assumption being that relative prices will not change over the scenario periods.

  One study takes a simple multiplier approach to estimating the impact on employment elsewhere in the economy.

  As with the Hungarian study reviewed, different scenarios generated radically different employment projections.

6.2.3 Examples of supranational (EU level) research

A significant amount of quantitative research into the likely employment and skills impacts of aspects of green building has been undertaken at EU level.

- The European Trade Union Confederation (ETUC) has led a consortium studying the impacts of climate change on employment in the EU. Its 2007 report looked at employment impacts across a number of sectors, including the construction sector (ETUC et al, 2007), and addressed the direct employment impact of thermal insulation and energy efficiency works, including construction work on-site and the design and production of equipment.

The study presents four scenarios:[42]

- Under the Business as Usual (BAU) scenario, based on strict application of the directives on energy performance of buildings and final uses of energy and energy service, an additional 20,000 to 62,500 FTE jobs are created in EU15 countries, and 45,000 jobs in the 10 new Member States.
- Under the Eurima alternative scenario, which assumes the extension of the energy performance of buildings directive to all buildings, 50,000 to 150,500 jobs are created in EU15 countries, and 135,000 in the 10 new Member States. A more modest version of this projects 20,000 to 50,000 FTE jobs for the new Member States.
- Under the Factor 4 alternative scenario, which assumes a reduction of 75 per cent in CO_2 emissions from the residential sector in the long term, new jobs generated will reach either 1,377,000, or between 146,000 and 456,000, depending on assumptions made about the relationship between spending and jobs. Under an accelerated implementation variant, under which the work is completed by 2030, the higher estimate of the number of jobs rises to 2,585,000.

Under each of these scenarios, the approach taken is to estimate the value of work to be done and specify the time period over which it will be undertaken. This is converted to estimates of employment, using assumptions about spending per job. While the basic approach is simple, the approach taken for estimating the value of work to be done is instructive. The Factor 4 scenario estimates the markets for 16 countries separately. This is wise, given significant differences in the condition of the housing stock and in the potential for cost-effective energy efficiency improvements between countries.

- An ex-ante evaluation of the initiative on building workforce training and qualification in the field of energy efficiency and renewable energy within the Intelligent Energy Europe Programme undertaken on behalf of the Directorate-General for Transport and Energy (DG TREN) was published in 2010 (Williams et al, 2010). This estimated a target group requiring the skilling of over 2.5 million workers across EU25 countries between 2006 and 2015, made up of three components:
  - 1.141 million in target group as of 2006

[42] Job numbers quoted here are the number of full time equivalent (FTE) jobs that will exist simultaneously under the scenario. We do not repeat the terminology of "jobs per year" used in the report as we have seen this misread in other contexts as meaning that employment will grow at the number of jobs per year mentioned.

- 0.745 million from greening of other parts of construction workforce to 2015
- 0.677 million from target group's share of demand from the construction sector associated with expansion and with the replacement of people leaving the sector (projected by CEDEFOP) between 2006 and 2015.

Calculations of the size and composition of the target group were based on two per cent of managers and professionals working in the sector being employed as inspectors and auditors, five per cent of technicians and associate professionals being employed as technicians in relevant work, and with ten per cent of craft workers and five per cent of operatives and elementary occupations being employed as installers and technicians.[43]
The report does not explain how these proportions were estimated.

6.2.4 Estimating employment and skills impacts of green building quantitatively

The examples above illustrate a number of important issues with estimating employment and skills impacts of green building quantitatively.

Because green building encompasses diverse activities and skills, it is necessary to be specific about which of these are included in the calculations. Existing quantitative assessments focus mainly on skills required for retrofitting buildings for energy efficiency and installing renewable energy solutions at the building level. There is a broad array of other skills required for green building that have not been tackled quantitatively.

The more specific it is possible to be about the work that will be covered by the quantitative assessment, the more specific it is possible to be about the skills required quantitatively.

- PERI's work focuses narrowly on skills required arising directly from public spending on weatherization, so it is possible to be fairly accurate about the volume, composition and timing of work that will be involved, and therefore about the skills required and when they will be required.
- Most other analyses are quite uncertain about the volume and composition of retrofitting work that will be done, and the period over which it will be

[43] For expansion and replacement, the proportions were instead 25 per cent for craft workers and 10 per cent for operatives and elementary occupations.

accomplished,[44] reflecting uncertainty about future policy and about how owners of buildings will respond to policy and economic pressures favouring green building. Significant uncertainty about future developments in energy prices and green building technologies contribute further uncertainty about future activity, and therefore about skills requirements. In many cases, there is even significant uncertainty about the state of the existing stock of buildings. When these analyses seek to look to the future through an array of plausible scenarios, the high level of uncertainty leads to a very wide range of projected employment and skills outcomes.

- Some of the analyses put forward a proposed target for upgrading buildings, and assume that it will be achieved through some mix of policy measures and economic pressures over a stated timescale. They seek to project the skills implications of the specific works involved. By assuming away much of the uncertainty, this approach makes it possible to focus in on a single coherent projection or set of projections. Even so, minimizing the remaining uncertainty requires significant research. Of the approaches reviewed, the more reliable seem to be ones built up from: specific information about the profile of buildings in each country covered, specific proposals as to the composition of measures that will be taken to address their deficiencies, and empirical evidence as to the skills required to implement these measures (such as case studies).

- Employment impacts are not necessarily the same quantitatively as skills impacts. While some workers may specialize in retrofitting work, others may do it as part of a portfolio of work, or may do it for a time and then move to other construction related work. Projections of FTEs required may therefore substantially understate the number of people requiring skills.

It is useful to illustrate the extent of the uncertainty about the volume of skills required for retrofitting.

- The Hungarian study referenced earlier, by Ürge-Vorsatz et al (2010), presents a number of scenarios, and projects the direct employment impact of each. In addition to the base scenario, under which the pace of retrofitting remains unchanged, it presents a range of four scenarios. Three of these are based on a deep retrofitting target, and vary in the pace at which they are implemented, ranging from 20 years to 44 years. One is based on a less rigorous retrofitting target, and takes place over a period of approximately 30 years. Under the 20 year scenario, FTE employment in retrofitting ramps quickly up to

[44] Periods from approximately 10 to upwards of 40 years appear in the examples reviewed.

120,000 and then tapers towards 70,000, falling to zero in 2032. Under the scenario with the less rigorous target, employment ramps up to 30,000 and stays at that level until 2041.

- One of the Irish studies referenced earlier also presents a number of scenarios, and again projects the direct employment impact of each. It presents eight scenarios based on two different estimates of the volume of work to be done, and on doing it over periods ranging from 10 years to 20 years. Under the 20 year scenario with the lower volume estimate, employment remains around 5,000 to 6,000 over the period. Under the 10 year scenario with the higher volume estimate, employment ramps up quickly to 25,000, falling sharply at the end of the period.

The total person – years of work to be done under the Hungarian scenarios is much higher, in relation to the population, than under Irish scenarios. This may possibly reflect a less modern stock of housing and a lower average household size.

For the sake of illustration, if we average peak employment in retrofitting per capita for the highest Hungarian and highest Irish scenario, and for the lowest Hungarian and Irish scenarios, and scale up to the population of the EU-27 countries, this produces a low scenario of approximately one million jobs at peak, and a high scenario of 4 million jobs at peak. This does not give a reliable indication of the range of possible peak employment levels in retrofitting across the EU-27 countries, but it at least gives a sense of the order of magnitude involved.

While most existing quantitative policy research in the area focuses on the specific skills required for retrofitting, these questions are not the only ones that can be asked. Other possible perspectives include (but are not limited to) the following:

- Green building is moving to the mainstream, and as this progresses all activities associated with building construction and retrofitting will be greened. It may be argued, from this perspective, that the skills of all those working in the area will have to undergo a transition, whether minor or substantial. Occupational statistics by sector, such as those shown for EU25 countries in Tables 6.1 and 6.2 and figures 6.1-6.3, provide a quantitative indication on this.[45,46] Women remain largely underrepresented in the sectors most

[45] In looking at these tables, it should be borne in mind that not all of NACE 43 or NACE 71 is concerned with buildings. Much of NACE 43 is concerned with civil engineering works, and NACE 73 is concerned with a range of technical professional services and other technical services that goes beyond building and civil engineering.

[46] See the Appendix for a similar analysis that covers more sectors. For individual countries, more disaggregated statistics may be available, allowing finer analysis of occupations and/or sectors. Dots in these tables represent data that falls below publication thresholds, as is explained in more detail in the Appendix.

Table 6.1. EU-25 occupational employment in three sectors most associated with green building

		Construction of Buildings	Specialist Construction Activities	Architectural and engineering activities; technical testing and analysis
	NACE 2	41	43	71
	ISCO-88			
Architects, engineers and related professionals	214	239 000	165 000	1 106 000
Computing professionals	213	–	–	54 000
Physical and engineering science technicians	311	180 000	306 000	503 000
Safety and quality inspectors	315	–	–	64 000
Finance and sales associate professionals	341	54 000	92 000	38 000
Administrative associate professionals	343	84 000	102 000	62 000
Building frame and related trades workers	712	2 196 000	1 612 000	–
Building finishers and related trades workers	713	272 000	3 100 000	–
Painters, building structure cleaners and related trades workers	714	77 000	827 000	–
Metal moulders, welders, sheet metal workers, structural metal preparers and related trades workers	721	55 000	160 000	–
Blacksmiths, toolmakers and related trades workers	722	–	65 000	–
Machinery mechanics and fitters	723	20 000	108 000	32 000
Electrical and electrionic equipment mechanics and fitters	724	–	354 000	21 000
Wood treaters, cabinet makers and related trades workers	742	–	162 000	–
Motor vehicle drivers	832	82 000	85 000	–

		Construction of Buildings	Specialist Construction Activities	Architectural and engineering activities; technical testing and analysis
	NACE 2	41	43	71
	ISCO-88			
Agricultural and other mobile plant operators	833	124000	222000	–
Assemblers	828	–	62000	–
Mining and construction labourers	931	529000	228000	–
Managers	1	538000	485000	255000
Other professionals	Remainder 2	35000	37000	130000
Other technicians and associate professionals	Remainder 3	22000	33000	79000
Clerks	4	238000	479000	200000
Service workers and shop and market sales assistants	5	–	38000	–
Skilled agricultural and fisheries workers	6	–	–	–
Other craft and related trades workers	Remainder 7	–	94000	–
Other plant and machinery operators and assembers	Remainder 8	24000	98000	24000
Other elementary occupations	Remainder 9	56000	100000	26000
Armed forces	0	–	–	–
No answer		–	21000	–
Total		**4899000**	**9079000**	**2690000**

Source: Analysis of extraction from Labour Force Survey data provided by Eurostat.

Table 6.2. EU-25 occupational employment shares in three sectors most associated with green building

		Construction of Buildings	Specialist Construction Activities	Architectural and engineering activities; technical testing and analysis
	NACE 2	41	43	71
	ISCO-88			
Architects, engineers and related professionals	214	4.9%	1.8%	41.1%
Computing professionals	213	–	–	2.0%
Physical and engineering science technicians	311	3.7%	3.4%	18.7%
Safety and quality inspectors	315	–	–	2.4%
Finance and sales associate professionals	341	1.1%	1.0%	1.4%
Administrative associate professionals	343	1.7%	1.1%	2.3%
Building frame and related trades workers	712	44.8%	17.8%	–
Building finishers and related trades workers	713	5.6%	34.1%	–
Painters, building structure cleaners and related trades workers	714	1.6%	9.1%	–
Metal moulders, welders, sheet metal workers, structural metal preparers and related trades workers	721	1.1%	1.8%	–
Blacksmiths, toolmakers and related trades workers	722	–	0.7%	–
Machinery mechanics and fitters	723	0.4%	1.2%	1.2%
Electrical and electrionic equipment mechanics and fitters	724	–	3.9%	0.8%
Wood treaters, cabinet makers and related trades workers	742	–	1.8%	–
Motor vehicle drivers	832	1.7%	0.9%	–

		Construction of Buildings	Specialist Construction Activities	Architectural and engineering activities; technical testing and analysis
	NACE 2	41	43	71
	ISCO-88			
Agricultural and other mobile plant operators	833	2.5%	2.4%	-
Assemblers	828	–	0.7%	–
Mining and construction labourers	931	10.8%	2.5%	–
Managers	1	11.0%	5.3%	9.5%
Other professionals	Remainder 2	0.7%	0.4%	4.8%
Other technicians and associate professionals	Remainder 3	0.4%	0.4%	3.0%
Clerks	4	4.9%	5.3%	7.4%
Service workers and shop and market sales assistants	5	–	0.4%	–
Skilled agricultural and fisheries workers	6	–	–	–
Other craft and related trades workers	Remainder 7	–	1.0%	–
Other plant and machinery operators and assembers	Remainder 8	0.5%	1.1%	0.9%
Other elementary occupations	Remainder 9	1.1%	1.1%	1.0%
Armed forces	0	–	–	–
No answer		–	0.2%	–
Total		**100%**	**100%**	**100%**

Source: Analysis of extraction from Labour Force Survey data provided by Eurostat.

Figure 6.1. Most important occupations in sectors most associated with green building EU 25: Construction of buildings (NACE 41)

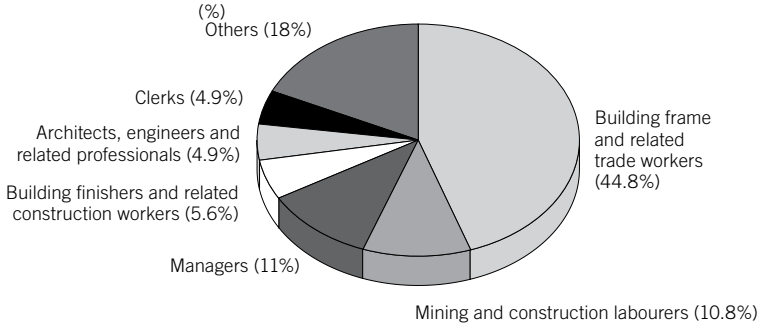


Figure 6.2. Most important occupations in sectors most associated with green building EU 25: Specialist construction activities (NACE 43)

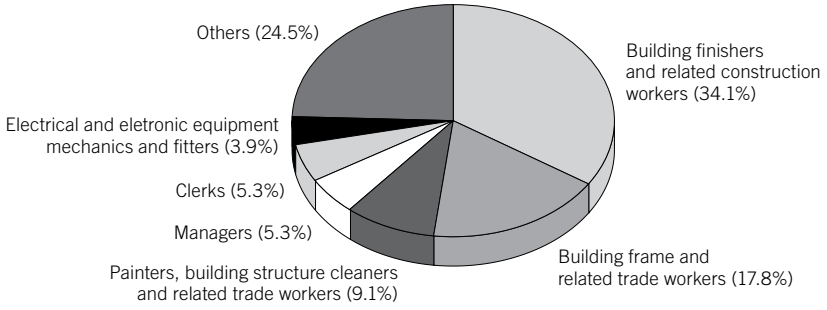


Figure 6.3. Most important occupations in sectors most associated with green building EU 25: Architectural and Engineering activities, technical testing and analysis (NACE 71)

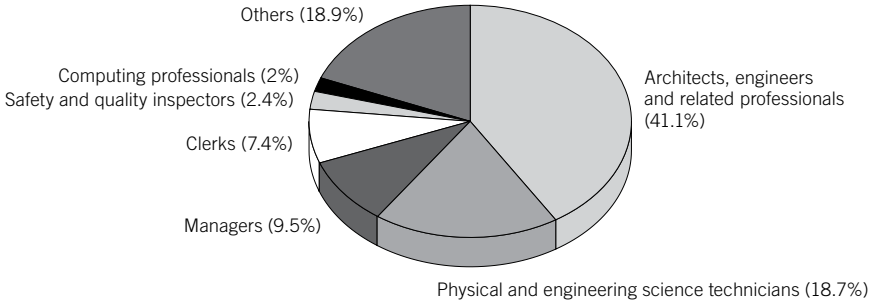


Figure 6.4. Employment in three sectors most associated with green building EU 25 (in Mio)

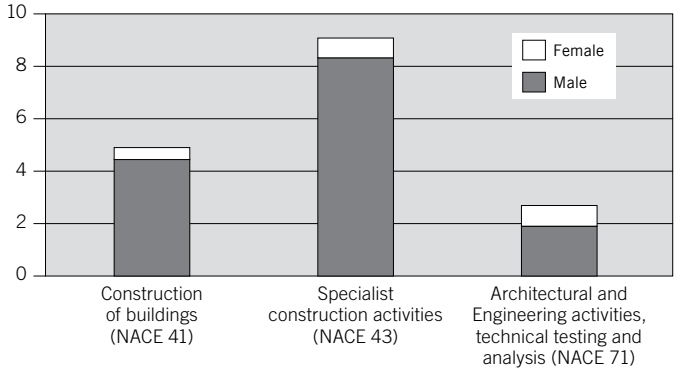
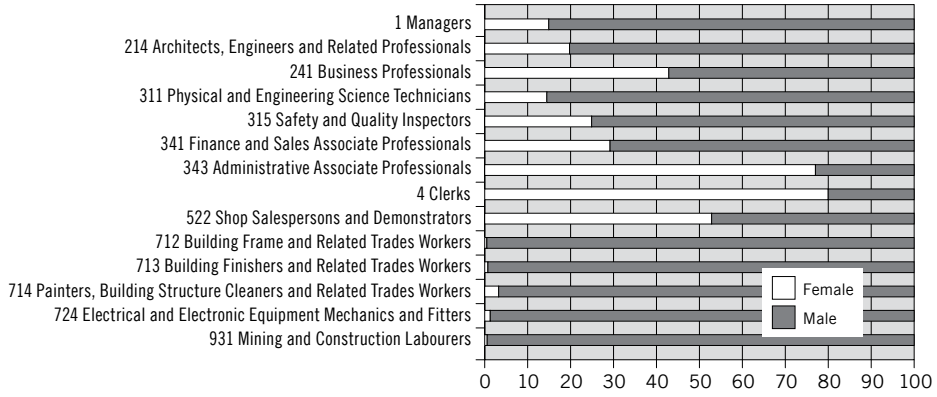


Figure 6.5. Share of female and male workers in selected occupations across NACE 41, 43 and 71, EU 25 (in per cent)



Source: Analysis of extraction from Labour Force Survey data provided by Eurostat.

associated with green building (see figure 6.4), except for a few occupations such as clerks, administrative associate professionals and shop salespersons and demonstrators (see figure 6.5).

- Even within the scope of activities associated with retrofitting, there can be a value in taking a wider perspective on skills. While a quantitative analysis of skills associated with retrofitting can be restricted to skills required for the installation and inspection of retrofitting measures, it can also focus on skills in areas such as project design, policymaking, commercial client skills or residential client skills.

- The green building product supply industries present within a specific country or region may be sufficiently coherent to justify a quantitative analysis of their skills requirements.

6.3 Green building skills anticipation in action

From reviewing research into green building, it is striking that governments, employer organizations, workers' organizations, providers of education and training, professional bodies and civil society organizations (such as green building councils, among others) all play a significant role in skills anticipation for green building. Not all are actively involved in every country reviewed, and not all anticipation initiatives encompass a range of interests, but the pattern whereby a range of interests gets involved is common.
It is logical that a wide range of interests would be interested in the area.

- If a government's priority in promoting green building is environmental policy, skills are an important enabling factor; therefore skills shortages and deficiencies threaten to damage policy implementation. If the priority is generating construction employment, then the question of the skills required comes to the fore immediately.
- From the perspective of employers in sectors related to building construction, green building is a growing area of opportunity that they need skills for to exploit. Skills deficiencies and shortages are also a threat in that: they will constrain the capability of an employer to exploit opportunities, may cause problems in complying with ever tightening building regulations, and there is much that can go wrong on a green building project if skills are deficient that can impose substantial rework costs on the employer and cause reputational damage.
- From the perspective of workers' representatives, green building is both an area with the potential to boost construction employment significantly and a key trend affecting the skills content of construction jobs.
- For providers of construction related education and training, green building is among the key trends affecting skills requirements to which they should respond when updating existing courses and developing new ones. Where demand for construction related courses is depressed, courses responding to the need for green building skills present an opportunity to attract more

learners. Employers' and workers' organizations are significant providers of training in many countries, and so their interests generally overlap with those of providers.

- For construction related professional bodies, green building is a key emerging area of activity to which they need to respond through their continuing development of professional activities, and through the influence they exert on provision from providers of construction related education and training.
- For green building councils, and for other civil society bodies concerned with promoting green building, skills development targeted on emerging skills needs is among their key areas of interest.

It is also logical that they would tend to cooperate on skills anticipation. In many contexts, ongoing construction skills anticipation activities involve employer, workers' representative organizations and providers of education and training anyway. An inclusive approach brings together multiple sources of often complementary expertise, and also contributes to developing a shared understanding that is useful in implementation of policy and training responses.

Section
7

Conclusions and Recommendations

7.1 Introduction

This section draws conclusions in the following areas:

- Strategic role of skills in green building
- Social dialogue in design and delivery of skills interventions for green building
- Need for training and education providers to prioritize green building
- Skills for vulnerable groups
- Need for a skills component to green building initiatives
- Assessment, advice and quality assurance
- Supply of trainers
- Innovation in training delivery
- Incentives to participate in training
- R&D on efficient low cost green building solutions
- Skills structure of skilled manual occupations
- Government Strategies

7.2 Strategic role of skills in green building

7.2.1 Overcoming barriers

There are significant barriers standing in the way of rapid progress in transforming the stock of building, and skills have a key role to play in overcoming them.

Cost of new green buildings

The cost of a new green building can be very similar to that of a new building designed traditionally, or it can be significantly more. This significant gap acts as a barrier to adoption.

If architects, civil engineers and building services engineers have strong skills in green building design, they will be able to maximize building sustainability and energy efficiency while still achieving a high standard of building functionality at a low, sometimes minimal or zero, cost premium.

Strong green building skills in other construction related occupations can contribute to this, ensuring that construction of new green buildings is undertaken efficiently, to a high standard and with a minimum of inefficient rework.

Cost of retrofitting projects

While investments in retrofitting for energy efficiency save money, in some cases payback periods are too long for the investment to be attractive financially to householders and businesses that do not have other substantial reasons to invest. The World Business Council for Sustainable Development (WBCSD) has found that "only a third of the investments required to achieve the IPCC's 77per cent emissions reduction target have discounted payback periods of 10 years or less". This is, for example, a major factor constraining installation of insulation on external walls and roofs in many countries.

Strong skills will not overcome this challenge by themselves, but by improving labour productivity they can reduce the payback period by enough to make some difference.

- Good retrofitting project design may succeed in reducing costs and/or improving energy savings.
- As labour accounts for a large share of the cost of retrofitting (often upwards from 50 per cent with wall insulation), maximizing labour productivity and eliminating the need for rework improves the economics of retrofitting. With skilled manual work of this nature, labour productivity and quality of work are both related closely to skills quality.

Maturing supply of green building services

Skills development plays an important role in moving green building technologies and techniques from early adoption to the development of mature mainstream markets. This is visible in many countries, where initiatives that have developed

green building skills at skilled manual and professional levels have created pools of skilled people with a strong interest in selling and delivering green building projects out of their own economic self-interest.

Over time, the accumulation of experience and competition between providers has matured green building processes and the green building value chain, improving labour productivity and making green building services more suited to the mainstream market.

Client skills

One of the major, widely recognized, factors that dissuades householders and businesses from purchasing green building projects is that there is typically a strong information asymmetry between the service provider who is very knowledgeable about the green building project and the client whose knowledge is limited. This creates a principal-agent problem, where the client (principal) cannot be sure that those providing green building services (agents) will act in the client's best interests.

As the market matures and services become more standardized, the severity of the information asymmetry decreases, reducing the extent of the principal-agent problem.

Education of potential purchasers of green building services plays an important contributory role in reducing the severity of the principal-agent problem in many countries. Examples of ways in which this operates include:

- awareness raising about green building through many channels including internet portals;
- television coverage of green building projects;
- adult education courses in green building;
- courses in energy management for facilities managers and general business managers; and
- education and training courses in energy management (higher education and TVET) to develop energy management specialists.

Training in business skills has the potential to make a useful contribution to maturing green building retrofitting as an industry. In many countries, significant numbers of small businesses are being formed in this area by skilled manual construction workers. Access to training in business skills including marketing, sales, operations management and quality assurance can help overcome management deficiencies, and thereby speed the maturing of the industry.

Skills in policy design

In all countries studied in which significant progress towards the transition to green building is being made, public policy is playing an important driving and enabling role. It is a complex area, with many choices to be made on regulations and on the design of economic incentives, and with many of these choices being made at multiple levels of government. The skills of those involved in policy design in this area will have a significant impact on the quality of the policy choices made. In turn, the policy choices made will have a major impact on the success of the transition to green building, as well as a major bearing on the economic efficiency of the transition.

Urban planning and enforcement

Urban planners have an important role in enabling and encouraging construction of green buildings and the renovation of buildings to make them more energy efficient and sustainable. Where public policy permits, they can do this through setting requirements that favour green building, through favouring plans that incorporate green building, through providing advice and support on green building to construction professionals, construction businesses and their clients, and through effective enforcement of green building regulatory requirements. Weaknesses in the enforcement of building regulations were identified by the research as a key factor limiting progress on building energy efficiency in a number of important emerging economies.

Where policy favours green building, the skills and knowledge of urban planners in the area are critically important to their ability to translate this policy into greener buildings.

7.2.2 Skills led green building strategies

The standard of energy efficiency and sustainability to which the mainstream of new buildings can be constructed, and to which renovations can be carried out, is constrained by the capabilities of the building construction value chain. If regulations require a level of energy efficiency far ahead of what can be constructed efficiently, this drives up construction costs and risks significant problems with non-compliance. While mainstream clients for building construction may be glad to get a greener building, most are unlikely to pay a large premium or to accept the use of techniques and technologies that are not well proven.

While most government strategies to promote green building are demand-led and focused on increasing demand for green building, there is also room for

supply led approaches, that focus particularly on boosting the supply of people with the skills required to deliver green building projects, both in terms of the number of people and in terms of their capabilities. Initiatives by professional institutes and bodies such as green building councils to provide training in green building to construction professionals are an important example of such a strategy. Initiatives by several governments to provide unemployed skilled manual construction workers with training in green building skills in areas such as insulation and the installation of solar thermal heating systems are another important example, even where the motivation is more about improving employability than driving green building forward.

Improving access to green building technologies is another supply led approach that can complement skills development. It is particularly relevant to developing countries where the penetration of green building is in many cases constrained in part by the lack of local sources of supply of green building materials and technologies, and the need to import them at a cost that puts them outside the means of most building construction projects.

7.3 Social dialogue in design and delivery of skills interventions for green building

Governments, employers' and workers' organizations have a shared interest in tackling skills gaps in the green building value chain. In many countries, they are already involved jointly or independently in anticipating and responding to the need for skills in green building, frequently along with providers of education and training related to construction, professional bodies and civil society organizations concerned with green building.

Governments, employers' organizations and workers' organizations all have capabilities that can be applied to meeting the need for skills.

- In most countries, all have relevant training and education capabilities.
- Employers' and workers' organizations have direct access to workers, and have a first-hand understanding and expertise in the nature of skills gaps and how they can most practicably be addressed. They bring different, but complementary, perspectives.
- Government sets the regulatory framework, and in many cases intervenes, directly and through indirect policy instruments, in support of the transition to green building.

For these reasons, dialogue between the social partners on anticipating and meeting the skills challenge is required to design and implement the best possible skills development responses.

7.4 Need for training and education providers to prioritize green building

A clear finding from the research is that it is important that providers of training and education that develop skills for construction related industries should prioritize skills for green building. Many already do this, but it is important that it should become more universal.

The need is both in initial training and education and in continuing education and training. It is relevant to education and training organizations, and to other bodies such as professional institutes and suppliers of construction goods and services that are also important players in construction industry training.

It is important at a wide range of levels; from raising the skills of unskilled construction labourers through the semi-skilled and skilled building trades, to construction professionals and managers of building businesses.

It is not only a matter of developing the skills required to conceive, design and construct exceptionally energy efficient and sustainable buildings. It is also a much more universal matter of developing the skills required to raise the energy efficiency and sustainability standards achieved by all new buildings and to improve the energy efficiency of existing buildings of substandard energy efficiency.

7.5 Skills for vulnerable groups

The research has highlighted two groups of workers in construction among whom there are serious problems with low levels of skill and qualification that make them vulnerable in the labour market, and constrain their ability to work on green building projects that require significant skills.

7.5.1 Informal building sector

Many developing economies have a large informal building sector that does not engage systematically in formal training arrangements, and which makes use of

a large amount of unskilled labour and people with skills that have been picked informally up on the job.

This is an important obstacle to green building. Very large numbers of new buildings are being constructed by the informal sector globally. As living standards rise, the standard of energy efficiency to which these buildings are constructed will have a major impact on greenhouse gas emissions.

Without additional training for these workers, and with many of these buildings being constructed outside the building regulatory framework, the prospects for building them to even minimally satisfactory sustainability standards are low. Without additional training, the prospects for making energy efficiency, water and other standards comparable to those in developed countries affordable to the majority of individuals and businesses are low.

In addition to being a challenge to the transition into a greener economy, this is also a Decent Work challenge. Low skills impact on the productivity and quality of work, impacting on the pay these workers can attract, and making their employment more precarious than it would otherwise be.

These two factors together make the informal building sector a good target for initiatives to improve skills. The evidence on effective mechanisms to reach these workers favours on-site training for those on substantial building sites, whether provided by training institutions, employers' or workers' organizations. For those working irregularly and on smaller projects, initiatives by training institutions and workers' organizations to provide training at times and places that suit informal workers will be needed.

Training in skills relating to green building appropriate to local conditions should form a significant part of these initiatives. Topics that will be relevant in many cases include: building energy efficiency, building water efficiency, insulation, passive techniques, solar photovoltaic systems and solar thermal systems, and using locally available materials, among others. Skills in more traditional areas should also be addressed, as these are needed for green building too, and training in these areas will be more generally important to addressing the vulnerability of workers in the informal construction sector.

7.5.2 Migrant construction workers

The problems with informal construction sectors in many developing countries are reflected in some of the more developed countries that are host to substantial numbers of migrant construction workers. For a number of these countries, the research highlighted deficiencies in skills that impact on the capability of the

building sector to deliver green building projects efficiently and to a high standard of quality.

As in developing countries, these skills deficiencies also pose a Decent Work challenge. Again, low skills impact on the productivity and quality of work including occupational health and safety issues, impacting on the pay these workers can attract and on types of contracts, and making their employment more precarious than it would otherwise be.

With well developed training systems available in most cases, these countries should take a tripartite approach to considering how the skills deficiencies in their construction labour force can best be addressed.

7.6 Need for a skills component to green building initiatives

It is apparent from the research undertaken that shortages of skills in green building identified by people, businesses, governments and representative organizations for employers and workers are frequently associated with initiatives to promote more green building that increase the demand for green building skills without at the same time taking sufficient action to provide for the resulting skills needs.
For example:

- Measures for implementing building energy efficiency assessments require the training of sufficient energy efficiency assessors.
- Measures to promote the installation of wall and roof insulation require the training of enough people to do the work, either through adding to the skills of existing skilled construction trades workers who specialize in a related area, or through more extensive training for people without existing skills.

The training does not always have to be provided as a part of the green building initiative, but there has to be an accessible way for businesses and individuals to source the training required if it is not. Plans for green building initiatives should include a plan for how the required skills will be sourced. If it is likely that the supply of skills will take time to ramp up, activity under the initiative should be planned to ramp up too, so that demand for skills does not move far ahead of the expected supply.

The need for training applies to active labour market programmes to create jobs in green building, as much as to other types of initiative. It is important that such programmes include a training complement.

7.7 Assessment, advice and quality assurance

A critical issue in green building is where householders, businesses and other green building clients can get reliable advice on what green building measures they should take. This is a universal issue.

There are different practices in different countries, and mechanisms vary within countries and between types of client. Advice can come from building professionals, including architects, civil engineers and building services engineers, from skilled construction trades workers with specialist training, from specialist energy efficiency advisers whose education may be in a discipline such as energy management, or from managers and sales staff of building energy efficiency businesses. It can come as solicited advice from a non-commercial service, as unsolicited advice from an inspection service,[47] as advice from a professional commercial provider (such as an architect), or as advice from a business providing energy efficiency services.

Clients need convenient access to reliable advice at a cost that does not deter them. There are not many cases where the solutions currently in place are satisfactory on all of these dimensions. For example, businesses providing retrofitting services can be the most convenient and lowest cost source of advice for householders, but internationally many are observed to advise householders to take the services they understand best, and have the capability to supply, rather than providing a holistic assessment of the building's retrofitting requirements.

The need for advice shares skills and knowledge content with three other important needs, and in many cases, the same person takes on two, three or even four of the roles. The other needs are for:

- reliable assessment of the energy efficiency of a building to be retrofitted;
- design of green building solutions, new and retrofit; and
- the need for reliable quality assurance on green building works.

There is no single optimal way to deliver these services. In some countries, they are provided mainly commercially, in others, advisery services are available, at least for retrofitting. In some countries, some or all of these services are provided as part of financing and other initiatives to promote retrofitting. A government providing subsidies needs to know that subsidized works are based on a good assessment of needs, and carried out to a high standard. A utility supporting retrofitting under an energy efficiency obligation, or likewise an energy service company (ESCO) recovering

[47] For example, chimney sweeps undertake unsolicited inspections in Germany.

the costs of retrofitting its clients' buildings from subsequent savings, need to ensure that projects are well designed and that works comply with specifications.

However the services are delivered, a strong supply of people with skills in energy efficiency assessment, advice, design and quality assurance across all the occupational groups involved in providing these services provides the best possible assurance that people and businesses will have convenient access to reliable services at a cost that reflects competitive market conditions.

People who layer skills in assessment and advising on building energy efficiency on top of existing construction industry skills have a large part of the base of skills and knowledge that they need to also work in design of energy efficiency projects and to undertake quality assurance.

Therefore, key areas for action on skills include:

- Training for substantial numbers of people with existing construction skills, leading to one or more standard qualifications in building energy assessment where this is not already in place; and
- Training in provision of advice on building energy efficiency for substantial numbers of people with construction skills at both professional and skilled manual levels, again leading to standard qualifications.

7.8 Supply of trainers

In many cases, one of the main choke points constraining employers and providers of education and training from responding adequately to changing skills requirements associated with green building is a shortage of suitable trainers and educators.

The biggest issue is that it is necessary to add to the skills and knowledge of people already working in training and education for the construction sector, at levels from training unskilled labourers in health and safety to educating professionals in disciplines including architecture and engineering.

There is also a need to train people to work as trainers and educators for new and fast growth occupations, where the need may be not just to train people differently but also train considerably more people. Examples of these occupations depend on the country context, but in some countries include energy auditors and specialist craft occupations such as solar photovoltaic installer.

Appropriate responses to these needs are diverse, and depend on the extent of the need to broaden the skills of people already working in training and

education for the construction sector, on the existing base of skills among people recruited from other occupations to work as trainers and educators, and on the level at which the training is to be delivered.
Good responses may include the following.

- Provision of train-the-trainer or continuing professional development courses for trainers and educators. These are particularly appropriate where a uniform new curriculum is being rolled out across multiple providers of training and education.
- Conferences and seminars on new techniques and technologies, targeting trainers and educators. These are particularly appropriate where trainers and educators design course content and choose pedagogical approaches themselves.
- Support for research relating to green building. Research is one of the main mechanisms through which teachers in higher education update their knowledge, allowing them to maintain and improve the relevance of their teaching.
- Initiatives to research good practice in training and education for green building. For example, the UK's Higher Education Academy, has an *Education for Sustainable Development* project. The EU has contributed to work of this sort through the Intelligent Energy Europe programme, which has supported projects addressing a range of occupational areas including, among others, architecture and the installation of small-scale renewable energy installations.

Governments and agencies responsible for promoting green building should invest the modest resources required to support responses such as these in a way that is appropriate to their country's institutional framework.

7.9 Innovation in training delivery

The key areas where there is scope for innovation in training delivery for skills in green building are in:

- bringing training to the workplace; and
- use of e-learning and blended learning approaches.

In countries where systems for construction industry training are not well developed, or where there is a substantial informal construction sector, reaching the manual construction labour force with training in green building techniques and technologies is challenging. On the basis of the research undertaken, it appears

that bringing training to the workplace is one of the most effective ways to address this challenge. Not only does it minimize disruption to construction operations, whether the training is undertaken during or outside working hours and provide a strong behavioural "nudge" to businesses and individuals to participate, it also recognizes that an unusually high level of motivation is necessary for people working long hours to spend significant time travelling to and from a training institution after work in addition to time spent in training.

In countries such as these, providers of education and training in construction skills and organizations promoting green building should seek to reach the broad manual construction workforce with training in skills for green building, and should strongly consider bringing training to the workplace to achieve this.

One of the main areas of innovation in the delivery of training and education globally is in the rising use of e-learning techniques, which are frequently combined with more traditional techniques to blend learning approaches. Under ideal conditions, e-learning can be used to cut the marginal cost of training close to zero and make it near-universally available by eliminating the need for trainers and making it accessible over the Internet.

In practice, ideal conditions are rare. For many areas of skill in green building, it is important that skills be practiced, and that they should be assessed by an expert trainer or assessor. Even in less hands-on areas of skills in green building a dialogue between trainee and trainer is important to ensure that key concepts are grasped and can be applied properly.

More generally, training systems that rely only on e-learning are prone to problems with trainees losing interest, and to being compromised by difficulties where literacy is weak or trainees are insufficiently familiar with computers.

Even so, there is significant scope for e-learning technologies to be used in support of other instructional approaches. One of the areas where e-learning often works best is in areas where it is necessary to ensure that workers cover very specific content, and where they are obliged to prove they have done this in order to work. E-learning materials (including instructional video, interactive content and tests to ensure the material has been absorbed) may be particularly well suited to complementing the work of trainers in health and safety and in installing specific technologies where certification is required. E-learning materials may also be very well suited to complementing the work of trainers preparing professionals to undertake regulatory functions such as energy audits, and preparing them to work as energy advisers where a high minimum standard of skills is required in quite a tightly delimited domain of expertise.

7.10 Incentives to participate in training

Even in many countries with established systems for continuing training, it is common for workers employed by small and medium-sized enterprises (SMEs), or working as individual contractors, to receive less training than those employed in larger businesses. In addition, construction is a sector in which workers receive less training than average; six hours in 2005 compared with an average of nine across all sectors surveyed in the EU's CVTS3 Eurostat survey.

There is a need to ensure that those working in construction receive sufficient training to develop the green building skills that are required. Different countries have different mechanisms to promote continuing training provision and to motivate workers in SMEs to take it up. They should apply these mechanisms to promote the provision and uptake of continuing education and training courses in green building skills.

7.11 R&D on efficient low cost green building solutions

Cost is a significant constraint on important types of investment in green building.

In the case of retrofitting, some key types of investment, such as external wall insulation, are at best marginally economically attractive to building owners under conditions in many countries, based on savings from reduced energy consumption. The wall insulation example is a function both of the cost of the materials and the labour-intensive character of the installation work.

In the case of new buildings, levels of energy efficiency well in advance of current standards are feasible at costs close to those of traditionally constructed buildings, given good design. However, buildings constructed to exceptionally high standards of energy efficiency still cost significantly more. Labour intensivity of installation work is again a factor in this for some technologies.

Making progress on green building depends in part on extending the range of technologies whose installation can be justified on cost saving grounds alone. This requires continuing research and development into efficient low cost green building solutions.

The connection to skills is twofold:

1. that there is a need to invest in R&D skills relevant to developing and improving green building technologies and techniques, for example through research funding for civil engineering, materials engineering and architecture; and

2. that this sort of innovation has the potential to tip the balance of economic advantage in favour of some important types of labour-intensive green building intervention, likely to boost demand for skills in installing green building technologies.

7.12 Skills structure of skilled manual occupations

There are considerable variations between countries in the skills content and the structure of manual occupations in construction.

- In many countries, particularly developed countries, there is a strong emphasis on initial the training of construction workers. A large share of all those doing manual work have substantial qualifications and a well rounded base of skills, most often from a formal structured apprenticeship.
- In contrast, in many less developed countries a large share of the construction workforce has very limited skills, mostly learned on the job.
- In some developing countries, there is a split between a formal and an informal construction sector. Those working in the formal sector are more likely to have substantive formal training, and those in the informal sector to have low skills learned on the job. The boundary between the two sectors is far from rigid, with many skilled and unskilled workers moving from one to the other based on the availability of work.

Where there are well developed systems of training, there are usually well defined occupational structures with clear divisions as to what construction work should be undertaken by which occupation. The emergence of green building, with new technologies and construction techniques, raises issues as to which occupations should do what green building work. As the installation of green technologies in many cases involves skills that cross existing occupational boundaries, it also raises issues as to whether an installation can be done by just one person, and, if not, how best to coordinate across occupational boundaries.
These issues are being resolved in different ways in different countries.

- In some cases, mainly where occupations have a strong institutional position, responsibility for a new or growing area of activity is being taken on by a specific occupation. For example, in Germany, painters/decorators install wall insulation.
- Where occupations are less strong institutionally, responsibility for a new or growing area of activity is usually being taken on by people from a mix of

related occupations. For example, in Ireland exterior wall insulation is mostly being installed by blocklayers and plasterers, and interior wall insulation is mainly being installed by a mix of semiskilled workers and plasterers; painters/decorators are brought in to finish the work.

- In some cases, even where a new area of activity is mostly within the competence of an existing occupation, initial training is provided specifically in the new area, effectively forming a new occupation. Examples include installers of solar thermal systems and installers of solar photovoltaic panels. While both of these require some skills in other areas, particularly roofing, the main content of the occupations overlaps with the occupations of plumber (solar thermal) and electrician (solar photovoltaic).

However, two significant issues remain common.

1. Problems often arise on retrofitting jobs where those involved do not have a broad understanding of green building. When asked for advice, their response may not identify everything that should be done. When delivering projects, they may not work efficiently with people from other occupations because they do not understand the whole process. Knowledge cutting across occupational boundaries is more important in retrofitting work than in building construction work generally.
   Responses to this issue include:
   - training for skilled construction trades workers and supervisors on green building projects to develop the knowledge and skills they require to team effectively with other occupations in the delivery of retrofitting projects; and
   - training for new occupations that crosses existing occupational boundaries (for example, training for installers of photovoltaic panels that includes electrician and some roofing skills, as noted earlier). There are wider suggestions in the literature reviewed that multidisciplinary training could be provided, for example to give plumbers the electrical skills required in the installation of high efficiency boilers and heating controls.
2. At least some courses focused on new skilled manual occupations appear to be too narrow. For example, in some countries problems with maintenance of solar thermal and photovoltaic systems lead to significant numbers of systems breaking down and not being repaired. These problems are partly a consequence of there being subsidies for installation and none for maintenance, but they appear to also be related to training for installers not also focusing on maintenance.

These issues have two important implications for training of skilled construction trades workers to work on green building projects:

1. The training should be broad enough to give them a good understanding of energy efficiency projects as a whole, and not just in the specific areas where they will work, and to prepare them to work efficiently in teams with other occupations. For senior skilled construction trades workers, this should include training in leading green building retrofit projects, and advising on energy efficiency.
2. Specialist initial training in installing green building technologies should be broad enough to prepare skilled construction trades workers to work on the technology through its lifecycle, from installation, through maintenance during its lifetime, to removal, disposal and recycling at the end of its life.

7.13 Government strategies

Based on the conclusions above, the main implications for government strategies for green building are as follows.

Skills have a strategically important role in developing green building. They are so important to enabling the success of other types of strategy for green building that every government initiative to promote and develop green building should have a skills component to it.

Skills led strategies to develop green building can give governments allies in their efforts to promote green building, and should be considered by governments when choosing from among the available policy instruments that can be applied.

Governments should consider addressing the following types of skills related issues in their strategies for green building:

- the need for social dialogue in the design and delivery of skills interventions for green building
- the need to ensure that vulnerable groups in the building sector have access to training in green building skills
- the need to ensure that well functioning services providing assessment, advice and quality assurance on green building projects are available at reasonable cost to householders and businesses, underpinned by an adequate supply of high quality skills in these areas
- the need to ensure that training and education systems influenced by the government develop the training skills for green building required to enable the delivery of an adequate volume of high quality green building training

- the need to encourage innovation in training delivery so as to reach more people with training in green building skills
- the need for governments to apply the systems they have in place to promote training at SMEs and among other groups that often under-train to developing skills for green building
- the need to support research relevant to green building so as to ensure that adequate skills in R&D are available to drive innovation in cost efficient green building solutions forward
- whether, given their own country context, there is a need to intervene to shape the structure of new and changing occupations associated with green building.

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Appendix

Employment Data

As a sample survey, the Labour Force Survey is subject to sampling errors. In consideration of this, Eurostat sets minimum thresholds below which data should not be published. In the case of EU 25 data for this quarter, the threshold is 20,000. Conventionally, data points below this threshold are replaced by a dot. For cells where there are no underlying data (for example, for many sectors no armed forces occupations are recorded), a dash has been used instead.

Table A.1. Occupational employment in main sectors relevant to green building, EU-25, Q4 2010

		Construction of Buildings	Specialist Construction Activities	Architectural and engineering activities; technical testing and analysis	Real Estate Activities
	NACE 2	41	43	71	68
	ISCO-88				
Architects, engineers and related professionals	214	239 000	165 000	1 106 000	36 000
Computing professionals	213	–	–	54 000	–
Physical and engineering science technicians	311	180 000	306 000	503 000	27 000
Safety and quality inspectors	315	–	–	64 000	–
Finance and sales associate professionals	341	54 000	92 000	38 000	447 000
Administrative associate professionals	343	84 000	102 000	62 000	123 000
Building frame and related trades workers	712	2 196 000	1 612 000	–	21 000
Building finishers and related trades workers	713	272 000	3 100 000	–	20 000
Painters, building structure cleaners and related trades workers	714	77 000	827 000	–	–
Metal moulders, welders, sheet metal workers, structural metal preparers and related trades workers	721	55 000	160 000	–	–
Blacksmiths, toolmakers and related trades workers	722	–	65 000	–	–
Machinery mechanics and fitters	723	20 000	108 000	32 000	–
Electrical and electronic equipment mechanics and fitters	724	–	354 000	21 000	–
Wood treaters, cabinet makers and related trades workers	742	–	162 000	–	–

	Total Manufacturing	Electricity, gas, steam and air conditioning supply	Public administration and defence; compulsory social security	Education	Civil Engineering	Rest of economy	Total EU 25. All Sectors
	Section C	35	84	85	42		
	1 361 000	141 000	240 000	110 000	141 000	2 377 000	5 915 000
	285 000	29 000	118 000	49 000	–	2 284 000	2 852 000
	1 838 000	169 000	274 000	103 000	95 000	3 067 000	6 560 000
	322 000	–	94 000	–	–	516 000	1 066 000
	863 000	59 000	147 000	38 000	–	5 723 000	7 476 000
	622 000	77 000	876 000	182 000	28 000	3 732 000	5 888 000
	386 000	–	51 000	–	267 000	633 000	5 200 000
	472 000	94 000	113 000	24 000	104 000	957 000	5 175 000
	162 000	–	22 000	–	–	656 000	1 768 000
	1 460 000	21 000	–	–	36 000	1 881 000	3 631 000
	1 426 000	–	–	–	–	1 582 000	3 122 000
	1 430 000	28 000	57 000	–	31 000	3 337 000	5 060 000
	679 000	169 000	46 000	–	37 000	1 399 000	2 732 000
	696 000	-	–	–	-	815 000	1 698 000

		Construction of Buildings	Specialist Construction Activities	Architectural and engineering activities; technical testing and analysis	Real Estate Activities
	NACE 2	41	43	71	68
	ISCO-88				
Motor vehicle drivers	832	82 000	85 000	–	–
Agricultural and other mobile plant operators	833	124 000	222 000	–	–
Assemblers	828	–	62 000	–	–
Mining and construction labourers	931	529 000	228 000	–	–
Managers	1	538 000	485 000	255 000	244 000
Other professionals	Remainder 2	35 000	37 000	130 000	62 000
Other technicians and associate professionals	Remainder 3	22 000	33 000	79 000	48 000
Clerks	4	238 000	479 000	200 000	278 000
Service workers and shop and market sales assistants	5	–	38 000	–	32 000
Skilled agricultural and fisheries workers	6	–	–	–	–
Other craft and related trades workers	Remainder 7	–	94 000	–	–
Other plant and machinery operators and assembers	Remainder 8	24 000	98 000	24 000	–
Other elementary occupations	Remainder 9	56 000	100 000	26 000	276 000
Armed forces	0	-	-	-	-
No answer		–	21 000	–	–
Total		**4 899 000**	**9 079 000**	**2 690 000**	**1 674 000**

Source: Analysis of extraction from Labour Force Survey data provided by Eurostat.

	Total Manufacturing	Electricity, gas, steam and air conditioning supply	Public administration and defence; compulsory social security	Education	Civil Engineering	Rest of economy	Total EU 25. All Sectors
	Section C	35	84	85	42		
	425 000	–	136 000	–	83 000	5 625 000	6 478 000
	481 000	–	51 000	-	219 000	1 181 000	2 287 000
	1 361 000	–	–	–	–	1 512 000	2 978 000
	40 000	–	90 000	–	206 000	204 000	1 321 000
	2 381 000	136 000	737 000	454 000	144 000	14 961 000	20 190 000
	776 000	88 000	2 327 000	8 792 000	32 000	11 878 000	24 125 000
	727 000	41 000	2 163 000	2 156 000	–	12 728 000	17 998 000
	2 642 000	216 000	2 670 000	795 000	100 000	17 452 000	24 971 000
	780 000	–	1 954 000	1 328 000	–	25 349 000	29 522 000
	54 000	–	140 000	34 000	–	6 640 000	6 902 000
	2 894 000	–	50 000	–	–	4 140 000	7 213 000
	4 987 000	100 000	34 000	–	29 000	6 278 000	11 565 000
	2 191 000	42 000	1 109 000	1 195 000	36 000	15 758 000	20 754 000
	–	-	1 299 000	–	-	22 000	1 326 000
	136 000	–	39 000	103 000	–	636 000	964 000
	31 880 000	**1 511 000**	**14 876 000**	**15 502 000**	**1 687 000**	**153 323 000**	**236 737 000**

Table A.2. Occupational employment shares in main sectors relevant to green building, EU-25, Q4 2010

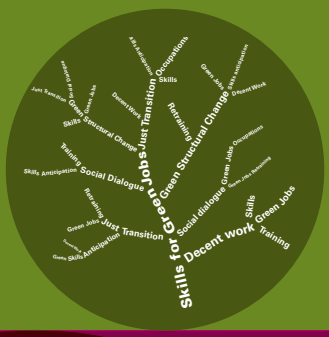
		Construction of Buildings	Specialist Construction Activities	Architectural and engineering activities; technical testing and analysis	Real Estate Activities
	NACE 2	41	43	71	68
	ISCO-88				
Architects, engineers and related professionals	214	4.9%	1.8%	41.1%	2.1%
Computing professionals	213	–	–	2.0%	–
Physical and engineering science technicians	311	3.7%	3.4%	18.7%	1.6%
Safety and quality inspectors	315	–	–	2.4%	–
Finance and sales associate professionals	341	1.1%	1.0%	1.4%	26.7%
Administrative associate professionals	343	1.7%	1.1%	2.3%	7.4%
Building frame and related trades workers	712	44.8%	17.8%	–	1.3%
Building finishers and related trades workers	713	5.6%	34.1%	–	1.2%
Painters, building structure cleaners and related trades workers	714	1.6%	9.1%	–	–
Metal moulders, welders, sheet metal workers, structural metal preparers and related trades workers	721	1.1%	1.8%	–	–
Blacksmiths, toolmakers and related trades workers	722	–	0.7%	–	–
Machinery mechanics and fitters	723	0.4%	1.2%	1.2%	–
Electrical and electronic equipment mechanics and fitters	724	–	3.9%	0.8%	–
Wood treaters, cabinet makers and related trades workers	742	–	1.8%	–	–

	Total Manufacturing	Electricity, gas, steam and air conditioning supply	Public administration and defence; compulsory social security	Education	Civil Engineering	Rest of economy	Total EU 25. All Sectors
	Section C	35	84	85	42		
	4.3%	9.3%	1.6%	0.7%	8.3%	1.6%	2.5%
	0.9%	2.0%	0.8%	0.3%	–	1.5%	1.2%
	5.8%	11.2%	1.8%	0.7%	5.6%	2.0%	2.8%
	1.0%	–	0.6%	–	–	0.3%	0.5%
	2.7%	3.9%	1.0%	0.2%	–	3.7%	3.2%
	2.0%	5.1%	5.9%	1.2%	1.7%	2.4%	2.5%
	1.2%	–	0.3%	–	15.8%	0.4%	2.2%
	1.5%	6.2%	0.8%	0.2%	6.2%	0.6%	2.2%
	0.5%	–	0.2%	–	–	0.4%	0.7%
	4.6%	1.4%	–	–	2.1%	1.2%	1.5%
	4.5%	–	–	–	–	1.0%	1.3%
	4.5%	1.9%	0.4%	–	1.8%	2.2%	2.1%
	2.1%	11.2%	0.3%	–	2.2%	0.9%	1.2%
	2.2%	–	–	–	–	0.5%	0.7%

		Construction of Buildings	Specialist Construction Activities	Architectural and engineering activities; technical testing and analysis	Real Estate Activities
	NACE 2	41	43	71	68
	ISCO-88				
Motor vehicle drivers	832	1.7%	0.9%	–	–
Agricultural and other mobile plant operators	833	2.5%	2.4%	–	–
Assemblers	828	–	0.7%	–	–
Mining and construction labourers	931	10.8%	2.5%	–	–
Managers	1	11.0%	5.3%	9.5%	14.6%
Other professionals	Remainder 2	0.7%	0.4%	4.8%	3.7%
Other technicians and associate professionals	Remainder 3	0.4%	0.4%	3.0%	2.8%
Clerks	4	4.9%	5.3%	7.4%	16.6%
Service workers and shop and market sales assistants	5	–	0.4%	–	1.9%
Skilled agricultural and fisheries workers	6	–	–	–	–
Other craft and related trades workers	Remainder 7	–	1.0%	–	–
Other plant and machinery operators and assembers	Remainder 8	0.5%	1.1%	0.9%	–
Other elementary occupations	Remainder 9	1.1%	1.1%	1.0%	1.6.5%
Armed forces	0	–	–	–	–
No answer		–	0.2%	–	–
Total		**100%**	**100%**	**100%**	**100%**

Source: Analysis of extraction from Labour Force Survey data provided by Eurostat.

	Total Manufacturing	Electricity, gas, steam and air conditioning supply	Public administration and defence; compulsory social security	Education	Civil Engineering	Rest of economy	Total EU 25. All Sectors
	Section C	35	84	85	42		
	1.3%	–	0.9%	–	4.9%	3.7%	2.7%
	1.5%	–	0.3%	–	13.0%	0.8%	1.0%
	4.3%	–	–	–	–	1.0%	1.3%
	0.1%	–	0.6%	–	12.2%	0.1%	0.6%
	7.5%	9.0%	5.0%	2.9%	8.6%	9.8%	8.5%
	2.4%	5.8%	15.6%	56.7%	1.9%	7.7%	10.2%
	2.3%	2.7%	14.5%	13.9%	.	8.3%	7.6%
	8.3%	14.3%	17.9%	5.1%	5.9%	11.4%	10.5%
	2.4%	–	13.1%	8.6%	–	16.5%	12.5%
	0.2%	–	0.9%	0.2%	–	4.3%	2.9%
	9.1%	–	0.3%	–	–	2.7%	3.0%
	15.6%	6.6%	0.2%	–	1.7%	4.1%	4.9%
	6.9%	–	7.5%	7.7%	2.1%	10.3%	8.8%
	–	–	8.7%	–	–	0.0%	0.6%
	0.4%	–	0.3%	0.7%	–	0.4%	0.4%
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**



Skills and Occupational Needs in Green Building

Demand for workers in retrofitting and new green construction is expected to grow over the coming years. Securing an adequate supply of suitably skilled workers is essential to capitalize on opportunities to further develop the sector and its potential to create jobs. Within this context, adequate training provision is vital to success. Green sectors will require new skills needs related to energy efficiency, water management and renewable energies in buildings. At times this may lead to the development of new occupations, such as energy efficiency analysts, but more frequently skills for many existing occupations, such as plumbers and electricians, will need to be upgraded. Workers displaced from declining sectors, including the traditional construction sector, may successfully relocate to green building, provided that relevant retraining programmes are accessible. Training offered in green building has increased notably over the past few years; however, employers still face difficulties finding qualified people to perform certain jobs. Skills-led strategies can drive the green building sector forward.

The study *Skills and Occupational Needs in Green Building* brings together the findings from 34 countries. It arises from a joint management agreement between the European Commission and the ILO on *Knowledge sharing in early identification of skill needs*. Two additional reports resulted from this cooperation: *Skills and Occupational Needs in Renewable Energy* and *Comparative Analysis of Methods of Identification of Skill Needs on the Labour Market in Transition to the Low Carbon Economy.*

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