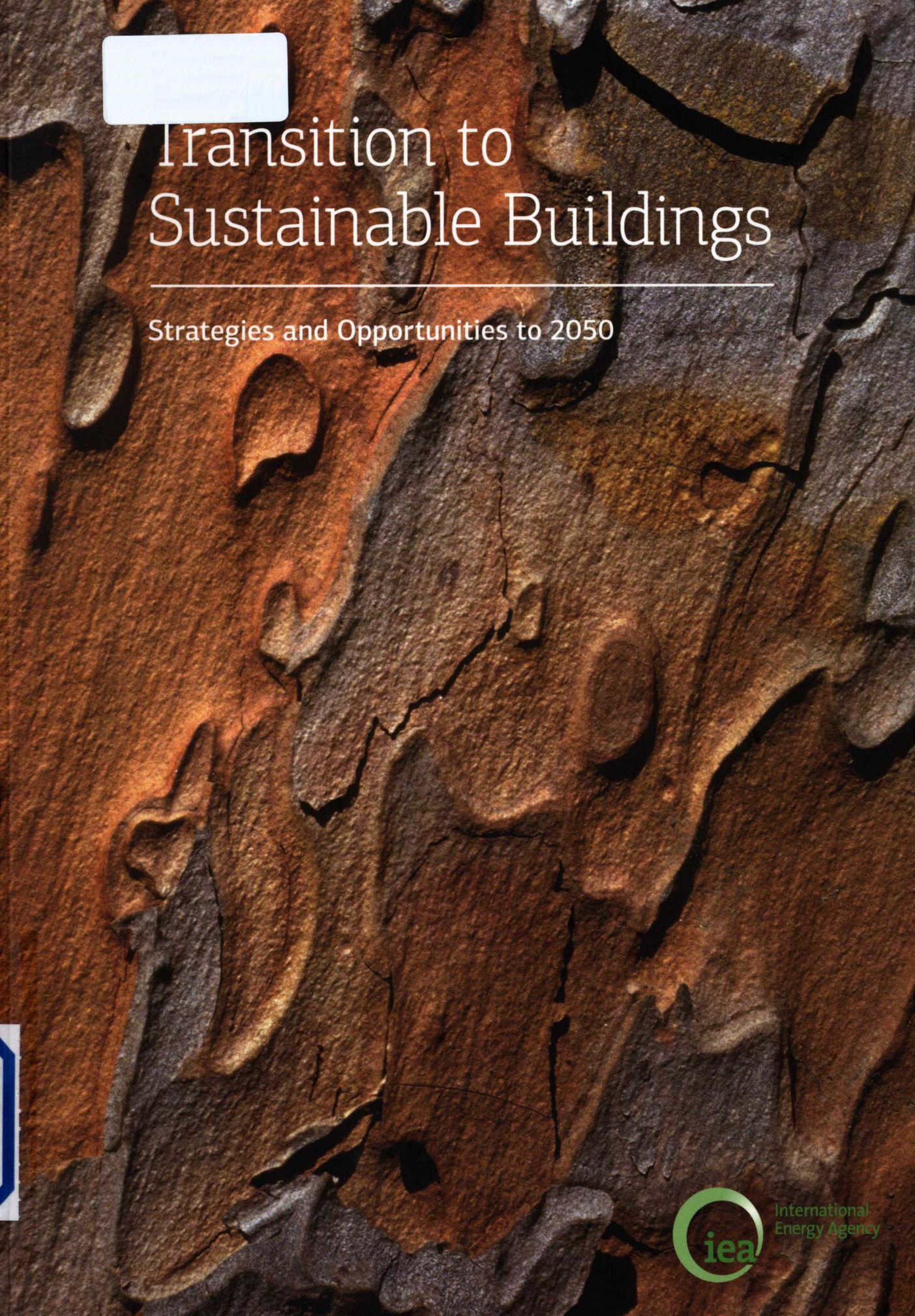
Transition to Sustainable Buildings

Strategies and Opportunities to 2050



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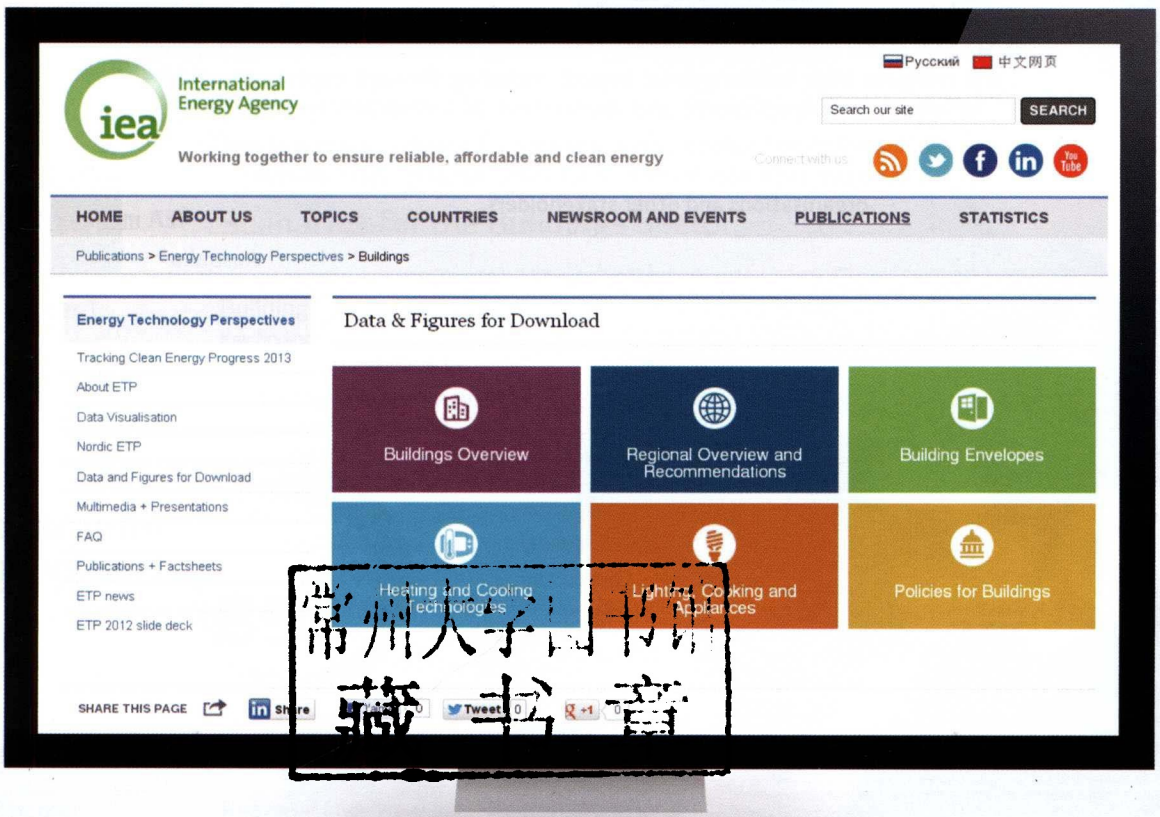

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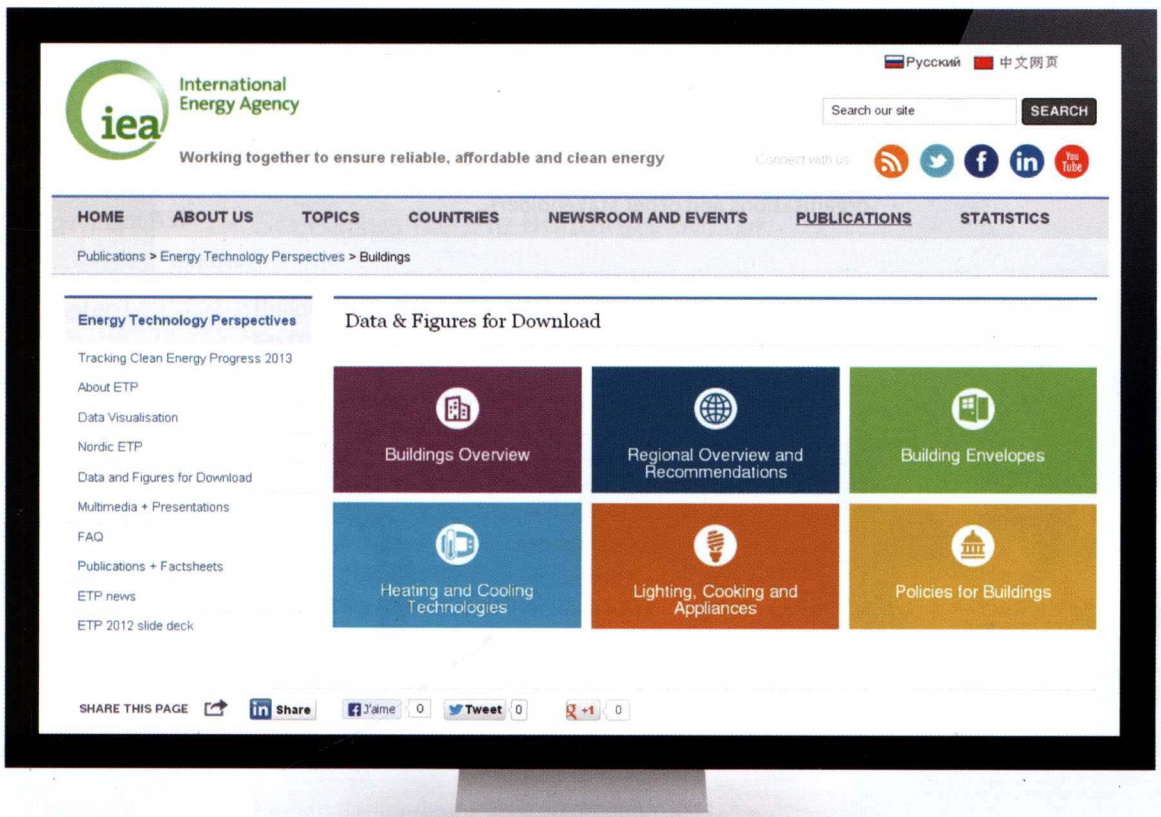

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INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 28 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

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New Zealand
Norway
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Sweden
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Turkey
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United States

The European Commission also participates in the work of the IEA.

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Foreword

Buildings represent the largest energy-consuming sector in the economy, with over one-third of all final energy and half of global electricity consumed there. As a result, they are also responsible for approximately one-third of global carbon emissions. With an expected population increase of 2.5 billion people by 2050, and given improvements in economic development and living standards, energy use in the buildings sector is set to rise sharply, placing additional pressure on the energy system.

However, technologies and measures already exist that allow the buildings sector to be more energy efficient and sustainable, and thus to play its part in transforming the energy sector. Unlocking the potential of energy efficiency, particularly in the buildings sector should be a priority for all countries. The *World Energy Outlook 2012* showed that in the absence of a concerted policy push, two-thirds of the economically viable potential to improve energy efficiency will remain unrealised through to 2035.

This publication is part of the *Energy Technology Perspectives* series and completes a suite of technology focused analysis for the three end-use sectors of buildings, industry and transport. It builds on other IEA energy efficiency analysis and highlights actions that can be pursued today and lessons learned in different countries on implementing energy efficiency policies for the building sector. The publication also provides a detailed overview of the key technologies that are needed to curtail growth in buildings energy demand.

Many cost-effective options are already available in the buildings sector that can significantly reduce both energy consumption and emissions. In the immediate term, the priority should be to work collectively to support investment in advanced, clean and energy efficient technologies in rapidly developing countries where the building stock is growing strongly. It is essential that new buildings be constructed to the highest possible standards, especially as buildings in some countries can last over 100 years. The construction methods of today can lock-in unnecessary emissions for a long time to come.

But lock-in need not be permanent. Within the existing built environment, deep renovations with best available technology and comprehensive building policies can significantly reduce energy demand. A systems approach with innovative products can be implemented in a cost effective manner which will support energy efficiency goals, while also helping to stimulate the economy, ensure greater energy security, and improve environmental sustainability.

Since barriers to efficiency measures are often due to market failures, mandatory buildings policies including standards and labelling programmes need to be expanded to more products and to all countries around the globe. Existing examples bear out the point. Successful market saturation of energy efficient technology in some countries and the banning of inefficient technology in others demonstrate the potential to dramatically curb energy demand and carbon emissions in buildings.

This publication highlights a path forward for the buildings sector to be much less energy and carbon intensive, while investing in high-performance buildings and highly efficient products. The result alleviates the need for additional and new sources of energy, with benefits for the environment and for energy security.

This publication is produced under my authority as Executive Director of the IEA.

Maria van der Hoeven,
Executive Director,
International Energy Agency

Executive Summary

Overview

The rationale for changing our current energy and climate path is compelling. Energy efficient and low-carbon technologies will play a crucial role in the energy revolution needed to make this change happen. The buildings sector is the largest energy-consuming sector, accounting for over one-third of final energy consumption globally and an equally important source of carbon dioxide (CO_2) emissions. In certain regions highly dependent on traditional biomass, energy use in buildings represents as much as 80% of total final energy use.

The buildings sector, including the residential and services sub-sectors, uses a wide array of technologies. They are used in the building envelope and its insulation, in space heating and cooling systems, in water heating, in lighting, in appliances and consumer products, and in business equipment. The long lifetime of buildings and related equipment presents both challenges and opportunities for the sector.

Some of the technologies needed to transform the buildings sector are already commercially available and cost effective, with payback periods of less than five years. Others are more costly and will require government intervention if they are to achieve wide market uptake. Unlike many of the technologies needed in the transport and industry sectors, only a small proportion require major research and development (R&D) breakthroughs. Many could, however, benefit from a combination of additional R&D and economies of scale to reduce costs, enhance performance and improve their affordability.

Market barriers in the buildings sector are complex and can be difficult to overcome, so successful implementation of public policy will be essential to achieving high levels of market diffusion. There is a need for integrated and comprehensive policies to help overcome a range of barriers, such as higher initial costs, lack of consumer awareness of technologies and their potential, split incentives and the fact that the true costs of CO_2 emissions are not reflected in market prices.

The transformation of the buildings sector will have positive benefits for other sectors, most notably the power sector, as over half of all electricity consumed today is used in buildings. Electricity savings in buildings will have far-reaching benefits for the power sector and will translate into avoided electrical capacity additions, as well as reduced distribution and transmission network expansion, with potentially huge savings for utilities.

Achieving significant energy and CO_2 emissions reduction is a challenging policy goal, but this publication demonstrates that it is possible with a combination of best available technology and intelligent public policy. Ensuring that all available options are tapped will require unprecedented effort and co-ordination among a diverse set of stakeholders, including policy makers, builders, technology developers, manufacturers, equipment installers, financial institutions, businesses and household consumers.

How to get on track for saving energy in the buildings sector

The International Energy Agency (IEA) annual report to the Clean Energy Ministerial categorised buildings as being in serious trouble for meeting energy savings and carbon

emissions reduction (IEA, 2013). While there has been significant technological progress, implementation has been delayed. Examples of best available building technologies combined with renewable energy sources in advanced buildings, such as zero-energy buildings, only represent a small niche market today.

In most cases, this trend can be changed with assertive policy action. However, it still may not be easy from a political perspective. With the world economy struggling, policy makers need to realise that promoting building energy efficiency can increase jobs, support economic development and lead to reduced energy consumption. For example, when a high performance value-added building material or equipment is installed instead of a typical product, that results in an immediate investment today, rather than continued purchasing of often imported fossil fuel for years to come.

This publication makes specific recommendations for policy actions, and is supported with the pertinent technological background to initiate the immediate implementation process. A whole-building approach is critical to get the buildings sector on track. A key action to curtail the energy consumption of fast-growing developing markets is the adoption of enforceable building codes. This publication and the forthcoming *Policy Pathway on Building Energy Codes* and *Technology Roadmap on Energy Efficient Building Envelopes* will significantly improve the knowledge base on how to do this. The IEA is calling on major economies in collaboration with leading product manufacturers to have greater focus on implementing building codes globally.

Constructing a sustainable buildings sector

If no action is taken to improve energy efficiency in the buildings sector, energy demand is expected to rise by 50% by 2050. This increase is driven by rapid growth in the number of households, residential and services floor area, higher ownership rates for existing electricity-consuming devices and increasing demand for new products. However this growth could be limited to just over 10% without changing comfort levels or requiring households to reduce their purchases of appliances and other electronic equipment.

An estimated 40 exajoules (EJ), equivalent to current energy use in Russia and India combined, could be saved in the buildings sector in 2050 through the wide deployment of best available technologies. Examples include high-performance windows, optimal levels of insulation, reflective surfaces, sealants, heat pumps, solar thermal heating, co-generation, energy efficient appliances and equipment, efficient cook stoves and solid-state lighting (SSL), among others.

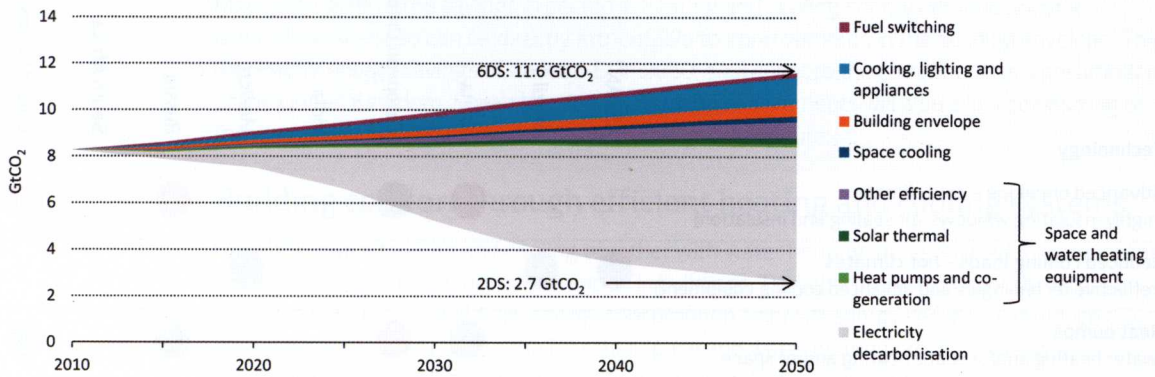
Achieving the goal of limiting global temperature rise to 2°C (*Energy Technology Perspectives 2012* [*ETP 2012*] 2°C Scenario [2DS]) would require an estimated 77% reduction in total CO_2 emissions in the buildings sector by 2050 compared to today's level. Energy demand reduction, increased use of renewables and, most importantly, a decarbonised power sector will be the main drivers of this decarbonisation in buildings (Figure ES.1).

A combination of efficiency standards, greater use of heat pumps, solar thermal and co-generation with waste heat and renewables could reduce growth in electricity demand by 2 000 terawatt-hours (TWh) in 2050. This is equivalent to half the final electricity consumption of the United States in 2010, or the final electricity consumption of South America, Africa and the Middle East combined in 2010. These savings would represent avoided capacity expansion of roughly 330 gigawatts (GW) of coal-fired capacity or 460 GW of gas-fired capacity and savings of between USD[1] 70 billion and USD 150 billion in new generation capacity.[2] In

1 Unless otherwise noted, all costs and prices are in real 2010 USD. Other currencies have been converted into USD using purchasing power parity exchange rates.

2 This is based on an assumed load factor of 70% for coal-fired capacity and 50% for gas-fired capacity.

Figure ES.1 Contribution of CO_2 emissions reduction in the buildings sector



Key point *Enhanced energy efficiency options in all end-uses combined with a decarbonised power sector can reduce CO_2 emissions in the building sector to just one-quarter of current levels.*

addition, there would also be savings from reduced investments in expanding distribution and transmission networks.[3]

Regional priorities and recommendations

Energy trends in the buildings sector can vary significantly from country to country depending on a number of factors ranging from climate, population, income, economic development and household sizes. Immediate priorities and future goals will need to reflect a country's energy supply and consumer profile. Most of the technology options and policy recommendations discussed in this book could be applicable to all countries either immediately or in the future. However, given constraints on resources there is a need to prioritise those actions that have the largest impact in each country. Nine countries or regions have been examined in detail in this publication and recommendations for policy and technology priorities are summarised below (Table ES.1).

End-use contributions

More efficient building envelopes to keep energy use down

The building envelope determines the amount of energy needed to heat and cool a building, and hence needs to be optimised to keep heating and cooling loads to a minimum. A high-performance building envelope in a cold climate requires just 20% to 30% of the energy required to heat the current average building in the Organisation of Economic Co-operation and Development (OECD). In hot climates, the energy savings potential from reduced energy needs for cooling are estimated at between 10% and 40%.

3 Savings from the distribution and transmission network are regionally specific and have not been calculated for this present study.