DEDICATED TO MAKING A DIFFERENCE

Facts & Trends

Energy Efficiency in Buildings

Business realities and opportunities

Full report

World Business Council for Sustainable Development

About

About the WBCSD

The World Business Council for Sustainable Development (WBCSD) is a coalition of some 200 international companies from more than 30 countries sharing a commitment to sustainable development. Much of its work is carried out through Focus Areas and projects developing sustainability themes and actions. Energy Efficiency in Buildings is one of those projects.

About the EEB project

The Energy Efficiency in Buildings (EEB) project was launched in 2006 and will run for more than three years. It is chaired by Lafarge and United Technologies Corporation and the companies shown below make up the Core Group (Actelios, ArcelorMittal, Bosch and Skanska joined after completion of this first report). The group adopted a multi-faceted approach to understanding and analyzing the issues, including several hearings and meetings with experts. This included commissioning a perception study to identify the attitudes, knowledge and understanding among building professionals and opinion leaders, and the readiness to adopt more sustainable practices. The project focused initially on “vertical” issues: energy, materials, equipment, and the broad topic of finance, development and operation. Then it developed ideas and material in the areas of policy, innovation and technology, finance and behavior.

Outreach to stakeholders in the building industry, such as business leaders, government officials and non-governmental organizations, is an important feature of this project, and the first major event took place in Beijing in March 2007. The China Forum was organized jointly with the International Energy Agency. More than 150 people took part over two days of workshops and plenary sessions, helping us to understand building energy efficiency issues specific to China. Forums took place in Brussels and India in 2007 and in Brazil in 2008.

An Assurance Group, chaired by the former head of the UN Environment Programme, Klaus Topfer, provides overall scrutiny of the project. Its role is to validate the research and conclusions. Its members are eminent experts from several countries who have had experience working in business, government and the world of academia:

- **Hon. Eileen Claussen** (USA), President of the Pew Center on Global Climate Change and Strategies for the Global Environment.
- **Thomas Johansson** (Sweden), Professor of Energy Systems Analysis and Director of the International Institute for Industrial Environmental Economics (IIEE) at the University of Lund, Sweden and Senior Advisor on Energy and Climate Change to the United Nations Development Programme (UNEP).
- **Vivian Ellen Loftness** (USA), Professor and Head of the School of Architecture, Carnegie Mellon University, and Senior Researcher at the Center for Building Performance and Diagnostics.
- **Shin-ichi Tanabe** (Japan), Professor in the Department of Architecture at the Waseda University.
- **Jiang Yi** (China), Vice Dean of the School of Architecture at Tsinghua University and Academician of the Chinese Academy of Engineering.

This report is the first output of the project. (A summary was published in October 2007.) A second report will be published in 2008, setting the direction to achieve progress towards zero net energy for buildings.

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The EEB Core Group

LAFARGE

World leader in building materials, LAFARGE has pursued its goal in the context of a sustainable development strategy for years, incorporating economic, social and environmental concerns.

LAFARGE has been able to reach a 14.2% reduction of its CO_2 emissions, on track to keeping its voluntary commitment of reducing the group's worldwide CO_2 emissions by 20%.

LAFARGE is the only company in the building material sector that is listed in the 2007 "100 Global Most Sustainable Corporations in the World".

United Technologies

United Technologies, a diversified technology company based in Hartford, Connecticut, has been measuring its environmental progress for more than a decade and regularly sets aggressive company-wide goals to reduce impacts. From 1997 to 2006 the company reduced its energy consumption, measured in BTUs, by 19% while the company doubled in size. It also invests in energy conservation projects and co-generation systems at many of its global facilities, including a LEED Gold building for its Otis China operations.

Actelios

Creating value through development, within renewable energy sources, of innovative and competitive projects that offer solutions to the environmental issues affecting the community as well as specific fields of industry in accordance with the principles of sustainable development: this is the Actelios mission.

Actelios is a member of the Falck Group, a major player on the Italian industrial scene for over a century. It is the only Italian listed company whose core business is power generation from renewable sources.

Actelios builds and operates electrical and thermal energy plants through the use of renewable sources, including biomass, household and special waste, and the sun, among others.

The Kyoto Protocol guidelines require that signatory states, including Italy, drastically cut their CO_2 emissions, the leading cause of climate change. Renewable sources, like those used by Actelios, play an increasingly crucial role in achieving the Protocol's objectives.

In 2007 Actelios produced about 400,000 MWh of electrical energy and avoided more than 250,000 tons of CO_2 emissions.

ArcelorMittal

ArcelorMittal, the world's largest and most integrated steel company, is transforming tomorrow through its core values of sustainability, quality and leadership. This includes operating in a responsible way with respect to developing and ensuring the health, safety and wellbeing of its employees, contractors and the communities in which it operates. We are also committed to the sustainable management of the environment and of finite resources.

ArcelorMittal recognises that it has a significant responsibility to tackle the global climate change challenge and is the leader of the Ultra-Low CO_2 Steelmaking (ULCOS) program, the industry's most advanced Research and Development effort to develop breakthrough steelmaking technologies to realise large-scale reductions in CO_2 emissions.

Steel, which is the most recycled material in the world, also bears remarkable potential with regards to innovative solutions that promote energy efficiency and use of renewable energies. ArcelorMittal is actively researching and developing steel-based technologies and solutions that improve the insulation and environmental performance of buildings, or that exploit solar or wind energy, and thus contribute to combat climate change.

The Bosch Group

The Bosch Group, which employs some 270,000 associates, is a leading global supplier of technology and services in the areas of automotive and industrial technology, consumer goods and building technology. The Bosch Group comprises Robert Bosch GmbH and its roughly 300 subsidiary and regional companies in over 50 countries. Bosch spends more than three billion Euros each year for research and development. The company was set up in Stuttgart in 1886 by Robert Bosch (1861-1942) as the "Workshop for Precision Mechanics and Electrical Engineering." In the spirit of its founder, the company particularly demonstrates social and environmental responsibility, wherever it does business. The special ownership structure of Robert Bosch GmbH guarantees the entrepreneurial freedom of the Bosch Group, making it possible for the company to plan over the long term and to undertake significant upfront investments in safeguarding its future. Ninety-two percent of the share capital of Robert Bosch GmbH is held by Robert Bosch Stiftung GmbH, a charitable foundation.

CEMEX

CEMEX works together with its customers and communities to provide integral sustainable building solutions that contribute to lower overall greenhouse gas (GHG) emissions. These solutions consist of: financing, design, planning support, as well as our products. They offer our customers practical and readily applicable products that are: economically feasible, can be used in mass scale, are durable, have better insulation properties, and provide comfort and reduce energy consumption for heating and cooling.

CEMEX also contributes to reducing GHG emissions in our cement production facilities; from 1990 to 2006 we achieved an 11% reduction in our CO_2 emissions. Our target is to reduce them up to 25% by 2015.

DuPont

DuPont is committed to sustainable growth. We believe that what is good for business must also be good for the environment and for people everywhere. DuPont has been taking actions to reduce greenhouse gas (GHG) emissions in our own operations since 1991. Over this period, we have reduced our global GHG emissions by 72%, while saving energy worth $3 billion.

By 2015, DuPont will further reduce our GHG emissions at least 15% from 2004 levels. We are also committed to growing revenues from products that create energy efficiency and/or significantly reduce greenhouse gas emissions for our customers.

EDF

The EDF group is an integrated European energy supplier that has a longstanding commitment to sustainable development. EDF is significantly increasing investments in renewable energy (wind, solar, hydraulic) to further improve its low-carbon profile. This will amount to a €3 billion investment out of a €40 billion, 5-year investment program. A third of its annual expenditures in R&D is related to environmental work. EDF also offers commercial energy efficiency services such as insulation, wood & solar energy, and heat pumps.

Gaz de France

A major European energy utility, Gaz de France produces, purchases, transports, distributes and sells natural gas, electricity and related services for its residential, corporate and local government customers. Its ambition is to be a leader in the energy market in Europe. Its strategic focuses are to develop an ambitious marketing strategy, pursue a supply and procurement policy that guarantees the Group's competitiveness, confirm its position as a benchmark infrastructure manager, and speed up its profitable growth in Europe.

Gaz de France aligns its strategy with a concrete and ambitious sustainable development policy. Its growth model is based on responsiveness to customers and constructive dialogue with its employees and partners.

In Europe, the Gaz de France Group operates the longest natural gas transmission network, manages the largest natural gas distribution network, and ranks among the leading suppliers of natural gas.

Kansai

Kansai Electric Power Company is actively promoting comprehensive measures strategically to reduce greenhouse gases, as a leading electricity utility. Achieving more efficient demand side energy use is one important element of such measures.

For corporate customers, Kansai has introduced equipment such as the Eco Ice and Eco Ice Mini thermal storage air conditioning systems that have excellent energy efficiency and help achieve outstanding energy conservation in buildings.

For household customers, along with electric water heaters, which typically use electric power late at night (off-peak), Kansai has further popularized the Eco Cute hot water heat pump system, which can utilize three times the heat energy per unit of electricity consumed.

In addition, Kansai provides a variety of information related to energy conservation to help customers achieve greater energy use efficiency.

Philips

Sustainability is an integral part of the way that Philips does business. In fact, Philips has a long history of inventing energy efficient solutions for many lighting applications – including applications for street lighting, offices and shops. And back in 1980 we were the first company to produce an energy saving light bulb for use in the home. Since 1994, we've put environmental product improvement at the heart of our business with our environmental improvement programs and our EcoDesign process. With EcoDesign we consider all phases of a product's life cycle as an integral part of the product creation process.

Philips is a recognized leader in environmental performance and sustainability, as evidenced by its consistently high rankings in the Dow Jones Sustainability Indexes, the Global 100 Most Sustainable Corporations in the World and the FTSE4Good Index.

Skanska

Skanska is a leading international project development and construction company. By combining our expertise and financial strength, we develop offices, homes and public-private partnership projects. We create sustainable solutions and aim to be a leader in quality, green construction, work safety and business ethics.

We are a Fortune 500 company and a member of the UN Global Compact. Skanska is one of the world's ten largest construction companies. Our history began in 1887 when the company was founded. We established our first international operations already in 1897. Today, 60,000 employees are active in selected home markets in Europe, the US and Latin America.

Skanska is headquartered in Stockholm, Sweden and listed on the OMX Nordic Exchange Stockholm. Skanska's sales in 2007 totaled SEK 139 billion.

Sonae Sierra

Sonae Sierra has long since heralded environmental good practice as one of its corporate values and has, over the years, made significant efforts to improve in this critical aspect of company performance. In 2005, we were the first property company in Europe to achieve ISO 14001 across the entire business. In 2006, we gained ISO 14001 certification on a further 8 of our centers under management and both construction sites of our projects completed in the same year. We were also the first Portuguese company in its sector to voluntarily start managing its GHG emissions, reducing electricity consumption per m^2 by 25% for the aggregated Sierra portfolio in the last five years and consequently GHG emissions.

TEPCO

TEPCO, the largest electricity supplier and one of the best ESCOs in Japan, has been active in promoting energy efficiency in residential and commercial buildings and factories. TEPCO owns many energy-efficient buildings, including an epoch-making retrofitted branch office, which has succeeded in reducing energy consumption and CO_2 emissions by over 30% compared to that of a typical building. The main driving technologies for energy efficient buildings are heat pumps and thermal storage, which will continue to play a leading role in reducing worldwide CO_2 emissions.

Summary

- Buildings are responsible for up to 40% of energy use in most countries, and that demand for energy is soaring as construction booms, especially in countries such as China and India. This means buildings can make a major contribution to tackling climate change and energy use. We need to act now because of the lifespan of buildings, and we can act now because the knowledge and technology to slash the energy buildings use is already available.
- There are three key elements to achieving progress:
  - Use less energy
  - Make more energy (locally)
  - Share surplus energy (through an intelligent grid).

  The most significant, long-term gains will come from using less energy.
- This report identifies three kinds of barriers – organizational, financial and behavioral – and three approaches to overcome them:
  - *Encourage interdependence* by adopting holistic, integrated approaches to whole communities and individual buildings
  - *Make energy more valued* by those involved in the development, operation and use of buildings
  - *Transform behavior* by educating and motivating building professionals and users.
- The building market is diverse and complex. The commercial relationships between the many specialists involved are intricate and are an impediment to action on energy efficiency. The sector is characterized by fragmentation within sections of the value chain and non-integration among them.
- Progress on energy efficiency depends on people in the building industry being aware of the importance of the issue, and then being able and willing to act on it. This project commissioned research that found awareness is high in most countries covered, but there are significant barriers preventing widespread involvement – serious gaps in knowledge about energy efficiency among building professionals, as well as a lack of leadership throughout the industry.
- Given a supportive policy framework, there are three approaches that can help break down the barriers: a holistic design approach, more appropriate financial mechanisms and relationships, and behavioral changes. This will increase the focus on energy efficiency in several ways:
  - The financial community will support investments in energy efficiency
  - The design community will produce energy-efficient designs
  - The materials and equipment community will offer products and services that support those designs economically
  - Building owners and operators will support and value energy-efficient operations
  - Utilities will support intelligent distribution and sustainable content of energy to and from buildings.

Chapter 1

Introduction

Urgent action is needed to reduce energy use in buildings and remove the barriers to addressing this major cause of carbon dioxide emissions. The World Business Council for Sustainable Development's (WBCSD) Energy Efficiency in Buildings (EEB) project will develop a roadmap from a business perspective, outlining the critical steps needed to transform buildings' energy consumption. The project has brought together leading companies in the building industry to tackle this vitally important subject. This group has bridged isolated specialist "silos" to develop a cross-industry view of energy efficiency and to identify the approaches that can be used to transform energy performance. It will develop practical action for property investors, developers, regulators, energy providers and suppliers of products and services to the building industry.

This report summarizes the first year's work of the project, which provides a platform for the next phase. This document therefore concentrates on presenting an assessment of the current situation. While it sketches some broad solutions, the focus of the next phase will be to add detail. The report combines findings from existing research with stakeholder dialogues during hearings, workshops and forums, plus a breakthrough market research study that measures stakeholder perceptions of sustainable buildings around the world.

This global project has focused on six geographic markets: Brazil, China, Europe, India, Japan and the USA. They were chosen because they constitute more than half of the world's population (approximately 3.5 billion people in 2004) and two-thirds of world energy demand, and because they include developed as well as developing economies and a range of climates.

Chapter 2 explains the EEB vision for a world in which buildings use zero net energy, and emphasizes the urgency of making substantial progress towards that vision. It also defines the project scope (buildings' core energy uses) and outlines the risks and opportunities for businesses engaging in markets relating to the role of buildings in climate change.

Chapter 3 presents a picture of buildings' energy use in the six markets and a description of the complexities in the building value chain, which create important barriers to progress.

The attitudes of individuals in the building industry are critical to achieving an energy transformation. EEB-commissioned research in eight countries provides insights into market perceptions on building energy efficiency, the level of understanding and readiness to act. The findings have been instrumental in developing an understanding of the barriers to progress. These barriers and perceptions are presented in **Chapter 4**.

This research and analysis helped to identify the critical business levers needed to help achieve dramatic improvements in building energy use. Government policies and regulations clearly provide an important stimulus, but the three critical levers businesses can most effectively engage are:

- The adoption of a holistic approach to energy in buildings
- Financial issues and relationships
- The behavior of all those involved in building energy demand.

These levers, along with the influence of policy and regulation, are described in **Chapter 5**.

Chapter 6 presents the conclusions of this first stage of the project, which form a platform to develop scenarios and identify a route to zero net energy in the next phases.

While this document brings together our analyses and key data, more information is available on the WBCSD's website: www.wbcsd.org/web/eeb. A summary of this document – Energy Efficiency in Buildings: Business realities and opportunities – is also available. See also the EEB blog for frequent updates and commentary.

Chapter 2

Our vision for urgent action

Summary

- Our vision is a world in which buildings consume zero net energy
- For buildings, that means: use less, make more locally, and share it through an intelligent grid
- Less energy does not mean less comfort
- Buildings already account for up to 40% of primary energy use and demand will grow rapidly with economic development, population growth and changing lifestyles
- There can be a market advantage for businesses that engage early in building energy efficiency
- Opportunities exist to dramatically improve energy efficiency using existing technologies and know-how

"The people who build buildings fully understand that the human society itself would be in danger if we continued destroying the environment."

Academic, Japan[1]

Vision, dream, ambition

The EEB vision is an aspiration. It is ambitious, but it can be achieved in stages – starting now.

It is good to have ambitious dreams, because that emphasizes the scale of the task and the need to achieve dramatic changes. It encourages people to reach for the sky even though they cannot touch it.

Big dreams are necessary to achieve a great leap forward.

The vision

Our vision is a world in which buildings consume zero net energy. This refers to the building industry[2] as a whole, over a seasonal cycle. It is ambitious, but we believe such dreams are necessary to achieve the huge progress that is urgently needed to deal with buildings' contribution to climate change and energy security.

The EEB vision is that, ultimately, the building sector as a whole would generate as much energy as it uses. Individual buildings may be net energy consumers, but others would be net exporters. The whole sector may consume net energy at certain times, but taken as a whole over a full year there would be zero net consumption.

This is a long-term vision. But already there is evidence that dramatic reductions in energy efficiency can already be achieved (see the case studies throughout this report). Industry bodies and even governments share the ambition - the European insulation industry body Eurima has concluded that "significant improvements" are possible now,[3] and the UK government has set ambitious targets for energy efficiency as part of its goal for all new homes in England to be carbon neutral by 2016.

It is important to have an aspiration as challenging as zero net energy, and it is necessary to begin working towards it now. The immediate aim is to vastly improve the energy efficiency of buildings, as the first step towards the vision.

Why energy, not carbon?
Using more non-fossil fuels (such as solar and wind) will address climate change and energy security, but cutting energy consumption is also vital because the contribution of these non-carbon fuels is likely to be constrained for several decades.

Why site energy, not primary energy?
The climate change impact of energy depends on the carbon content of generation, i.e., primary energy supply rather than site energy use. But this project focuses on the demand side of buildings' energy and on action within the building value chain rather than on energy generation and transmission. (The WBCSD Electric Utilities project is addressing electricity generation – see www.wbcsd.org/web/electricity.htm.)

Why zero net energy?
The zero net energy vision is analogous to the "zero accidents" objective which many companies adopt as part of their health & safety policy – achieving zero accidents seems a remote possibility, but setting this goal highlights the scale of the challenge and the level of ambition needed to address it. That is demonstrated by a modeling exercise for this project to investigate the energy-efficiency improvements needed in the US under several assumptions (see figure 2.1). If all the improvement came from new construction, a 94% reduction in energy use would be needed to restrict emissions to 2002 levels by 2050. We will further develop this modeling in the next stage of the project.

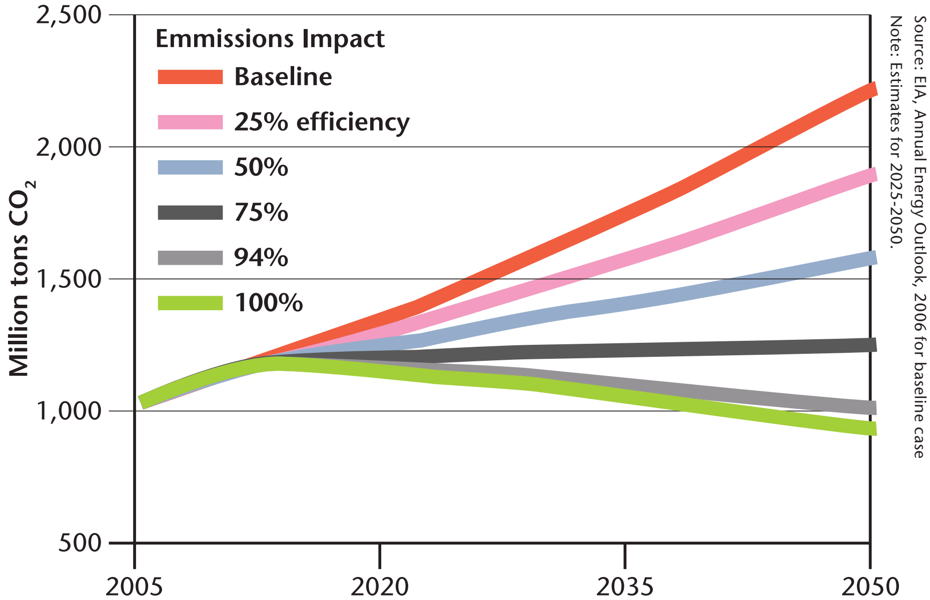


Figure 2.1: The scale of the building energy challenge

How zero energy?
Analysis of the potential to reduce carbon dioxide emissions from energy shows that substantial reductions are needed both in energy generation and consumption. There are three elements:

- Use less energy - cut buildings' energy demand by improved design, using insulation and equipment that is more energy efficient
- Make more energy locally - produce energy locally from renewable and otherwise wasted energy resources
- Share energy – create buildings that can generate surplus energy and feed it into an intelligent grid infrastructure to balance the energy needs of other buildings

End-use efficiency gains are likely to take the lion's share of energy reductions, and in many cases will be the most economically viable option. For example, a study by McKinsey[4] into the cost of various means of reducing emissions found that reducing energy demand could make the largest contribution to emissions reductions at the lowest cost, compared to options such as carbon capture and renewable generation. The authors estimated that demand reduction measures with no net cost could almost halve expected growth in global electricity demand.

"A building has a long life cycle, so its effect on the environment is a long and continuing issue to consider, so low emissions is a very important topic."

NGO, China

Why energy efficiency?
The term "energy efficiency" in this project refers to reduced energy consumption for acceptable levels of comfort, air quality and other occupancy requirements. This includes the embodied energy in the building materials and construction, spread over the whole life of the building. (See the next section for more on the EEB scope.)

Urgent action is necessary

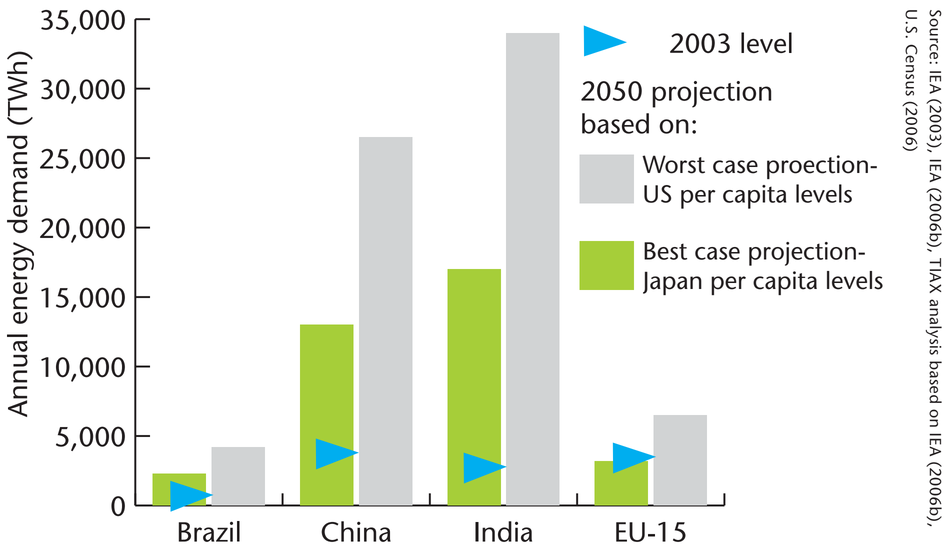
The WBCSD identified buildings as one of the five main users of energy where "megatrends" are needed to transform energy efficiency (the others being mobility, power generation, manufacturing and consumption). They account for up to 40%[5] of primary energy in most countries and consumption is rising. The International Energy Agency (IEA) estimates that energy demand for buildings will stimulate about half of energy supply investments to 2030. The challenge of reducing greenhouse gas emissions to combat climate change is even greater than projections had suggested because current emissions are even higher than the "business as usual" reference curve that is used as the basis for official projections. In other words, we are starting from a worse position than had been anticipated.[6]

Consumption is being driven by several adverse trends. The first is the scale of new building, especially in China where 2 billion square meters are being added each year.[7] Such huge building activity is propelled by rapid economic development, which is accompanied by a rush towards urbanization in developing countries. Changing lifestyles also tend to result in higher energy use as people aspire to higher levels of comfort and "western" lifestyles. (We explore these trends in more detail in the next chapter.)

If there is no drastic change in energy consumption trends, our six target markets (Brazil, China, Europe, India, Japan, USA) will represent 56% of the world's projected population in 2030 (4.5 billion out of 8.1 billion) and:

- **Population** will have increased by 27% compared to 2004. China & India alone will account for nearly 3 billion, more than 35% of the global population.
- Over 50% of **new buildings** in the world will be in China & India.
- A 53% increase in **energy demand** over 2004; more than 70% of the increase coming from developing countries; **China's** share rises from 15% to 20% of total world demand.
- **Fossil** resources remain the main energy source in world final energy demand (64% in 2030 against 66% in 2004). **Electricity's** share increases from 16% to more than 20%.[8]

Clearly, energy demand in developing countries will depend on their development trajectories. The level of energy use per head is one important indicator. The next stage of this project will develop scenarios exploring different trajectories. Figure 2.2



(Site annual energy consumption in terawatt-hours based on forecast population and developed country consumption levels)

Figure 2.2: Projections of site annual energy consumption in 2050

shows one projection based on reaching Japanese and US levels of electricity use per capita, allied to current population projections. If China and India's site electricity consumption grew to current US levels, it would be respectively about 4 and 7 times greater than today. Even if their electricity consumption reached only relatively low Japanese levels, buildings in China alone would consume approximately 5% more site energy than the EU-15, Japan, and US combined (assuming consumption per head in those countries remains the same as now).

It is essential to avoid this projected dramatic rise in energy consumption, for two main reasons:

- The world needs to reduce greenhouse gas emissions from energy generation to stabilize climate change (see "What the experts say 1").
- Countries need to achieve security of energy supply, which will not be possible in many cases as demand continues to rise

Action is needed now, not just because of energy trends but also because property is a low-replacement industry. It will not be enough merely to act on new buildings. Urgent work is also needed to transform the energy consumption of existing property. In developed countries, new building represents less than 1% of existing stock, which means many existing buildings, as well as new property being built now, will still be standing in 2050. Those buildings will be consuming energy unnecessarily unless energy-efficient approaches are adopted now.

What the experts say 1 – Buildings and energy

The UN Intergovernmental Panel on Climate Change (IPCC) – Working Group 3

Between 1970 and 1990 direct emissions from buildings grew by 26%, and remained near 1990 levels thereafter. However, the buildings sector has a high level of electricity use and hence the total of direct and indirect emissions in this sector is much higher than direct emissions alone.

Key mitigation technologies and practices currently commercially available

Efficient lighting and daylighting; more efficient electrical appliances and heating and cooling devices; improved cook stoves, improved insulation; passive and active solar design for heating and cooling; alternative refrigeration fluids, recovery and recycle of fluorinated gases.

Energy efficiency options for new and existing buildings could considerably reduce CO_2 emissions with net economic benefit. Many barriers to tapping this potential exist, but there are also large co-benefits

- By 2030, about 30% of the projected GHG emissions in the building sector can be avoided with net economic benefits.
- Energy efficient buildings, while limiting the growth of CO_2 emissions, can also improve indoor and outdoor air quality, improve social welfare and enhance energy security
- Opportunities for realizing GHG reductions in the building sector exist worldwide. However, multiple barriers make it difficult to realize this potential. These barriers include availability of technology, financing, poverty, higher costs of reliable information, limitations inherent in building designs and an appropriate portfolio of policies and programs
- The magnitude of the above barriers is higher in the developing countries and this makes it more difficult for them to achieve the GHG reduction potential of the building sector.

"Warming of the climate system is unequivocal….It is very likely that it is not due to known natural causes alone."

IPCC 2007

What the experts say 2 – Climate impacts

The UN Intergovernmental Panel on Climate Change (IPCC) – Working group 1

The world has been getting hotter for many years. The 12 years since 1995 include 11 of the 12 warmest since 1850 (1990 was the 12th) .[9] Average temperatures this century have been 0.76°C higher than in the second half of the 19th century. That is not just a short-term blip - warming over the last 50 years has been twice as fast as over the past 100 years, probably making this the hottest 50-year period in the last 1,300 years.

Climate change has meant more heat waves, more downpours, more droughts, shrinking glaciers and ice caps and higher sea levels. The seas rose by 17 centimeters during the 20th century and the annual increase has grown to more than 3 millimeters in the last decade.

The forecast is for more of the same. Average temperatures are expected to continue rising, perhaps by 4°C during this century if the world continues with rapid, energy-led economic growth driven by fossil fuels. The increase could be below 2°C with less resource-intensive growth and cleaner energy. Related sea level rises are expected to be at least 18 centimeters and could be as high as 59 centimeters by the end of the century.

These climate changes are caused mainly by increased concentration of greenhouse gases in the atmosphere due to human activity. Carbon dioxide (CO_2) is the most important greenhouse gas and its concentration is more than a third higher than before the industrial revolution, so that it is now higher than at any time over the last 650,000 years. Annual CO_2 emissions from fossil fuel increased from an average of 6.4 gigatons of carbon (GtC) in the 1990s, to 7.2 GtC in 2000-2005 – and the rate of increase has accelerated.

Including other greenhouse gases such as methane, the concentration in the atmosphere in 2006 was 430 parts per million (ppm) CO_2 equivalent. It is rising at 2-3 ppm each year[10] and will continue to increase for some time regardless of action to curb emissions now. Even if the concentration of greenhouse gases remained at the levels in 2000, there would be further warming of about 0.1°C per decade.

Development, equity and lifestyles

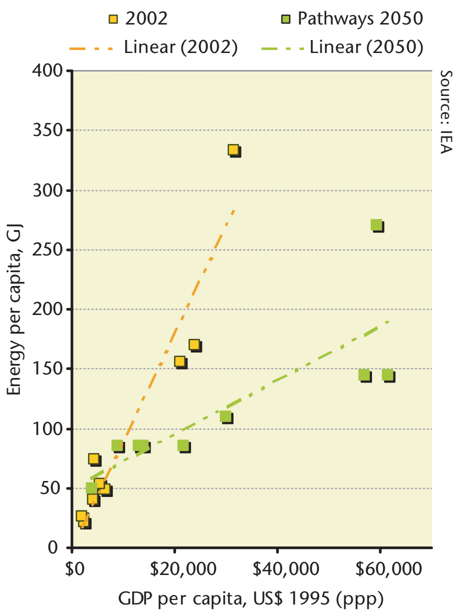


Figure 2.3: Energy and development

Energy needs evolve according to standard of living and lifestyle. Increased energy use is therefore often perceived as a measure of comfort and wealth. This correlation between energy use and comfort needs to be broken. That is, developing countries need to find ways to increase comfort levels in a more energy efficient manner than has been the norm in developed countries. At the same time, developed countries need to find ways of maintaining comfort levels with lower energy requirements.

Figure 2.3 illustrates the current relationship between wealth and energy, and the extent to which that needs to change to achieve necessary reductions in energy use, based on the WBCSD *Pathways to 2050* projections.

This is an important issue and we are conscious of the need for equity – within developed countries as well as globally. Buildings need to meet the needs of poorer communities while meeting energy efficiency targets, and the two can work together. Energy tends to be a much more significant financial burden for those on lower incomes. For example, in the USA energy is 14.5% of total expenses for a poor household compared to just 3.5% for those with higher incomes.[11] Energy efficient social housing is therefore important for equity, as well as climate change and energy security.

Business risks and opportunities

Climate change and energy security are significant issues for national economies and all businesses (see "What the experts say 2"). The resulting need for much-improved energy efficiency presents risks and opportunities. In the building sector, all the players need to understand changes in the market, strategic and operational threats

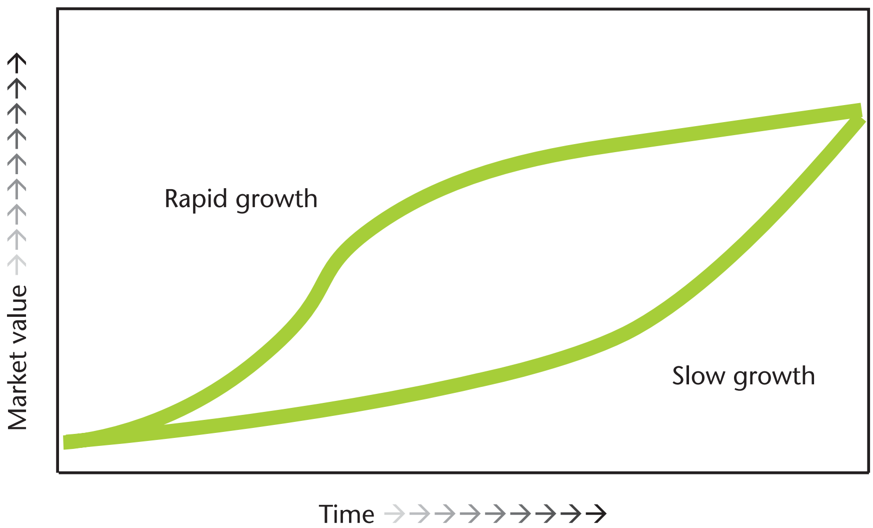


Figure 2.4: timing risks relating to market growth

as energy efficiency becomes a significant factor. The specific risks and opportunities will vary to some extent from sub-sector to sub-sector, from country to country and from one part of the value chain to another. Here we present a broad overview, which demonstrates that energy efficiency is a serious business opportunity.

Market risks (external to the company)
The analysis summarized in the table suggests minimal risk in the potential for growth, but uncertainty about the timing as to when the market will demand energy-efficient buildings. The market will grow and will present valuable opportunities, but the speed and timing of that growth presents business risks. Figure 2.4 illustrates two alternative paths. Businesses risk entering the market too soon if growth is slow, but missing opportunities if growth is rapid.

Factor	Description	Risk level
Demand	Energy efficiency will continue to grow in importance, due to the increasing evidence of the urgency of climate change action and energy security needs	Low
Timing	The pace at which energy efficiency is integrated in the building sector is uncertain. The current surge of interest could accelerate in a steeply rising curve, or it could slip into a gentle gradient such that it takes much longer to achieve wide penetration, as illustrated in Figure 2.4.	High
Value/ volume	Ultimately, energy efficiency will spread through the whole market, and it is clear that the value proposition can be compelling given the right market structures and instruments	Low

Table 2.1: Market risks

Operational risks (internal to the company)
Currently it is not clear whether energy-efficient products and services can be competitive with existing, less-efficient versions, because of reluctance among potential buyers to pay an adequate price. This reluctance is based on the value proposition not having been fully developed and communicated.

Factor	Description	Risk level
Cost/price	Buyers are currently reluctant to pay an adequate price for energy efficiency and it is uncertain how fast this will change.	High
Know-how	Our perception research found there is a widespread lack of know-how in the market, and a reluctance to innovate with energy efficiency. Research and development is largely restricted to isolated “silos” rather than broad energy efficiency, missing the value created at the intersection of these sectors.	High

Table 2.2: Operational risks

Strategic assessment
We can see potential first-mover advantages for businesses that make an early entry into the energy-efficient building market. The table summarizes factors based on Porter’s “5 forces”.[12]

Factor	Description	Positive/negative (for early entrants)
Barriers to entry (to energy-efficient building market)	Will increase due to need for specialized knowledge and skills which are in short supply	Positive
Supplier power	Will increase due to shortages of materials, products and skills resulting in poor availability	Negative
Competitor rivalry	Will decline due to lack of competition in this new market	Positive
Threat of substitution	Will increase as concerns regarding energy use increase the attraction of working from home and on-line shopping and reduce the appeal of out-of-town shopping malls	Negative
Buyer power	Will decline due to the low number of suppliers in this new market	Positive

Table 2.3: Strategic assessement

There could be an analogy with the Toyota Prius, suggesting the potential for the "hybrid house" to exploit a similar market opportunity. Toyota entered the market without a clear understanding of timing for demand, and therefore considerable risk. Toyota also bore the risk of an immature supply chain and threat of substitutes. The surprising market uptake of the Prius weakened buyer power and as a result purchasing prices often exceeded suggested retail prices. In retrospect, the Prius created a new market niche, which has developed because of consumers' concerns with carbon dioxide emissions and fuel efficiency. By entering the market early, Toyota turned risk into opportunity and has built first-mover advantage through its belief in the potential of this market. Its initial success has generated wider brand benefits for the whole Toyota range. There may be similar opportunities for architects, engineers, property developers, the finance community and others in the building sector to capitalize on energy efficiency opportunities to build the "hybrid house".

Opportunities
Urgent improvements in energy efficiency are not only necessary, they are also possible. We know that vast improvements can be achieved with existing knowledge, and this is illustrated in figure 2.5.

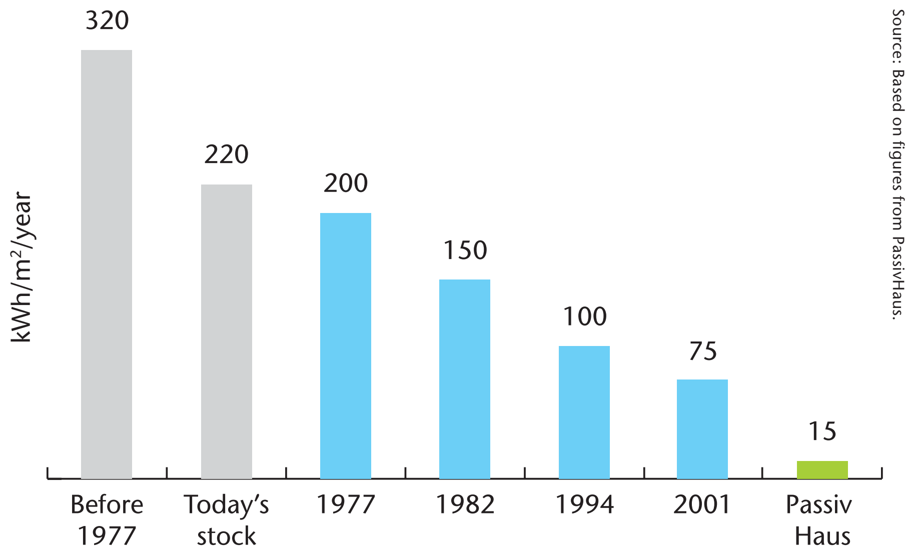


Figure 2.5: The evolution of Germany's energy code for space heating energy demand

There are still significant challenges, especially in the commercial sector and in renovating existing buildings, but the examples in the box demonstrate the potential for a step change in energy efficiency. They emphasize that the main obstacles are not just technical. We believe there are two groups of barriers to energy efficiency in buildings.

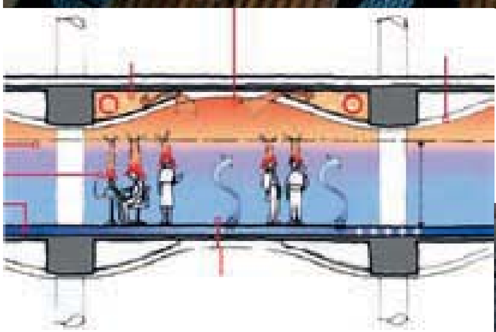
First, our perception research in the market shows that although there is high awareness among professionals in the industry, they have little involvement and a lack of know-how and leadership. Second, our analysis has identified four areas where action could make a significant difference: the policy and regulatory framework, the fragmented approach to building energy use, financial instruments and relationships, behavioral and cultural factors.

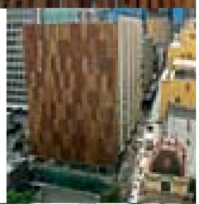
We explore these barriers in the rest of this report, after setting out in the next chapter the current picture of building energy use in the six markets.

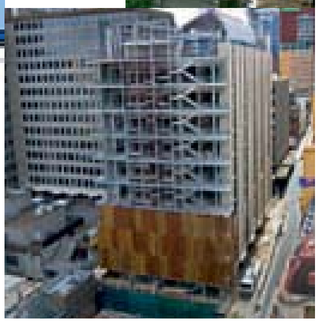
Australia | Melbourne

Low energy now I

This example demonstrates that there are already buildings in several countries which consume close to zero net energy.







The technologies used include:

- Undulating high thermal mass concrete ceilings which improve air circulation, cooling and natural light and reduce energy demand by 14% in summer
- Photovoltaic cells, which power a façade of louvers
- Rooftop solar panels for water heating
- Glare control throughout the building
- "Shower towers" that cool water and air using low amounts of energy
- A green roof space generating oxygen
- Roof-mounted wind turbines that purge air during the night and generate electricity during the day
- Solar shading on the exterior and interior of the building and automatic night-purge windows to cool the concrete ceilings.

The building consumes approximately 35 kWh/m²/year. Compared to the previous Council building (c1970), this equals savings of:

- 82% electricity consumption
- 87% gas consumption
- 72% mains water supply
- US$ 1.196 million annually, including US$ 272,366 in electricity, gas and water. CH2 will pay for its sustainability features, worth US$ 9.330 million, in a decade.

Council House 2 (CH2) is a 10-story office building for City of Melbourne staff. It has ground-floor retail spaces and underground parking and was officially opened in August 2006. CH2 was designed to copy the planet's ecology, using the natural 24-hour cycle of solar energy, natural light, air and rainwater to power, heat, cool and supply water to the building.

The north façade has 10 dark-colored air ducts that absorb heat from the sun. The hot air rises, taking the stale air up and out of the building. The south façade has light-colored ducts that draw in fresh air from the roof and distribute it down through the building. The west façade has louvers made from recycled timber that move according to the position of the sun and are powered by photovoltaic roof panels.

What the experts say 3 – Economic impacts

The Stern Review

"Climate change presents a unique challenge for economics: it is the greatest and widest-ranging market failure ever seen….. Ignoring climate change …… could create risks of major disruption to economic and social activity, later in this century and in the next, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century."

The recent Stern Review[13] for the UK Treasury concluded that continued climate change will have widespread impacts on the global economy, and that the benefits of strong, early action considerably outweigh the costs.

Stern estimates that "business as usual" would be likely to reduce global per-capita consumption by at least 5% over this century and next.

Stern examined the feasibility and costs of stabilizing greenhouse gas concentrations in the context of continuing global economic growth, which will result in an output of three to four times current levels by 2050.

The Review recommends stabilizing concentrations at between 500-550 ppm CO_2 equivalent by 2050, consistent with an average temperature rise of about 3°C. This is likely to cost around 1% of GDP per annum. Stern describes this as "significant but manageable", and contrasts it with the likely significant costs of inaction. Delaying action implies higher costs, as does targeting earlier stabilization and quicker emissions reductions.

Improving energy efficiency is very important to achieving the target stabilization, and essential given that fossil fuels are still expected to contribute about half the world's energy even in 2050. Stern quoted the International Energy Agency's belief that this can provide the biggest single source of emissions savings in the energy sector, which would combine environmental and economic benefits: reducing emissions as well as saving money.

The review suggested the potential for emissions reductions from building's energy use is higher than in many other sectors. Much of the energy efficiency savings, especially from appliances and lighting, could be delivered at low or even negative cost to society, taking account of total costs including investment in generation capacity.

Chapter 3

A complex sector

Summary

- The building market consists of many segments with quite different characteristics, beyond the basic distinction between commercial and residential
- Floor space per capita and building energy consumption vary widely from one market to another
- Energy demand is expected to rise dramatically in China and India, where it is driven primarily by population, economic development and urbanization
- The vast majority of energy consumption occurs during a building's occupation
- Building energy use is driven by demographics, economic development, lifestyles, changes in energy sources, and technology
- The sector is characterized by fragmentation within sections of the value chain and non-integration between them
- Incentives to reduce energy use are usually split between different players and not matched to those who can invest in energy-saving measures

Energy consumption

Energy consumption in buildings will grow dramatically without action to substantially improve energy efficiency. The construction boom, especially in China, is driving energy demand, but economic development and other factors are adding to the problem because they are increasing buildings' energy needs.

This chapter sets out the current scale of the building energy challenge and explains the complexities within it. As noted in Chapter 2, buildings typically account for up to 40% of national energy consumption, and a substantially higher proportion in developed countries where electricity is a higher proportion of total energy. This chapter reports the size of the existing building stock in the key markets, expected growth rates, and energy characteristics. But other aspects of the market are critical to understanding the challenge of energy efficiency – especially the structure of the market and commercial relationships between the many specialists involved. The attitudes of these specialists are vital to the development of greater energy efficiency and the final section of this chapter provides an insight into market relationships and behaviors.

Buildings and segmentation

The market and its energy-efficiency considerations are far from homogenous across the building sector. They vary according to geography, climate, building type and location. The distinction between developed and developing countries is extremely important, as is the contrast between existing buildings, which require retrofitting, and new construction. In all cases there are different building and renovation standards – it is vital that energy efficiency permeate all quality levels, including social housing, and not be restricted to high-end property.

The major division by property type is between commercial and residential – two-thirds of energy being used in residential buildings. But it is necessary to consider rural as well as urban housing, while there are significant differences between commercial sub-sectors (e.g., offices, retail, banking, hotels). There is less fragmentation within these sub-sectors, however. And some sub-sectors are dominated by a small number of players. For example, in the US the top 50 property managers manage half of commercially leased office space; the top 40 lodging/hotel companies account for 70% of the market; the top four food wholesalers make almost half the sales in their sector.[14]

The EEB project is working with four universities (Birla Institute of Technology in India, Carnegie Mellon in the USA Lund in Sweden and Tsinghua in China) to develop a rich database of information on the nature of each sub-sector and its energy use characteristics. We will use this database to build scenarios during the next phase of the project. The diagram below illustrates the data to be gathered for each market.

"Right now it's the owner – they drive the show. If the architect wants to design a sustainable building and the owner doesn't want to pay for it or drive it that way, the architect – even if they're great at it – fails."

NGO, US

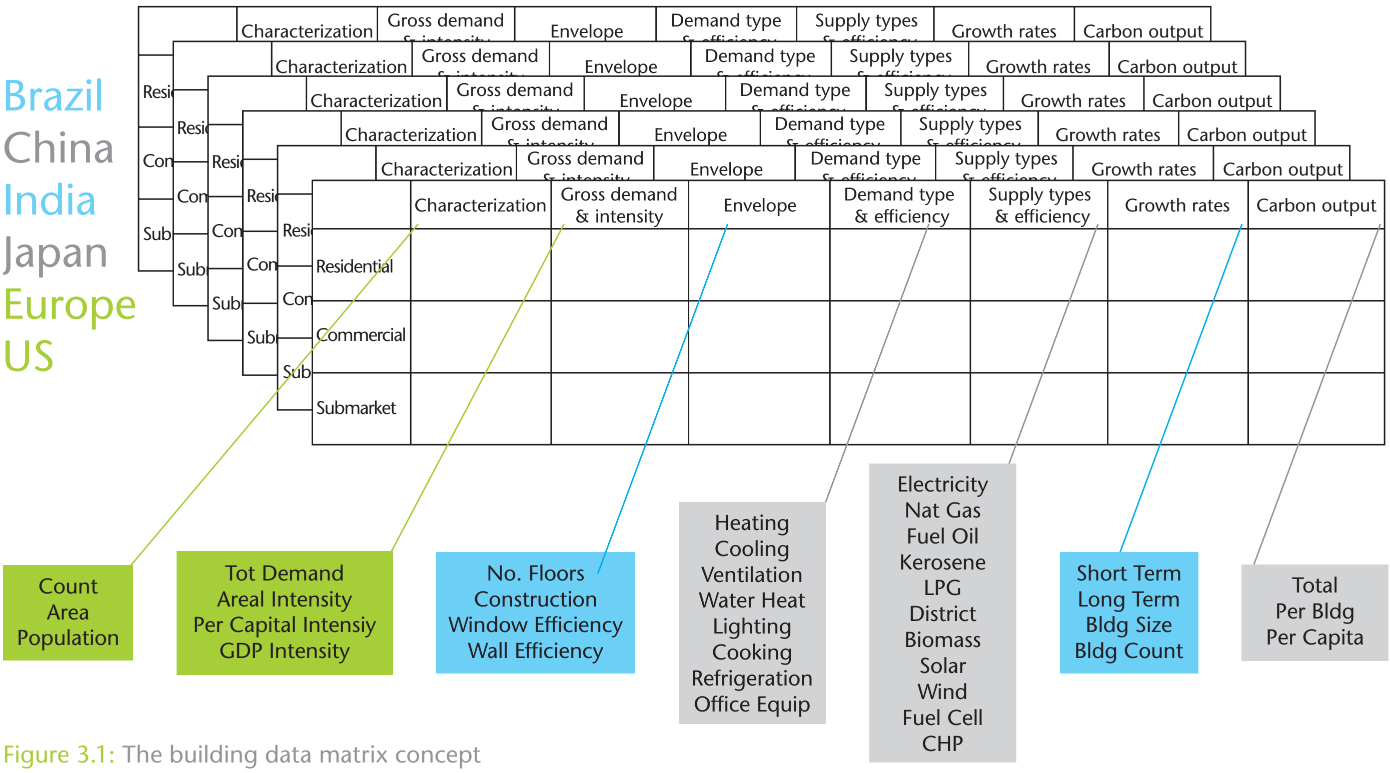


Figure 3.1: The building data matrix concept

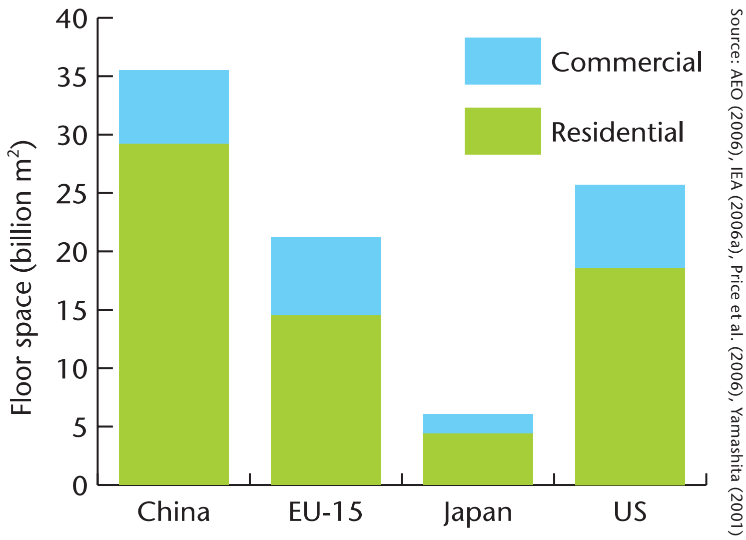


Figure 3.2: Existing floor space

"A single architect cannot do anything sustainable. He needs electrical engineers, structural engineers, all these professionals working together."

Architect, Brazil

The building stock[15]

The charts show the scale of current property stock in key markets covered by this project, analyzed between commercial and residential occupancy. The existing scale of property in China is particularly notable – the absolute amount of residential space, which dwarfs other regions, and the fact that commercial space is comparable with that in the US and Europe.

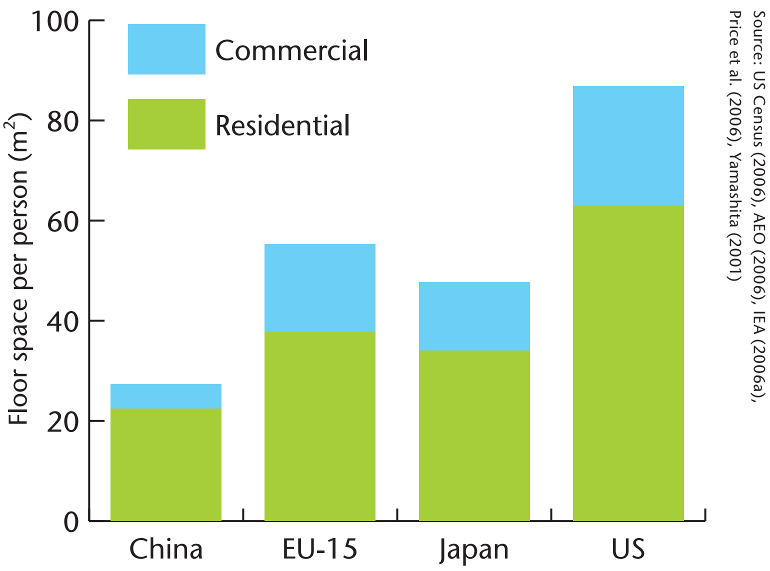


Figure 3.3: Floor space per head

Figure 3.3 shows the significant differences in space per capita from region to region, especially the much greater residential space per head in the US. The differences are less marked in commercial space, except for China, which currently uses much less space per head than other regions.

This clearly has significant implications for energy use, assuming that space demands in China move up towards those in Europe and Japan, if not the USA.

Characteristics of building segments

The complexity of the building industry means it can be segmented along several dimensions, in addition to the key distinction between commercial and residential property. This analysis helps to understand the variables and the challenges to radically improving building energy efficiency.

New/existing

New building is dominated by developing countries, especially China. The country is adding 2 billion square meters a year[16] to a stock of 40 billion square meters, equivalent to twice the existing office building stock in the US. This 5% growth rate compares with 1% in developed countries. In some developing countries the growth rate is even higher.

New buildings can be designed and built with very low energy requirements. The main challenges are stimulating an appropriate design approach, reconciling this with financial objectives and overcoming behavioral barriers. (See Chapter 5.)

The energy-efficiency challenges for existing property are different from those in new building. Technical difficulties and financial constraints can be significant in retrofitting properties.

Rural/urban

Energy use patterns are different between rural and urban centers, especially in developing countries where many rural homes rely on local biomass sources. Economic development tends to extend grid and gas supplies and increase energy consumption in these areas. The balance between the numbers of rural and urban properties differs widely between developed and developing countries. This can make country averages misleading.

Developed/developing
As already noted, the scale of new construction and the rural/urban balance are linked to a country's stage of development. Other important factors include the sophistication and effective implementation of building codes, relative costs in new buildings between materials and labor, and lifestyle factors in driving demand for property and energy use.

Floor space per capita is another significant difference between developed and developing economies, with important consequences for energy demand as energy and floor space are typically closely related. Increasing floor space demand is related to large-scale economic development, such as is occurring in China today. However, figure 3.4 shows that this trend does not only apply to developing economies. Residential floor space per capita in developed markets has also grown as these economies have become wealthier.

Energy efficiency needs to benefit all sections of society, including poorer people. As energy costs are a larger proportion of low-income household spending, improved energy efficiency can help alleviate poverty.

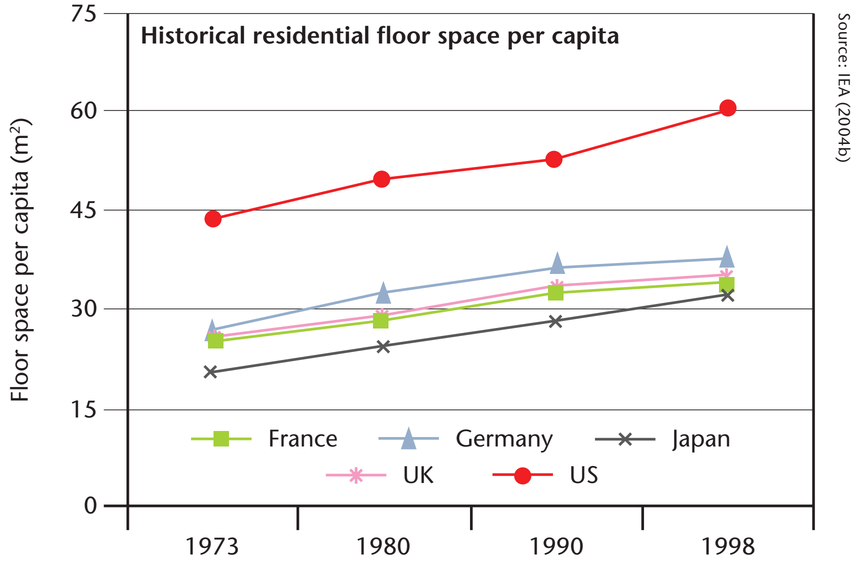


Figure 3.4: Growth in floor space

Climate
Climate clearly has a significant influence on the nature of buildings and their energy demands. Most obviously, the demand for heating energy is highest in colder climates, while hotter regions require more attention to cooling. Climate strongly influences design, for example colder climates already tend to have better air tightness and insulation.

Humidity and rainfall are also important factors, as well as temperature. The Koeppen climate classification defines six major groups, which are used by organizations such as the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE). ASHRAE assesses energy-related design conditions through a combination of factors, including the numbers of heating and cooling days.

Considering all these influencing factors on building energy use and design, it is impossible to create a single technical solution to energy efficiency that will work in all markets and all cultures. However, through analysis and effective scenario planning, myriad technical approaches, market factors, and policy drivers can be combined to achieve the necessary improvements. These will be more carefully developed and scrutinized in the next stage of the project's work.

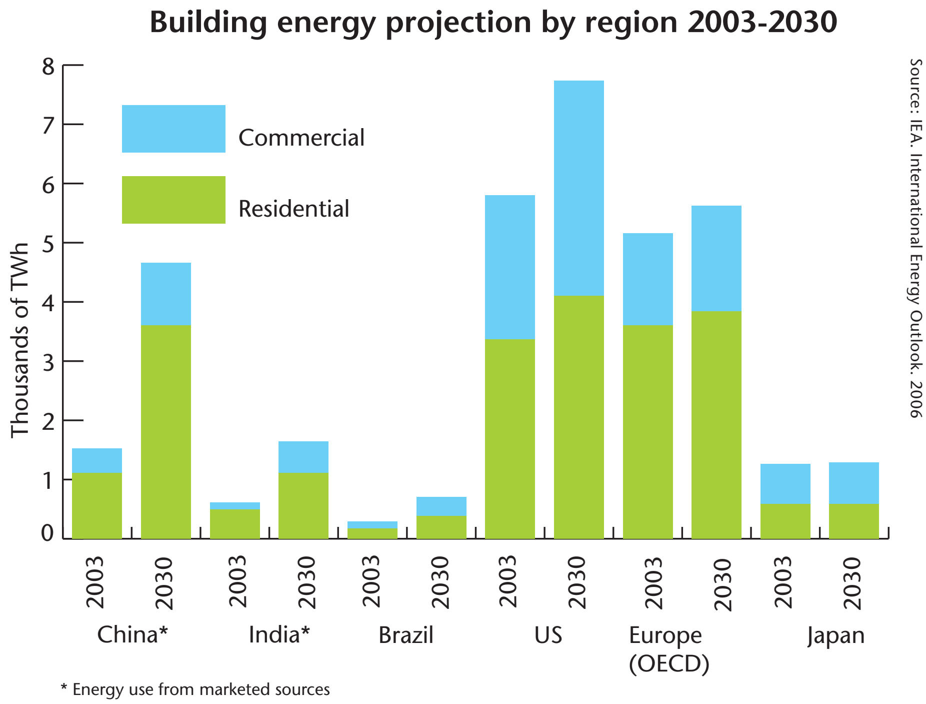


Figure 3.5: Building energy forecasts

Energy use and sources

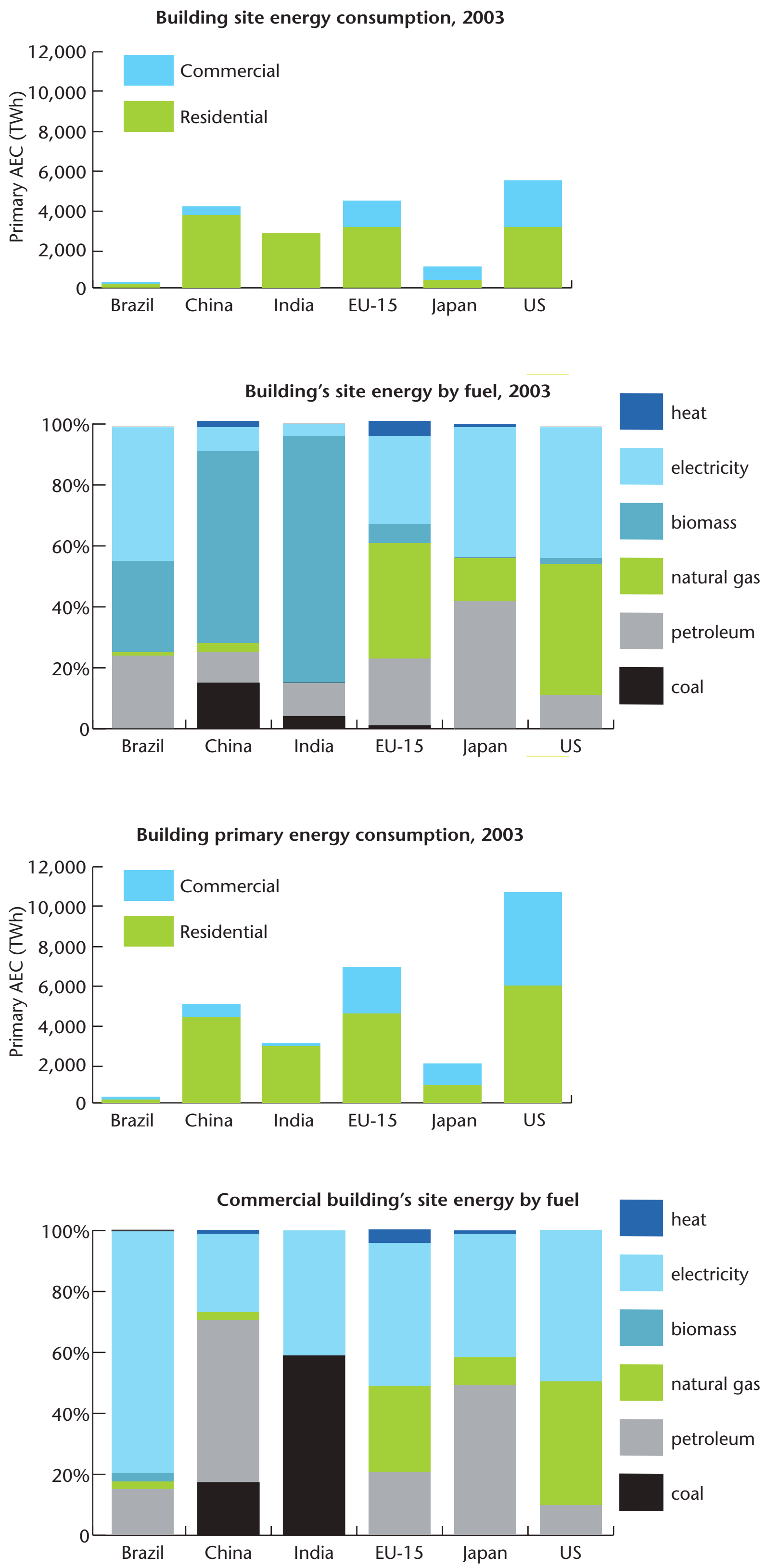
Figure 3.5 shows existing building energy demand in key markets, and forecasts for 2030 (energy from marketed sources only).

Energy use for buildings in the US is substantially higher than in the other regions, and this is likely to continue. Consumption in China and India will grow rapidly, however, and China's building energy consumption will approach Europe's by 2030, while India will have overtaken Japan. If current trends continue, commercial building energy use in China will more than double during this period. Energy consumption in Western Europe will rise only moderately and will remain flat in Japan. Building energy use in Brazil will grow, but will remain relatively small in 2030 compared with other regions.

Energy sources and uses

The four charts below (figure 3.6) show the level of energy consumption in our target markets, together with fuel sources.

The sources of energy vary greatly, with a significant amount of coal and biomass burned on site in China and India, but with a much higher share of electricity being used in other countries. This variation contributes to large differences in primary energy consumption because of the additional energy demands of power generation and distribution. Development and urbanization are associated with increased electricity use, which will significantly increase primary energy demand in China and India. Figure 3.6 also emphasizes the scale of primary energy demand by US commercial space.



Source: WBCSD EEB Phase I Facts & Trends Equipment Sector Report

Figure 3.6: Energy consumption and fuel sources

The vast majority of energy consumption occurs during a building's occupation. Figure 3.7 shows the findings of one study, which are broadly supported by research in other countries and climates, that suggest four-fifths of energy use occurs in the operational phase. The proportion of energy embedded in materials and construction will rise, however, as operational energy efficiency increases and if building life spans shorten, as is the case with some commercial buildings.

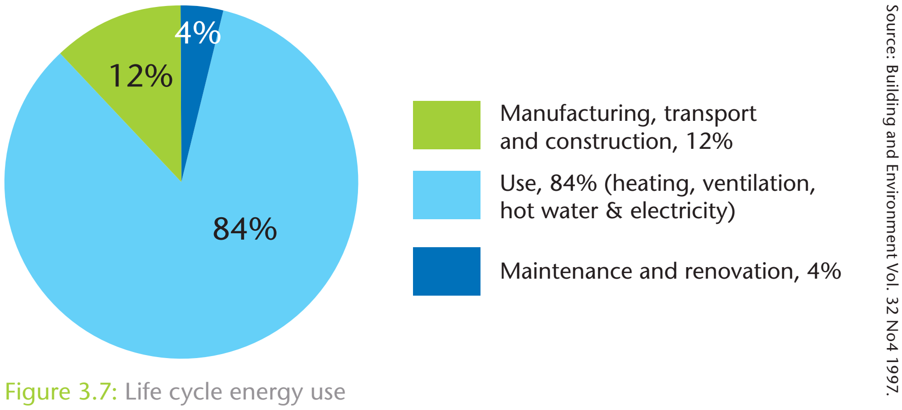


Figure 3.7: Life cycle energy use

End uses vary from sector to sector, region to region and climate to climate. For example, food retailers use more energy for refrigeration than non-food retail, which uses substantially more energy for lighting. Figure 3.8 illustrates the variation in energy intensity and total energy used by non-residential sub-sectors in the US. Food service and food sales are high-intensity sub-sectors, but the scale of office space means this is by far the greatest overall energy user.

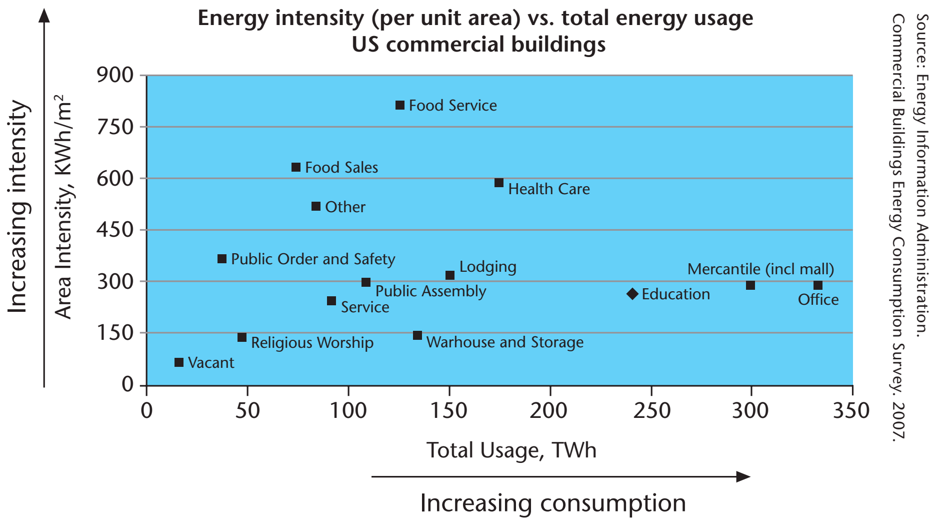


Figure 3.8: Demand by sub-market

Energy use is different in residential buildings but space and water heating are substantial components in most regions. This is true for the US despite the widespread use of energy for space cooling in the hotter states.

Drivers of energy use in buildings

Energy use is determined by three broad factors: population size, square meters of building per head of population, and energy per square meter. It can be expressed in this formula:

total energy use = population x space per head x kWh per m^2

These fundamental factors are in turn influenced by others. For example, space per head changes according to demographics, because an ageing population tends to result in more single person households, but also economic development and lifestyles – which influence new household creation. Economic development, lifestyles and technology all influence energy use per square meter, as desired comfort levels change and electrical equipment becomes affordable. Climate change itself could drive energy use, as increasingly extreme weather conditions result in higher energy demand to achieve desired comfort levels.

This section briefly describes the factors (apart from climate change) that are driving energy use and that are especially significant in developing countries such as India and China.

Demographics

More buildings inevitably mean more energy needs, so demand is driven largely by population growth – which is most relevant in developing countries. But other changes such as the age profile can also be significant, especially in developed economies. For example, several European countries have a growing proportion of older citizens, which tends to lead to a higher proportion of single occupancy and therefore an increase in residential floor space per person.

Migration can also be important, for example some areas (e.g., parts of eastern Germany) are becoming depopulated as younger people move to cities elsewhere.

Economic development

Development is typically associated with rising energy use due to industrialization. The growth of the service sector also creates demand for commercial buildings. Subsequently, a shift from manufacturing to services can reduce energy intensity in developed countries.

Higher incomes allow people to spend more on residential energy, and development is typically accompanied by a shift from rural to urban centers. This shift creates demand for new housing in urban centers, which has substantial additional impact on energy demand, and especially electricity demand. In developed economies, people use greater wealth to acquire additional properties such as holiday homes.

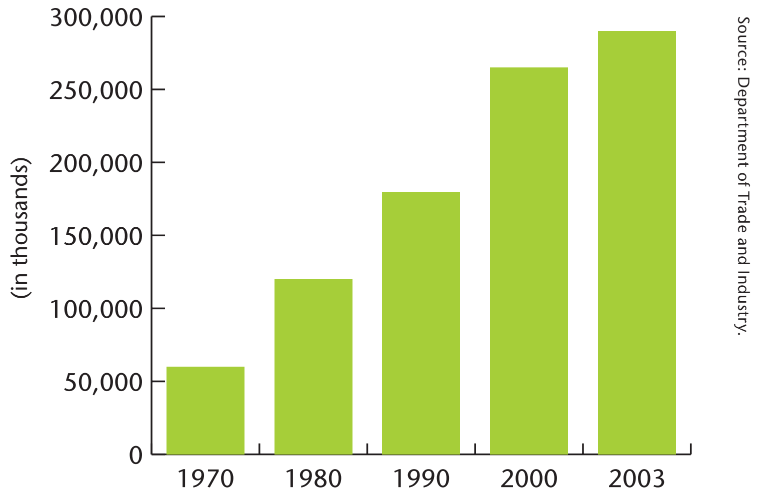


Figure 3.9: household appliances in the UK

Lifestyles

Energy demand is determined by how people use buildings as well as the numbers being built. Growing prosperity means that more people expect to have air conditioning to combat heat, and central heating to fend off the cold. More and more computers, televisions and other communications equipment, refrigerators and other appliances are also adding to the load. For example, In the UK household energy use for lighting and appliances has nearly doubled since 1971, driven by a quadrupling of the number of devices, as figure 3.9 demonstrates.

Greater wealth has been associated with growing energy demand in most countries. People expect larger living space and higher comfort levels, which result in higher energy consumption, although energy-efficient buildings can be more comfortable.

Energy sources

Currently the mix of energy sources for buildings varies widely from country to country. Electricity is much more prevalent in developed countries, while countries such as China and India use large quantities of biomass at site. Coal is also a significant site energy source in China. This mix of site energy use is likely to change as China and India develop, with growing use of electricity.

Primary energy sources derived from fossil fuels are a principle source of global carbon emissions, the major source of greenhouse gases. If energy demand from buildings increases without decarbonizing the primary energy supply, greenhouse gases will inevitably rise. According to a recent study published in the Proceedings of the National Academy of Sciences in the US, levels are accelerating at greater then 3% per year. Nearly constant or slightly increasing trends in the carbon intensity of energy have been observed recently in both developed and developing regions and no region is decarbonizing its energy supply. The growth rate in emissions is strongest in rapidly developing economies, particularly China.[17]

Technology

Improved communications have made it possible for people to work from home, reducing demand for new office space. Technological development has introduced building management equipment to optimize offices' internal climate. But advances have also made equipment more affordable and therefore more widespread. IT equipment has also become more energy-hungry, e.g., broadband "always-on" Internet connections; data centers with increasingly dense servers. Security fears have also led companies to duplicate data centers to protect against catastrophe.

Computers are estimated to account for about 2% of worldwide energy consumption[18] and the industry has recognized that they can become much more energy-efficient. For example, PCs are believed to waste half the power they consume. The technology is available to achieve much greater efficiencies.

Accelerating urbanization

Today's cities consume three-quarters of the world's energy and are responsible for at least three-quarters of global pollution. The urbanization process dramatically affects energy consumption. A recent analysis from the World Bank (2003) showed that a 1% increase in per capita GNP leads to an almost equal factor increase in energy consumption. However, an increase of 1% in urban population increases energy consumption by 2.2%.

The second half of the last century was the most intensive period of urbanization that our planet has ever experienced. The urban population increased from 160 millions in 1900 (one-tenth of world population) to about 735 million in 1950, to reach 3 billion in 2000 (50% of world population). The UN forecasts a further increase to reach about 5.1 billion by 2025 (62% of world population), illustrated in figure 3.10.

In developed countries, 75% of the population already lives in cities, compared to 35% in developing countries. But the rate of urbanization in those countries is much higher – 3% compared to 0.5% in developed countries. Estimates show that by 2030, about 84% of the population of developing countries will be living in cities.

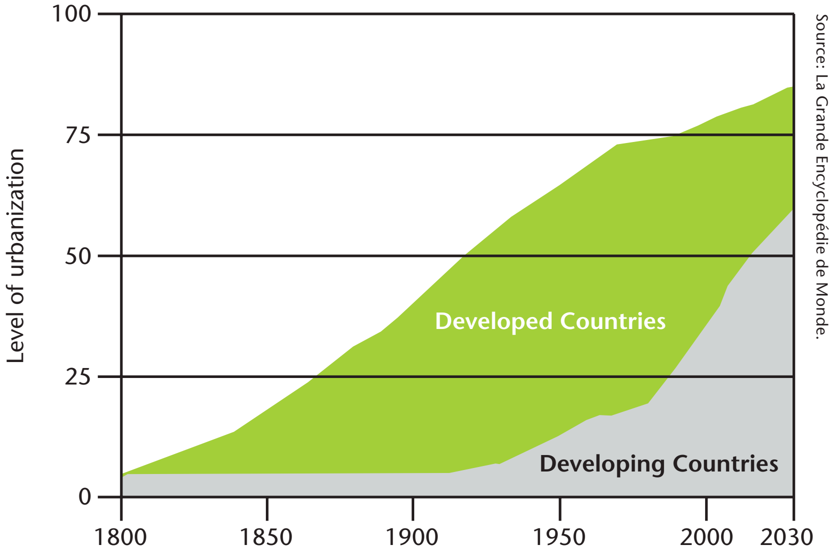


Figure 3.10: Accelerating urbanization

Mega cities and their impact on energy consumption

According to the UN,[19] there were 19 cities with more than 10 million inhabitants in 2000, 22 with 5-10 million people, 402 with 1-5 million people and 433 with 0.5-1 million people. There are likely to be 23 such megacities by 2015.

The growth in city sizes has been dramatic over the last 200 years: the average size of the 100 largest cities has increased from 200,000 people to 5 million. By 1863, only London and Paris had more than 2 million inhabitants. This threshold was reached by 4 cities in 1900, 10 in 1920, 29 in 1950 and 148 in 2000. At the beginning of this decade those cities held about one-seventh of world population (882 million people).

Cities are growing faster than the growth of existing populations, swollen by a move from rural areas. The movement of people and activities towards these mega cities has led to a generalized spread of roads, increased car use and a growing level of energy use and pollution.

Market dynamics

The sector is characterized by fragmentation within sections of the value chain and non-integration between them. These characteristics are important in understanding the market mechanisms for how to improve energy efficiency in buildings. Current mechanisms appear to reinforce a tendency towards short-term financial criteria to dominate decision-making. Financial aspects such as investment returns and rental yields are critical to commercial property investors. To some extent this also extends to residential owners, for whom a house is by far the most significant personal financial transaction they are ever likely to make. The implications are explored further in Chapter 5. In the next chapter we report the results of specially commissioned research into the perceptions of professionals in the value chain.

Fragmentation

Fragmentation is a significant issue in the building sector. Even the largest players in the supply of buildings are small by international business standards; for example the largest construction group in the FT Global 500 spring 2006 list, the French company VINCI, appears in the bottom 20%. The largest construction companies are international, but barely multinational (they do not tend to operate on all continents). Property developers and investment companies, architects and engineers tend to be even less international. One consequence is that research and development spending within the industry is significantly low (less than 1% in the US[20]) as a proportion of the revenues generated. Research also tends to be focused on specific technical aspects rather than integrating different technologies.

The value chain

There are many stakeholders in the building supply chain. The main commercial relationships are illustrated in figure 3.11. The complexity of interaction between these stakeholders is one of the greatest barriers to energy efficient buildings.

Local authorities influence the value chain through building policies for their area, which are typically layered over national regulations. While the local authorities set codes and standards for buildings, they typically are a compromise between high levels of energy performance and cost considerations. [21]

"The client needs to invest for a higher-performance building. We have to convince clients it's worth looking 10 years ahead but many of them prefer to design for now. Most clients want minimum cost – developers are driven by profit.

Owner-occupiers are usually more interested. And tenants are becoming more interested, especially in the public sector. Most tenants pay for electricity so they get the benefit from lower energy needs.

But we never know who's coming in and if you can't get through to the tenants you're wasting your breath.

Letting agents are the really naughty people – they set the standards. But they are starting to sell on the basis of sustainability because they think this is what's going to drive the market."

David Lewis, Arup London

Capital providers – as lenders or investors they are overwhelmingly concerned with the risk and return equation. This is often over a short time period, although mortgage lending clearly involves longer timescales. Their decision-making is dominated by financial criteria, and as chapter 5 describes, energy is not normally sufficiently significant to influence decisions.

Developers are the primary actors in commercial construction and are frequently speculative, making capital gains rather than holding the property to reap returns from rental income. This inevitably results in a short-term focus on buildings' value, and value being dominated by estimates of potential rental income. Once a project has the necessary commercial and regulatory backing, there is usually intense pressure to complete construction as quickly as possible, as cheaply as possible, meeting only minimum requirements. These pressures can squeeze out any non-essential aspect considerations.

Speculative developers have only a short-term interest in a property, which is quickly sold on to an owner or investor. Their concern is with the attractiveness of the property to potential buyers. Only if energy efficiency was a significant factor in the buying decision would it concern the developer.

Developers who hold property to receive income from tenants have a longer-term view. They are likely to be concerned with long-term operating costs, possibly for as long as 50 years. This perspective makes energy-saving investments potentially attractive, even if the payback period is relatively lengthy. But in many countries it may not be possible for developers to reap the benefits of such investments – the energy savings goes to the occupier, even though the developer incurs the investment cost.

Developers are typically conservative. They are naturally reluctant to take technical risks given the scale of commercial risk involved in major projects and the perceived conservatism of potential occupiers. This makes it difficult for architects to incorporate new ideas in many developments.

Developers commission *designers (or architects), engineers and construction companies* – who have the most expertise in technical aspects of construction, including energy efficiency, but who usually have only limited influence on key decisions. Architects, engineers and contractors often work in relative isolation, even if they all work for the same firm. Financial pressures can mean that proposed enhancements such as energy-efficient features are eliminated in a value-engineering exercise in later design stages, especially because projects are typically carried out as a sequence of separate segments rather than in an integrated fashion.

The role of *agents* can be important. They often stand between developers and tenants, and between owners and occupiers. Their interests are typically short-term and financial; for example, the agents who act for developers and tenants in a commercial transaction are interested primarily in the lease agreement, focusing mainly on price. Developers complain that this intermediation makes it more difficult to talk to potential tenants about the longer-term, non-financial aspects of buildings, including energy efficiency.

Owners are frequently not the same as *end users* in residential or commercial buildings. The owner may lease the property to occupiers, sometimes with timescales of only a few months. Agents or property managers may stand between owners and end users, without knowing or communicating the benefits of energy efficiency to either side.

Owners may have a short-term or long-term perspective, depending on their objectives. Some owners buy to sell on (and make a capital return), others buy to lease (as an investment), or buy to occupy. The latter group is in the best position to consider investments that may have lengthy pay-backs. Owners of investment properties are in a similar position to long-term developers. They may be able to consider investments with lengthy payback periods, but may be inhibited by split incentives, which means that they cannot reap the benefit of the investments.

Users are likely to be in the best position to benefit from energy savings, but may not be able to make the necessary investments (the reverse of the owner/developer position). More significantly, as described in Chapter 5, energy costs are likely to be a small proportion of their total occupancy costs, and may therefore not receive enough attention to drive energy-saving activit.

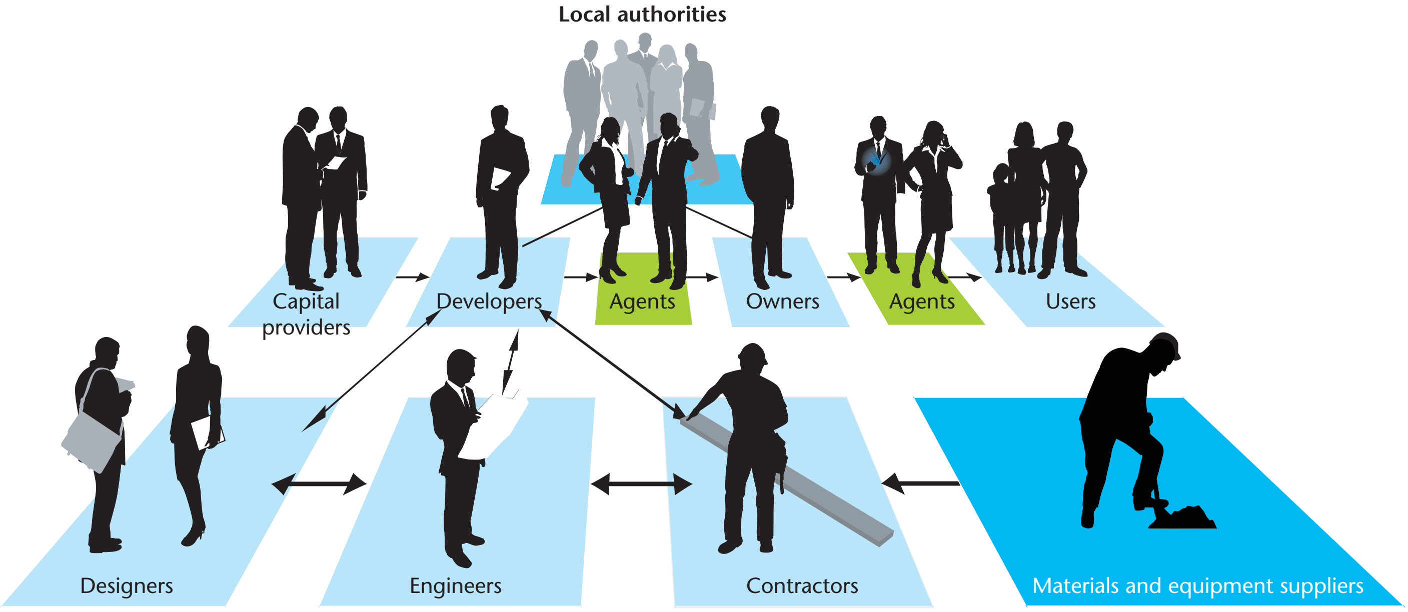


Figure 3.11: Relationships in the building value chain

The design process

One way to visualize the complexity of interaction is shown in figure 3.12. The first pyramid describes the various technical disciplines involved in the building sector. The second pyramid describes the building delivery process. Combined, the third pyramid highlights the ineffective coordination that exists between the functional gaps and management discontinuities. For example, there are often lengthy delays between the design stages, due to differences with planning permission, project financing or signing up anchor tenants for commercial property. The risk to completing the project is highest in the early stages, which means there is financial pressure to limit the amount of money at risk early in the process.

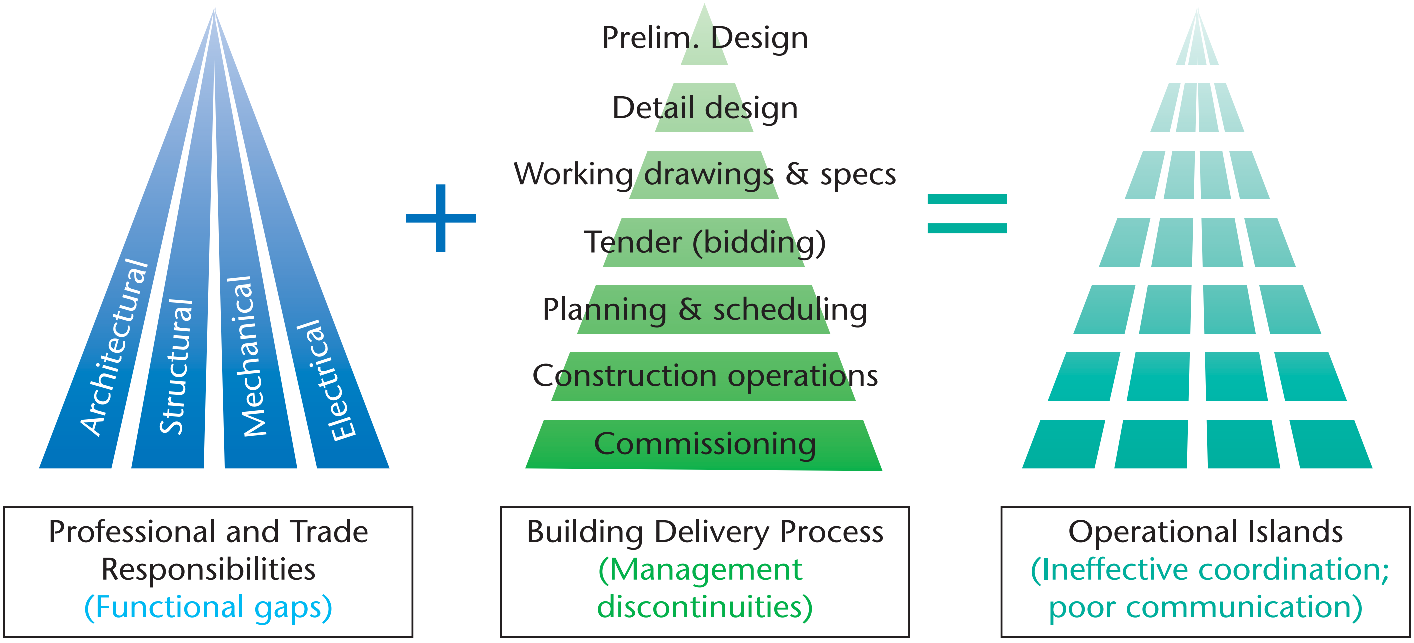


Figure 3.12: players and practices in the building market[22]

More prevalent vertical integration in the supply chain can improve energy efficiency in buildings. While there are a number of major companies which integrate these design and delivery functions (e.g., Skanska, Hochtief, Peter Kiewit) they rarely carry out such fully integrated design/build projects, which are perceived to be more costly to implement.[23] Property developers may prefer not to integrate because they believe competition within each specialty generates value (i.e., results in lower bids in a tendering process). The question of holistic design and the cost implications is covered in Chapter 5.

The extent of integration varies from market to market. A more directly integrated relationship exists in the public sector, where the state may finance, develop and own property such as schools, hospitals and other public buildings, including public housing. The residential sector is in any case more integrated. Housing developers typically design and build properties and sell them directly to owners, who are also often the end customers.

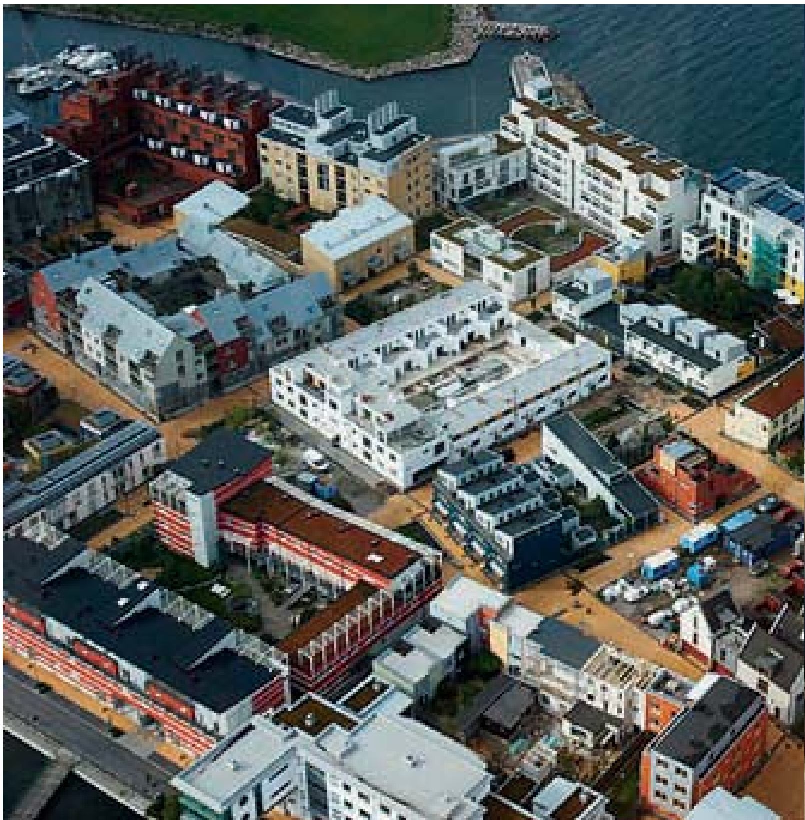
The individual roles and ineffective coordination between participants in the value chain have two important consequences:

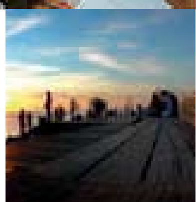
- Incentives to reduce energy use are usually split between different players and not matched to those who can invest in energy-saving measures
- There is normally very little opportunity for users to provide feedback through the market to developers or designers.

This aspect is exacerbated by the one-off nature of property transactions. The market consists of a relatively small number of large transactions. In most business sub-sectors, buyers seldom have the opportunity to return to the same seller. Retail and warehousing are the main exceptions, where customers acquire a series of outlets based on a standard model over several years.

Low energy now II

This example demonstrates that there are already buildings in several countries which consume close to zero net energy.





Sweden's Bo01 housing estate (the first stage of the Western Harbor redevelopment) was completed in 2001. It was designed as a sustainable urban environment, including 100% renewable energy supply, increased biodiversity and a waste management system designed to use waste and sewage as an energy source.

The houses are built to minimize heat and electricity consumption. Well-insulated buildings with low-energy windows decrease heating needs, and the installed electrical equipment is highly energy efficient. Each unit is designed to use no more than 105 kWh/m^2/year, including household electricity.

Barriers revealed by perception research

Summary

- Some building professionals are willing and ready to lead green building progress but many are skeptical, uninformed or unenthusiastic
- They tend to underestimate the contribution of buildings' energy to climate change, and overestimate the cost of saving energy
- Know-how and experience is lacking, as relatively few professionals have actually been involved in green buildings
- Four key deficiencies create barriers to adoption of green building practices: personal know-how, business community acceptance, corporate conviction and personal commitment
- There is a lack of leadership on sustainability in buildings

Progress on energy efficiency depends on people in the building industry being aware of the importance of the issue, and then being able and willing to act on it. The EEB project commissioned research to investigate these two aspects. It found that awareness is high in most countries covered by this project, but there are significant barriers preventing widespread involvement. There are serious gaps in knowledge about energy efficiency among building professionals, as well as a lack of leadership throughout the industry.

The research investigated perceptions of sustainability in relation to buildings, including the use of the terms "green" and "sustainable". The word sustainable tends to be more prominent in Europe, while green is more suited to Asia, especially Japan. Regardless of the term used, energy costs and energy use were the highest priorities for building professionals.

Their other prominent objectives were occupant well-being and productivity, conservation of water, and reducing the risks from rising energy costs. Potential future resale value and reputational benefits for companies were ranked lowest of the main factors.

"The market has the greatest power to change and motivate things."

Architect, International

Technical details

On behalf of the EEB Project, Lippincott Mercer designed qualitative and quantitative research (carried out by GFK) in eight countries – Japan, China, India, Brazil, the US, Spain, France and Germany. The research investigated perceptions of building sustainability, and attitudes to broader aspects than just energy efficiency. Respondents identified saving energy as the most important objective of green or sustainable building.

Qualitative research was with three groups:

- Opinion leaders – architects, journalists, NGOs, academics
- Regulators – policy-makers, politicians, regulators
- The finance community – analysts, financiers, property investment companies

Researchers carried out in-depth interviews between October 2006 and January 2007, either face-to-face or by phone, with 45 people, the majority in the Opinion Leader group. The interviews covered attitudes towards sustainable buildings, barriers, and the role of the EEB project in driving change.

Quantitative research questioned three broad sub-groups of building professionals:

- Specifiers and developers – including architects, engineers, builders and contractors
- Agents and professional landlords – including corporate building owners
- Corporate tenants

Researchers interviewed 1,423 people using a telephone questionnaire between November 2006 and February 2007.

The research did not include input from private landlords and homeowners.

Results from Japan were anomalous but are included here, for completeness.

An unengaged respondent:

"[The provision of finance for a sustainable property] really doesn't affect us at all…I don't even know if the projects we finance are sustainable – I just care about the risk."

Financier, Europe

Attitudinal segments

The research identified four broad attitudinal segments among building professionals (see figure 4.1). The segmentation is based on personal knowhow and the extent of personal conviction or commitment to sustainable buildings. Each box in the figure shows the characteristics of the segment, including the level of awareness of and involvement

in sustainable buildings. (The figures relate to the "purchase funnel" in figure 13.) The boxes also indicate the key requirements to move groups toward the "leader" quadrant. The figure also indicates the key requirements to move groups towards the "Leader" quadrant.

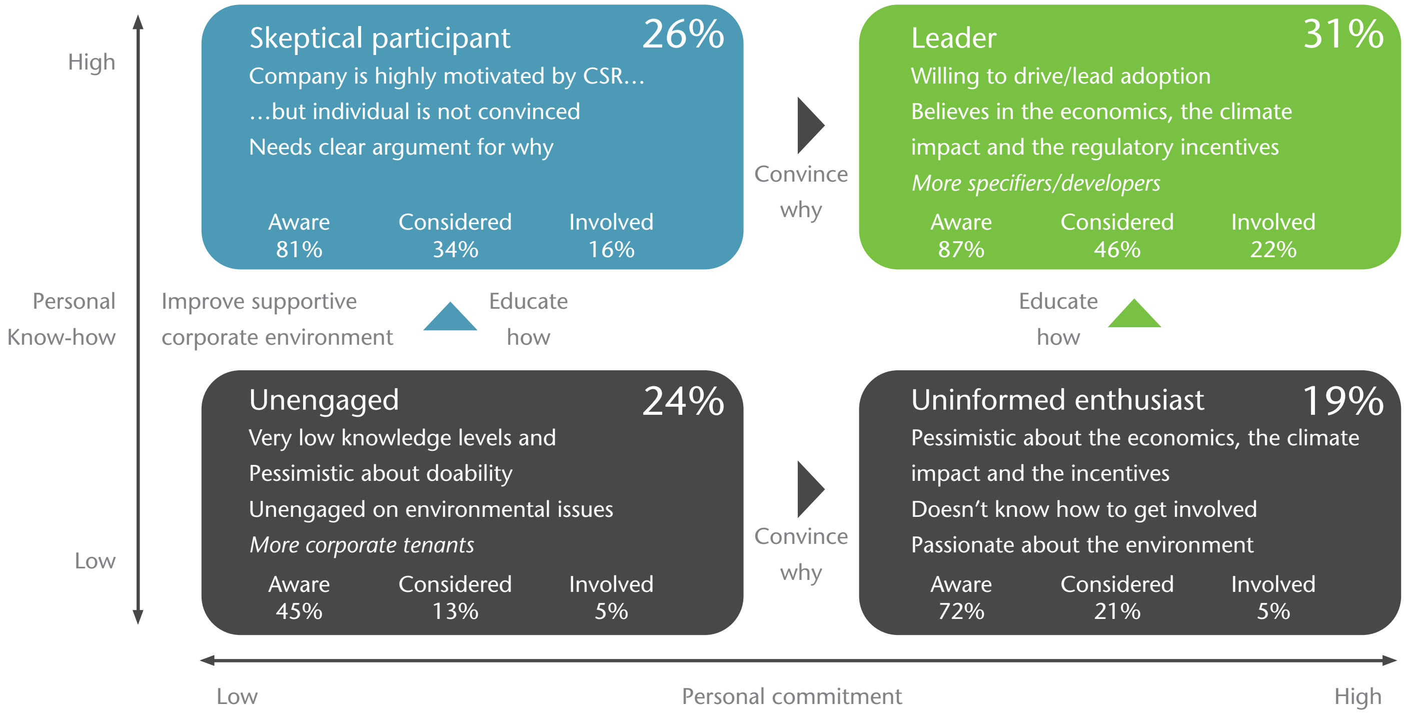


Figure 4.1: Segments among building professionals

Professionals' sustainable building knowledge

"If we can motivate the building owners to demand sustainable building, then the building industry will change its priorities."

Academic, Germany

Respondents recognize that sustainable buildings are important for the environment, but underestimate buildings' contribution to greenhouse gas levels – which is up to 40% (see figures 4.2 and 4.3). They also generally overestimate the likely cost premium, which is likely to be under 10% in developed countries (although the estimates from China, Brazil and India may be more appropriate to those countries). This cost differential is discussed in more detail in chapter 5.

"What percentage of CO_2 emissions do you think buildings give rise to – directly and indirectly?"

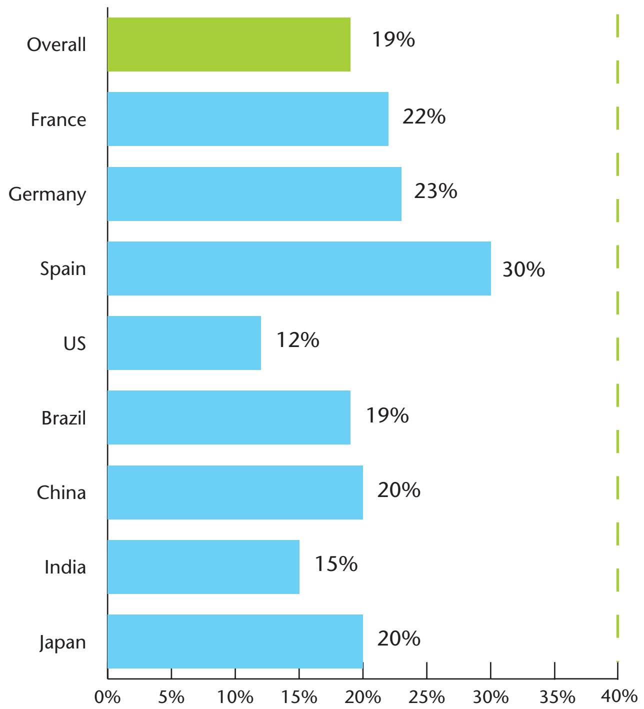


Figure 4.2: Estimates of buildings' emissions as a percentage of total

"How much more do you think a certified sustainable building would cost to build relative to a normal building?"

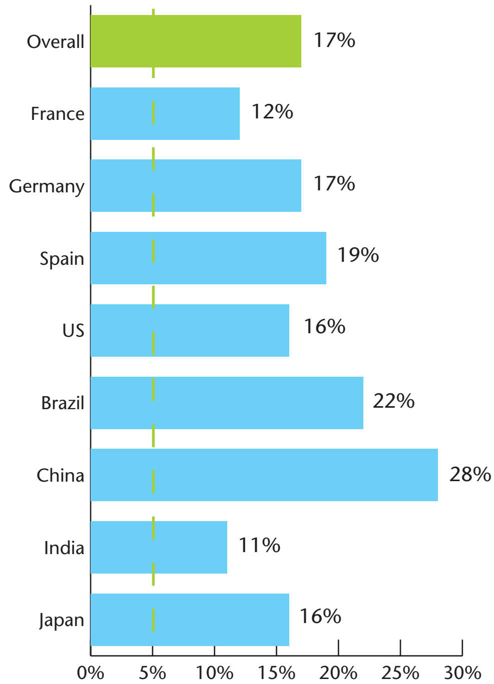


Figure 4.3: Estimates of cost premium for "a certified sustainable building"

Awareness and involvement

Awareness of environmental building issues is relatively high in all markets and across the three broad professional sub-groups. But in most markets the numbers drop fairly sharply on questions about involvement in green building activity (see figure 4.4 below). Typically only a third of those who said they were aware of green building had considered involvement, and only a third of those had actually been involved (11% of the total).

The highest awareness was among specifiers and developers and in western Europe. The lowest awareness was among corporate tenants in Japan and India.

Results in Japan are particularly interesting: the 13% level of awareness of green/sustainable buildings contrasts to an average 84% overall awareness in the other surveyed countries. Japan's unusually low awareness response is odd given building energy use, per capita and per floor area, is the lowest of the developed countries.

Overall, only 13% of those questioned have been involved in green or sustainable building, although this figure ranges from 45% in Germany to just 5% in India, and from 20% among specifiers and developers to just 9% among owners and tenants.

"I think the real estate agents don't know anything about it, I think the bank is a barrier, because they're not demanding it for their loan. I think the appraisers in the US need a lobotomy, or a transplant into their brain to understand value."

NGO, US

"What is your level of awareness of green/sustainable buildings?"

Note: Figures between the blue columns represent the proportion of the previous column number; for example, in France 32% of those who were aware had considered, and 30% of those had been involved.

Figure 4.4: Awareness and involvement of building professionals

The majority of respondents say they would be likely to consider involvement in a sustainable building in the future. As previously, the responses were generally more positive for specifiers and developers, but there was little regional difference except for India, which was the most positive country.

Barriers to progress

Qualitative research found that people believe financiers and developers are the main barriers to more sustainable approaches in the building value chain. The quantitative research identified eight factors that influence decision-makers about sustainable buildings (see figure 4.5). Four of these are the main barriers to greater consideration and adoption by building professionals and are the most significant in influencing respondents' consideration of "sustainable building":

"I would say that a lack of in-depth understanding is a barrier, but not a lack of awareness. 100% of the developers in the United States have heard of Green buildings. They might not really know what it is; they have preconceived notions of what it is that are probably not correct, but there is certainly I think a widespread awareness."

US Politician

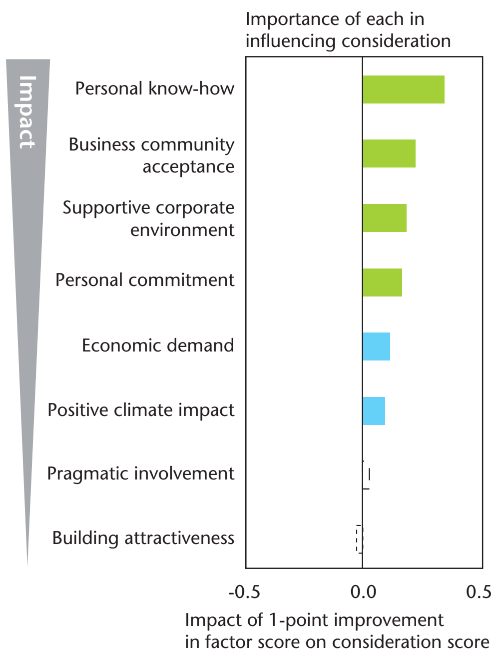


Figure 4.5: Factors influencing adoption of sustainable building practices

Technical note

The statements connected with each barrier are grouped together based on statistical analysis of responses. These four deficiencies were identified as the most significant contributors to barriers out of the eight dimensions because of their importance in influencing respondents' consideration of "sustainable building."

Personal barriers

- **Personal know-how** - whether people understand how to improve a building's environmental performance and where to go for good advice. This is based on reactions to these five statements:
  - *I know where to go for advice on sustainable buildings*
  - *I know which components will deliver the greatest environmental benefit*
  - *I try to persuade colleagues/clients to consider sustainable options*
  - *Sustainable building rating is well-known and easy to understand*
  - *Architects and designers are knowledgeable about sustainability*
- **Business community acceptance** – whether people think the business community in their market sees sustainable buildings as a priority. This is based on reactions to these statements:
  - *Sustainable building is practical and important for my country*
  - *Environmental issues are one of my top priorities in building*
- **A supportive corporate environment** – whether people think their company's leaders will support them in decisions to build sustainably. This is based on reactions to these statements:
  - *My company donates a lot of money to charity*
  - *My company is generally first to bring new innovations to market*
  - *My company has a strong corporate social responsibility culture*
- **Personal commitment** – whether action on the environment is important personally
  - *It is critical that we make sacrifices now to protect the future*
  - *I always stand up for what I believe in*
  - *I make a big effort to live an environmentally friendly lifestyle*

It is interesting to note that building attractiveness, the actual climate impact of action and economic demand were considered much less significant influencing factors.

The ranking of these barriers is broadly consistent across the groups of professionals, with two exceptions. The specifier/developer group scored much higher than the other two groups on know-how and business community acceptance, while corporate tenants scored much higher on the supportive corporate environment. This suggests there is potential for demand and competent supply, but a fragmented discontinuity between the two.

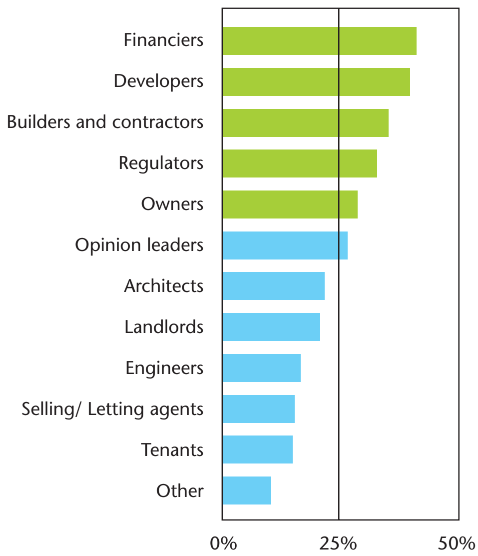


Figure 4.6: Who are the biggest barriers to more sustainable buildings?

"We are advertising the benefits of this new building technique a lot. People will realize that sustainable buildings are the best and they will be highly demanded. As it becomes more common, they will also pay more for these buildings."

Financier, Brazil

Perceptions of barriers by business group

Respondents identified financiers and developers as the main barriers in the building value chain. It is interesting that landlords and tenants come low down in this ranking, while builders
and contractors are seen as more significant than owners.

Leadership

When asked about their responsibility in driving change, very few of the decision-makers saw their task as leading the move to sustainable building (see figure 4.7). The answers suggest some willingness to adopt new practices, but also hint at the conservatism for which the industry is renowned.

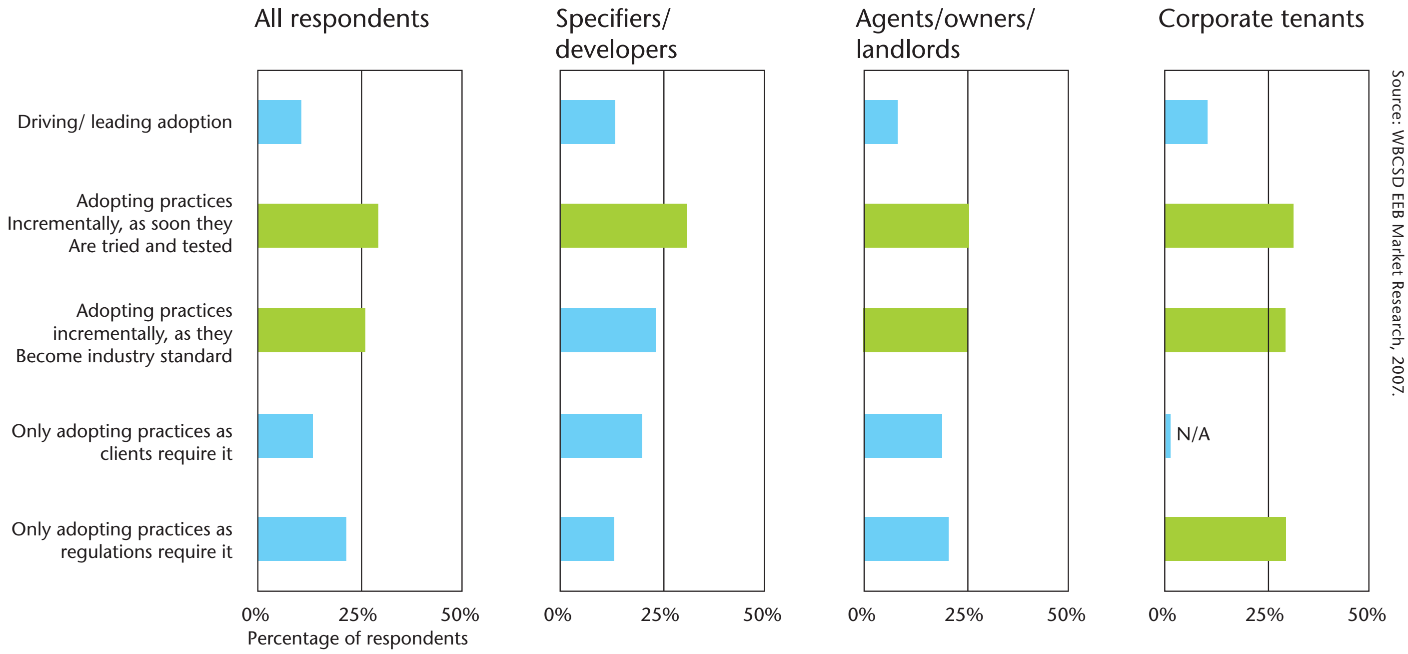


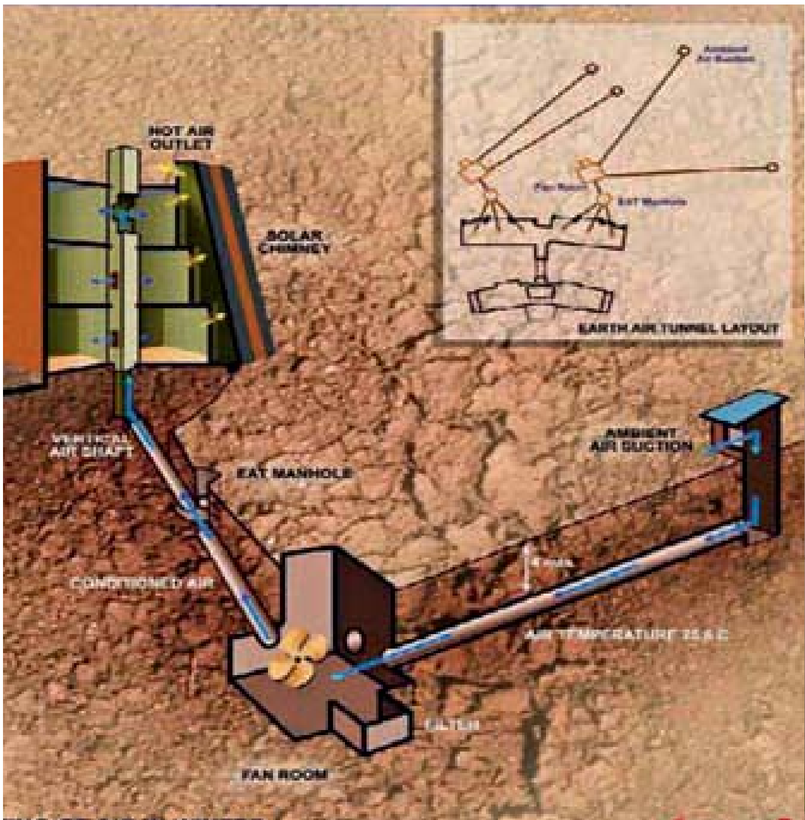
Figure 4.7: What do you see as the role of your company in the adoption of sustainable building practices?

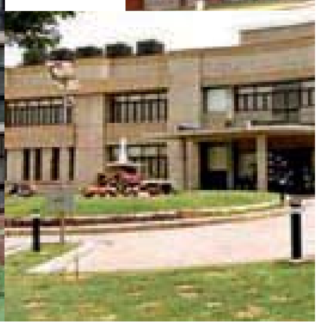
"The biggest barrier is that investors have the final decision-making authority on buildings and, under current circumstances, they are pursuing profit maximization. Sustainable building option conflicts with profit maximization."

Academic, Japan

Low energy now III

This example demonstrates that there are already buildings in several countries which consume close to zero net energy.





The RETREAT is a part of TERI's Gual Pahari campus, about 30 km south of Delhi. It demonstrates efficient use of natural resources, clean and renewable energy technologies and efficient waste management. The 3,000 m² training center is independent of the city's electricity grid system. The peak electricity load is only 96 kW, compared to a conventional 280 kW peak. There are three important aspects of the design:

- The functionality of the building and how energy is used in it
- "Passive" concepts that minimize energy demands, such as solar orientation, latticework for shading, insulation and landscaping
- Space conditioning and lighting demands that are met through energy efficient systems using renewable energy sources.

Various passive design concepts have resulted in the reduction of space conditioning loads by 10–15%:

- The building is oriented along the east–west axis to have maximum exposure along north and south
- Roof insulation uses vermiculite concrete and China mosaic white finish
- Wall insulation uses expanded polystyrene
- Part of the building is sunk into the ground to stabilize internal temperature
- Shading devices and windows have been designed to cut out summer sun and to let in winter sun
- Glare-free daylight has been provided, using specially designed skylights
- Landscaping affects wind directions
- Deciduous trees are used in the southern side of the building to shade it during summer but let in the winter sun.

Chapter 5

Levers to achieve change

Summary

Policy intervention is necessary to correct market failures that inhibit energy efficiency in buildings

Public authorities increasingly expect business inputs and commitments, and are willing to support that with regulatory activity

Cooperation between public authorities and the business community can achieve progress in breaking down barriers to energy efficiency

Policy action is particularly relevant in light of research showing a lack of leadership in the building industry

Policies are needed to stimulate energy-efficient approaches in six areas: urban planning, building codes, information, incentives and taxes, energy pricing, enforcement measurement and verification

"There has to be a demand for sustainable building for these types of buildings to be built. Otherwise it won't happen."

NGO, France

The "best in class" examples in this report demonstrate that the knowledge, technology and skills are already available to achieve dramatically lower energy use. But barriers such as industry structure and practices, professionals' lack of know-how and support, and a lack of leadership (identified in the previous chapters) are preventing widespread adoption.

Introduction

Market structure (described in Chapter 3) and perception research analysis suggests there are three levers that can help remove the barriers that prevent widespread energy-efficient building: a holistic approach, finance, and the behaviors that shape the actual uses of energy. We believe these levers (explored in detail in this chapter) can be instrumental in achieving rapid progress towards our vision of zero net energy buildings, when they are underpinned by appropriate policy and regulation.

The **policy** and regulatory framework is critical to ensuring the right conditions are in place for the market to work effectively. Policies in most countries do not currently go far enough to incentivize broad market adoption of energy efficiency. Important policy areas include technical aspects specific to buildings, measures to improve information flow, financial and other incentives. Getting this framework right will mean the market can work more effectively towards low energy use, based on sound minimum standards.

The three business levers that could drive energy efficiency can change how the market and individuals respond and increase the market value of energy efficient buildings.

A **holistic approach** is essential in order to integrate the potential of individual technologies and innovations, beginning at the highest level to gain efficiencies on a larger scale than can be achieved in individual buildings. Efficiency is improved where there is a greater degree of interaction and integration across sectors in the early stages of the design process. It helps to integrate technologies that can significantly lower energy use in buildings in economically attractive ways. Costs can be minimized with a holistic approach.

Financial aspects are fundamental to the building sector, and to energy efficiency. Property development and investment are financially dominated activities – the level of financial returns is critical to project and investment decisions. Buildings have become a financial rather than functional product. Energy aspects tend to be overlooked in these decisions, and in the management of buildings in occupation. Financial relationships and instruments are needed that will increase the focus on energy costs and savings, and drive energy-efficiency investments.

Finally, all these issues are ultimately shaped by **behaviors** - the behaviors we all adopt as stakeholders in the decision and investment process and our behaviors in the use of our buildings. The way we think, reason and behave has a profound impact ultimately on the energy efficiency of buildings. For example, there is a huge range covering what different cultures and different people find as acceptable indoor comfort conditions – these can have a dramatic effect on the heating energy used in buildings.

Policy as a supportive framework for business levers

Given a supportive policy framework, the three business levers will enable the separate "silos" in the building industry to work across boundaries and increase the focus on energy efficiency in several ways:

- The financial community will support investments in energy efficiency
- The design community will produce energy efficient designs
- The materials and equipment community will offer products and services that support those designs economically
- Building owners and operators will support and value energy efficient operation
- Utilities will support intelligent distribution and sustainable content of energy to and from buildings.

These separate elements need to work together to maximize the potential of each, supported by effective policies and regulation, as figure 5.1 illustrates:

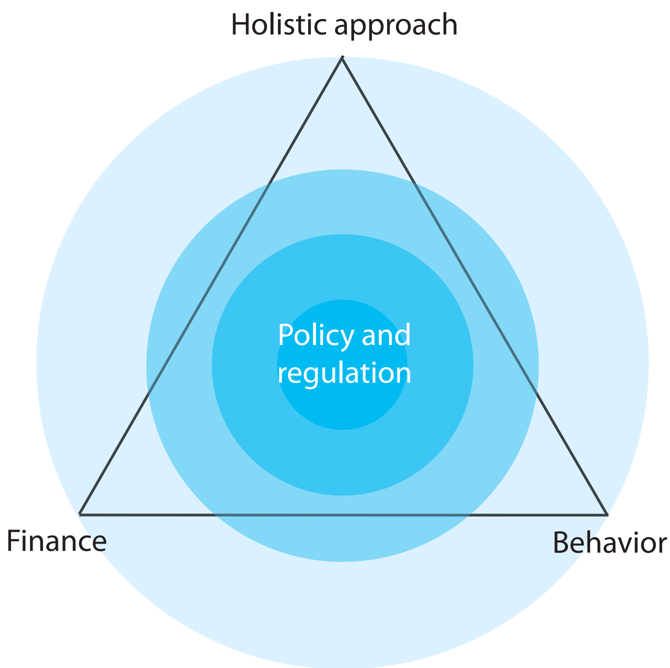


Figure 5.1: Three levers in a supportive framework

"When we design a building for a landlord – which he is letting out to the tenant – the tenant is master. So they will tend to say this is all fine but this requires an enlightened user so let me not take that risk."

Architect, India

Policy and regulation

Summary

Policy intervention is necessary to correct market failures that inhibit energy efficiency in buildings

Public authorities increasingly expect business inputs and commitments, and are willing to support that with regulatory activity

Cooperation between public authorities and the business community can achieve progress in breaking down barriers to energy efficiency

Policy action is particularly relevant in light of research showing a lack of leadership in the building industry

Policies are needed to stimulate energy-efficient approaches in six areas: urban planning, building codes, information, incentives and taxes, energy pricing, enforcement measurement and verification

Appropriate policies and regulations are essential to achieve market changes. Climate change was described as "the greatest and widest-ranging market failure ever seen" by Sir Nicholas Stern in his review for the UK government (see Chapter 2). He concluded that several types of interventions by governments are necessary to correct this market failure in several ways, including:

- Establishing a carbon price, through tax, trading or regulation
- Technology policy to support low-carbon innovation
- Removal of barriers to behavioral change, for example through information and standard setting.

The WBCSD supports the view that businesses need the right policy framework to achieve the necessary transformation. Its *Policy Directions to 2050* states:

"Business cannot develop and deploy the technologies needed on such a scale without help from government. International policy efforts must align with long-range business investment cycles. A broad and efficient mix of policies and programs targeted at mitigation and adaptation and backed by supportive regulation and governance frameworks will reduce investment uncertainty and assist business in its role."

This applies to the energy efficiency in buildings challenge, just as in other aspects of tackling climate change. Businesses in the building industry need a supportive policy and regulatory framework to achieve dramatic improvements in energy efficiency. This policy framework, developed in partnership between the business and political communities, should support the key elements of holistic design, finance and behavior described in the subsequent sections. Policy changes will require a mix of political will, regulation, innovation and best practice, but the first two are necessary to support the business contribution. This is supported by EEB research findings on industry leadership, which reveal that many building industry professionals only adopt new practices if they are required by regulation (see chapter 4).

Public authorities increasingly expect business inputs and commitments, and are willing to support that with regulatory activity. This project can see that cooperation is needed between public authorities and the business community, based on common aims and values, balancing private initiative and regulation.

Governments in most countries covered by this project have introduced building codes and been developing other relevant policies in this area, as table 5.1 illustrates. But more needs to be done to encourage vastly improved energy performance. It is not the role of this project to define policy details but this chapter sets out the key areas where policy initiatives can help influence design, behaviors and financial decision-making.

Brazil

Measures to improve the efficiency of lighting equipment

China

- Tighter efficiency standards for appliances and equipment
- New mandatory energy labeling for domestic appliances
- China Green Lights Program

India

- Efficiency standards and new mandatory energy labeling for new appliances and equipment
- Measures to improve the efficiency of lighting equipment

Japan

- *Top Runner* efficiency standards for equipment
- Local government promotion of the CASBEE energy labeling scheme

USA

- New equipment efficiency standards
- Extended Energy Star® buildings program
- Energy efficiency programs for utility companies

Source: IEA. "World Energy Outlook 2004".

Table 5.1: Examples of government action

Governments need to concentrate on the most efficient and cost-effective approaches. Research for the UNEP Sustainable Buildings and Construction Initiative (SBCI) found that the most effective instruments achieve net savings for society and that packages of measures combining different elements are desirable.[24] The study identified policies that were both cost-effective and successful in reducing emissions. Table 5.2 shows the most successful instruments in each of four categories.

	Effectiveness for emission reductions	Cost effectiveness
Control and regulatory instruments		
Appliance standards	High	High
Mandatory labeling & certification programs	High	High
Energy efficiency obligations & quotas	High	High
Utility demand-side management programs	High	High
Economic and market-based instruments		
Energy performance contracting	High	Medium High
Fiscal instruments and incentives		
Tax exemptions and reductions	High	High
Support, information and voluntary action		
Voluntary certification and labeling	Medium High	High
Public leadership programs	Medium High	High

Table 5.2: Effective policy instruments

"People think it's more expensive. If you only look at the first year, the construction of the building might be a little bit more expensive. But if you look at the first ten years I think they are cheaper because you get more attendance, you can get more rent per square meter, more money per square meter, and you use lower energy, so you have lower energy costs."

Architect, International

The scope of an effective policy framework

In line with business interests, a more effective policy framework for energy efficiency should cover the following:

- Urban planning
- Building codes
- Information and communication, training and skills development
- Incentives and taxes
- Energy pricing
- Enforcement, measurement and verification

Urban planning is covered in chapter 4, section 2. *Building codes* increasingly incorporate energy standards in many countries, but enforcement remains a key challenge (see below).

EEB research (Chapter 4) shows that professionals tend to underestimate the contribution of buildings' energy to climate change, and overestimate the cost of saving energy. This can be addressed through public *information and communication* campaigns about the issue, and also by highlighting the energy performance of individual buildings. A combination of voluntary and mandatory schemes is already emerging. For example, voluntary labeling schemes such as CASBEE (Japan), BREEAM (UK) and LEED (USA) are used in many countries. They are effective for owners who wish to specify a required level of performance in a building they are commissioning or acquiring.

Such schemes are voluntary, although they achieve quasi-mandatory status in some cases when they are incorporated into local authorities' planning requirements or building regulations. But this kind of label is currently available only for a small proportion of buildings. Greater transparency is necessary so that the energy performance of buildings is clearly visible to potential buyers and occupiers. One approach is the building "passport" required by the EU Directive on Energy Performance of Buildings. This requires energy performance certificates in all buildings above a certain size when they are constructed, sold or leased. This approach may be helpful in stimulating the kind of behavior changes necessary to increase energy efficiency because it will make energy performance more visible and therefore affect building values.

Incentives and taxes already exist in several countries but are often inadequate to achieve major behavior changes. They range from subsidies for cavity wall insulation to income tax allowances for energy-efficient expenditures.

Energy prices are often a relatively insignificant cost component and therefore receive inadequate attention from building occupiers and owners. Government policies can affect the level of prices directly, and can also influence behavior.

It is necessary to decouple utilities' revenues from the amount of energy supplied. Instead, current pricing patterns tend to encourage increased energy use, for example by offering "volume discounts" where the unit energy price declines as consumption rises. Utilities need to be rewarded for providing and managing the grid infrastructure, and prices should encourage reduced energy consumption, perhaps through increased unit prices as consumption rises.

Pricing policies are also important in stimulating markets for local and renewable generation. For example, electricity consumers in Germany receive credit for power fed into the grid from local generation at a rate four times the cost of the electricity they use from the grid. "White certificates" can also be seen as part of an energy pricing regime. They are certificates that relate to energy savings achieved, and can be traded in an energy market, providing monetary value for energy savings.

"It is necessary for the State to determine that greener buildings must receive more financial aids. When most of the market sees that everything carrying the sustainability label receives a bigger financial public support and a bigger support from investors, the market will move into this."

Architect, Spain

Policy is ineffective unless performance is *measured, verified and enforced*. For example, buyers basing a decision on an energy label need to know the label is credible. Similarly, energy savings need to be reliably measured if they are to be given value in the form of white certificates, or as part of a commercial arrangement, possibly involving an Energy Service Company (ESCO) as described in Chapter 5.

Governments can be instrumental in establishing standards that underlie reliable measurement and verification, and in enforcing instruments such as building codes. Inspection and measurement may be carried out by commercial organizations, but public policies may be necessary to ensure that this activity is carried out. Enforcement of building energy codes is particularly important to ensure that the design intent is implemented, but official inspection regimes are often inadequately resourced in many countries. For example, more than 80% of completed space in China fails to meet state-required efficiency standards.[25]

A holistic approach

Each individual player in the building sector needs to make a contribution towards zero net energy buildings using an approach that integrates all the individual aspects – a holistic approach. This also means considering the whole lifespan of the building, accounting for construction and demolition as well as operation. This chapter describes the holistic approach concept, which includes master planning, life cycle analysis, and integrated building design to obtain the broadest impact possible in the building industry.

Many energy-efficient technologies that can help move towards zero net energy buildings are readily available. This chapter also presents an assessment of the main technologies that are available today or on the horizon.

Summary

- Energy-efficiency in buildings needs to begin at the neighborhood or city planning stage and be integrated throughout the value chain
- The holistic approach needs to consider energy use over the whole lifecycle of the building
- Energy efficiency can be hampered by building life spans becoming shorter, which also increases the importance of embedded energy
- Holistic design combines different components of the building in an integrated approach, rather than focusing on individual elements
- Key aspects of energy-efficient design are shade, orientation, ventilation, the building "envelope"
- Substantial energy savings can be made in each of these fields, and the sum can be greater than the parts with integrated design
- Design should include on-site energy generation from renewable and otherwise wasted resources

A. Master planning

It is necessary to consider the community in its entirety as well as the single building to make a substantial difference to the sustainability of urban centers. This allows us to look on a broader scale and identify efficiencies or energy resources that a more restricted view could have missed. Master planning extends beyond buildings to include energy supply (production, transmission, distribution and in some cases storage), transport systems, working and living conditions.

Proper master planning is therefore crucial to optimizing urban centers and reducing their total ecological footprint. There is no point making a net zero energy building if the transport needed to reach it offsets its energy savings. In established urban centers the master-planning cycle must be accommodated retrospectively, working with the existing city structure. However, some new urban centers are being created as an entirely sustainable plan: such as Dongtan near Shanghai, and Songdo in Korea.

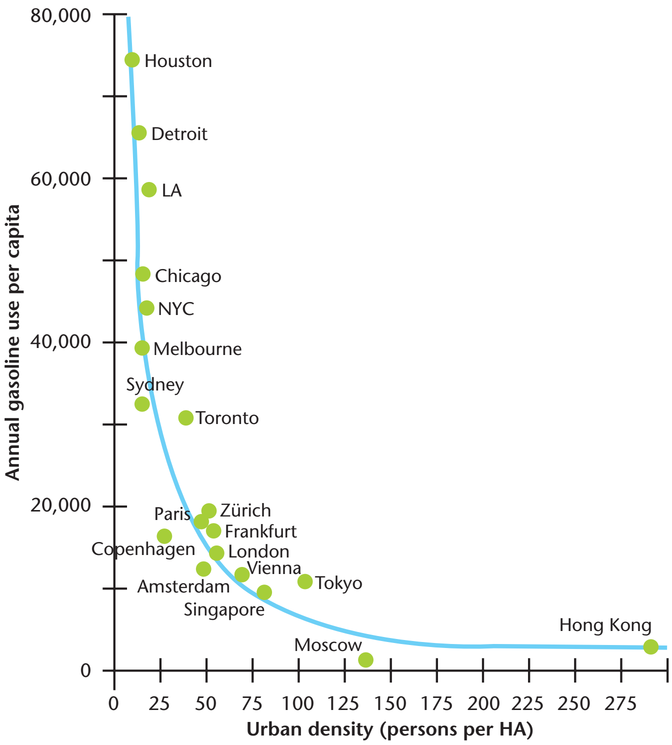


Figure 5.2: Energy intensity and urban sprawl

"The government has to take [policy] more seriously, through the building regulations. And the planners have to take [policy] more seriously at a strategic level."

Politician, International

The need for sustainable city planning
Energy efficiency requires that we think in an integrated manner – gaining an overall view of the various energy flows from energy production to mobility (transport) and building performance. One dramatic example of the need for this is shown in figure 5.2, which relates cities' per capita consumption of gasoline to urban sprawl. Los Angeles, with about 25 people per hectare, uses more than 3 times as much gasoline per capita as London, which has twice the population density but roughly the same size population. Population in the Los Angeles region grew by 45% between 1970 and 1990, while urbanized land area grew an astounding 195%.[26]

The impact of population growth is demonstrated by the fact that for every 1% increase in urban population, there is more than a 2% increase in a city's energy consumption. On the other hand, a 1% increase in per capita GNP leads only to an equivalent increase in energy consumption.[27]

Mechanisms exist to execute effective urban planning, such as regulations on density, building heights and the mix of land uses (e.g., residential, commercial), energy use and effectiveness metrics. But these mechanisms may not be implemented, especially in relation to energy efficiency, and established centers may have little or no incentive or room to maneuver due to existing constraints.

Ideally, urban centers should have high population density with a mix of residential and commercial buildings, and connected through high speed transport systems, as shown in the diagrams below. This would leave more room for agriculture, recreation areas, etc.

B. Life cycle considerations

Life cycle analysis (LCA) is a specific methodology to evaluate the environmental impact of a product, service or process over its projected lifetime. But it is also a general approach to considering impacts holistically rather than focusing on only one portion, such as manufacturing, use or disposal.

LCA is applicable to a material or a component, a single building element (wall, window, equipment, etc.) as well as to the entire building or even to a city. The analysis rapidly becomes very complex as the boundaries widen, and as the scope extends from fundamentals such as energy and resource consumption to other parameters such as land use, labor, capital and pollution. Practical application therefore tends to limit the boundaries. For example, the Building Research Establishment (BRE) in the UK chose to focus on energy, minerals and water consumption, air and water emissions. A similar approach has been taken in France with the "Fiches de déclarations environnementales et sanitaires" (see www.inies.fr).

The building lifecycle
Life cycle calculations depend heavily life expectancy assumptions. Choosing a building lifespan of 20 years, 60 years or 100 years will show a very different result. A building lasting 20 years may have a low embodied energy but it then needs to be multiplied by a factor of 5 when comparing it with a similar building with higher embodied energy but which is expected to last 100 years.

The building sector's environmental footprint needs to be addressed at every phase of the building's existence: production of building materials, construction, performance throughout its lifetime and its end of life. Figure 5.3 shows the impacts during these four phases.

"Today it is possible, based on the geographical positioning of the building, the type of construction, thinking about the thickness of the walls, insulation, all that… it is possible to employ techniques that allow us to spend less energy."

NGO, Brazil

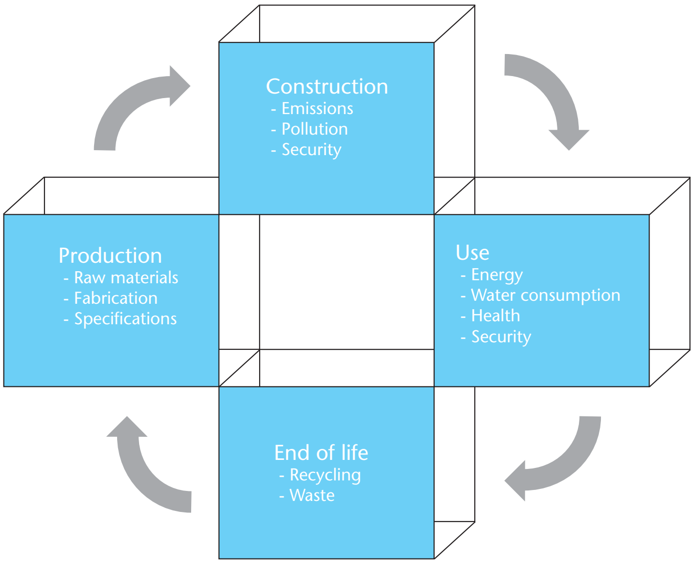


Figure 5.3: The building lifecycle

For residential buildings, life cycle analysis reveals that about 75-85% of total energy is consumed during the use phase, assuming a building lifespan of more than 50 years. The exact value depends on climate, building lifespan and occupier lifestyle and consumption patterns.

Sustainable buildings will have a long life, and adaptable, low-energy design can prolong the service life of a building. Anticipating and "designing out" maintenance and repair, and design flexibility for change of use during its lifetime, can also extend service life. Durability and longevity of building materials therefore becomes important. The life of buildings is decreasing and this trend needs to be reversed to avoid shorter construction–demolition cycles resulting in greater annual energy use because the embodied energy is spread over a shorter period.

"I think green building practice is best done when there is early integration of sustainable, high-performance design at the outset of the process, and that's not typically how developers can ….. move through the permitting process. So there have been some difficult experiences with Green building with people trying to incorporate more sustainable development practices further into the process, which can drive up costs."

Politician, USA

Building lives can be increased through high building quality that combines architectural attractiveness, flexible design for future alternative use, quality construction systems and building materials.

Embodied energy

The energy used in the extraction and processing of a material is described as its embodied energy, distinguished from the energy used at other stages in the life cycle.

Once an element or building has been defined, the whole life of the materials and products can be included in the energy value – the energy used to extract, transport and process raw materials, to convert them into manufactured products and components, to transport them to the construction site and incorporate them in a building.

The significance of embodied energy can only be understood in the context of the system that is using the material rather than the material itself. The whole system needs to be compared with alternatives performing the same function. It is not possible to assign a life to a pile of bricks or tonne of insulation – they only have a true "life" when considered in the context in which they are used. For example, as a wall, building components do assume a life. Different materials can then be compared on a like-for-like basis as components that fulfill the same or very similar functions. This means that important variables, such as the mass of a material required to fulfill a particular function, are taken into account.

For example, the results of a direct comparison between a tonne of one material and another would be misleading. Instead, a comparison must be made between one square meter of a wall made of either honeycomb brick or concrete block with insulation. This comparison needs to be based on similar insulation levels and life expectancy. Transport, construction and disposal aspects must also be taken into account.

It is also important to note that the primary energy used to calculate embodied energy of a functional unit (i.e., a wall) is dependant on the country's fuel mix. For example, the electricity that goes into the calculation of the embodied energy of a functional unit will be different if its generation comes from nuclear power or coal power plants.

If buildings become more energy efficient in their use phase, the proportion linked to the other building life cycle phases becomes more important. The challenge for the industry is therefore to reduce the energy demand of buildings during the use phase without increasing the embodied energy of the materials and equipment, while also reducing the energy used for the other phases.

C. Integrated building design

The performance of a building depends not only on the performance of individual elements, but on how they work together.

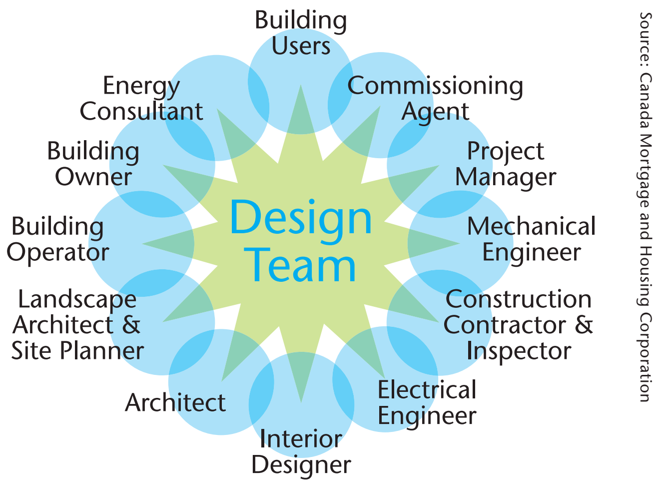


Figure 5.4: An integrated design process

Many factors need to be taken into account to design a high-performance building, such as climate, comfort levels, materials, building shape, health and security, structural security, architecture. Designers need to carry out extra design iterations to optimize all those factors, but firms traditionally wish to avoid the extra work because the fee structure is not adapted to this approach. Most buildings therefore follow a conventional design approach, operating on a sequential basis. But there is great potential in multi-disciplinary work, bringing together architects, engineers and others responsible for creating the building.

Unless barriers are removed, professionals will tend to continue working in isolation and buildings will continue to miss the benefits of using a multi-disciplinary approach.

An integrated design process (IDP) involves participants from the various value stream stakeholders in the design phases of the project, as depicted in figure 5.4. It is often suggested that the benefits of an IDP are increased building performance and lower downstream cost and disruptions. As shown in figure 5.5, the earlier in the process that IDP occurs, the bigger the impacts.

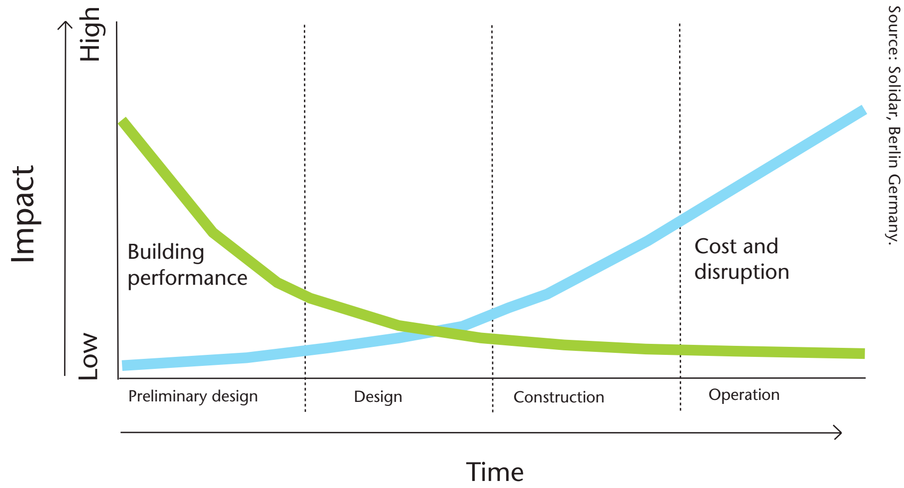


Figure 5.5: The benefits of early integration

The result of effective design is that primary energy use is not primarily dependent on the cost of construction and HVAC equipment, as figure 5.6 shows, based on a study of German offices. The chart shows that very similar energy balance can be achieved despite wide variations in cost.

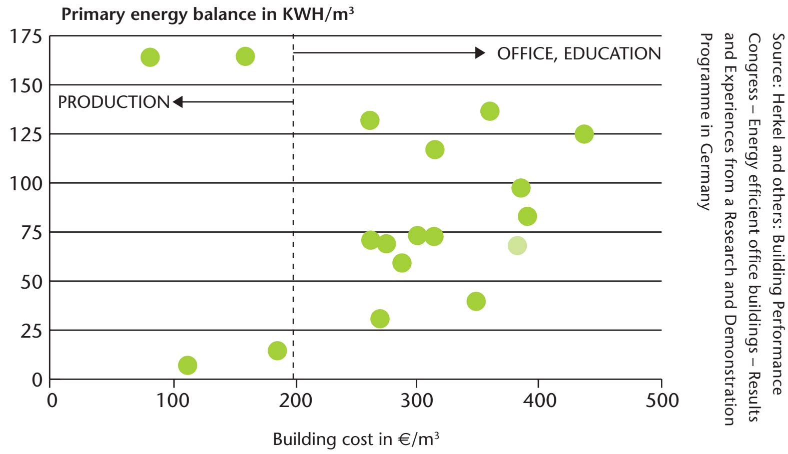


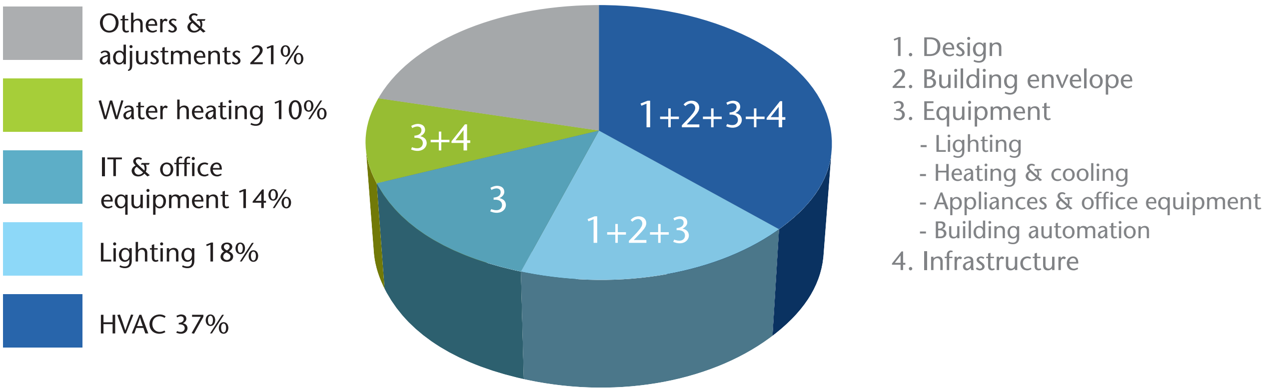
Figure 5.6: Building cost related to energy performance

D. Components of energy efficiency

Integration is crucial to effective building design and construction, and appropriate user behavior is necessary to achieve design performance. But we can identify several components that work together to create an energy-efficient building. Detailed elements are summarized in table 5.3.

The building “envelope” is particularly important. It is the starting point of energy-efficient buildings and the main determinant of the amount of energy required to heat, cool, and ventilate. Specifically, it determines how airtight a building is and how much heat is transmitted through “thermal bridges” that breach insulation and allow heat to flow in or out.

Figure 5.7 illustrates the inter-relationships between the main influences on energy efficiency and the key energy uses (percentages of total energy are for US buildings). The chart shows that most categories of energy use are affected by more than one influence. For example, all four elements affect the energy needs for heating, ventilation and air conditioning (HVAC). Table 5.3 summarizes the key aspects of the main technologies.



Source: US Department of Energy. 2004 Buildings Energy Databook. 2004.

Figure 5.7: Design impacts on energy use

PassivHaus

PassivHaus, which began in Germany in 1991, has developed an approach that can reduce the energy demands of a building to one-twentieth of the norm but still provide comfortable conditions. There are more than 6,000 buildings that meet the PassivHaus standard – offices as well as apartments and houses, new and renovated buildings.

There are five key elements in this approach:

1. The "envelope" – all components of the structure that encloses the internal space should be highly insulated
2. Airtightness – stop air leakage through unsealed joints
3. Ventilation – use a mechanical system with heat recovery so that hot air leaving the building warms the cooler incoming air
4. Thermal "bridges" – eliminate heat loss from these poorly insulated points in windows, doors or other parts of the envelope
5. Windows – minimize heat loss in winter and heat gain in summer

Five broad categories of product or service can influence a building's energy efficiency. Specific examples are shown in table 5.3 below.

Design: shade, orientation, ventilation, "envelope"
These factors affect the extent of heating from sunlight, the airtightness of the building, and therefore the internal cooling or heating requirements, and the need for artificial ventilation.

Materials
Structural materials affect the building's thermal mass and therefore its ability to store heat and moderate temperature swings. Other construction materials affect the airtightness and insulation of the building and the extent to which it absorbs heat from sunlight.

Equipment
Improved equipment such as heat pump dryers, and improved use of equipment, such as power management on office equipment and metering, can save substantial energy during a building's use, as well as more efficient equipment and appliances.

Energy generation
Heat pumps, combined heat and power systems, solar panels and wind turbines can generate energy on-site, possibly with the potential to feed unused energy into an intelligent grid.

Services
New approaches such as retro-commissioning can ensure that a building's potential energy efficiency is achieved through fine-tuning building systems so they perform effectively.

Table 5.3 summarizes the potential and barriers to key technologies in each of these categories.

Table 5.3: Characterization of energy-sawing building technologies[28]

Technology	Potential savings	Cost (unsubsidized) low, medium or high	Brief description	Barriers to broad implementation
Design				
Integrated design & modeling tools		L	Software systems and IT that enable collaborative design	Fragmented value chain – lack of collaboration; lack of data to demonstrate viability
Favorable building siting		L	Orientation that favors shading and natural lighting	
Natural and mixed-mode ventilation	**10%** of HVAC energy use	L	Ventilation strategies that use outside air for cooling & ventilation, often in combination w/HVAC; retrofitting not possible – new design only.	Complex design, climate limitations, potential fire code concerns; no retrofits
Thermal mass, trombe walls, and passive solar heating	Can reduce cooling energy by **8-18%** depending on climate	L-H	Use of thermal mass (brick, concrete, stone) to moderate swings in building's indoor temperatures and take advantage of outdoor temperature differentials between day and night: e.g., bring in cooler outdoor air at night to pre-cool the building structure (night purge) – reduce cooling loads. The effectiveness of thermal mass can be enhanced by use of solar heating to provide additional heating during cooler months (reduce heating loads). Trombe walls – special design.	Consumer and builder education; aesthetics; better integration into traditional HVAC design and construction; cost of more complex system; specialized design

Technology	Potential savings	Cost (unsubsidized) low, medium or high	Brief description	Barriers to broad implementation
Materials				
Building airtightness	**10-40%** of HVAC energy use (depending on climate and airtightness level)	L	Reduce energy loss through unintentional air leakage through the building envelope; retrofitting possible.	Lack of understanding (of cost and impact); poor construction practices; limited code regulations
Cool roofing	**6-16%** of cooling energy use (depending on climate)	L-M	Coatings with high solar reflectance – reflect heat, transfer less heat to the buildings	Residential: aesthetics – generally white coatings; commercial: limited life cycle – degrade properties within few years; limited code regulations
Electrochromic windows	**19-26%** of cooling loads; **45-65%** of lighting energy	H	Adjust light transmission properties of the glazing to minimize solar heat gain and maximize natural lighting	High first cost: incremental cost for electrochromic windows are ~US$ 1,000/m^2 of glazing (US$ 93/ft^2)
High performance windows	**39%** of heating and **32%** of cooling energy for HIT; **19%** of cooling energy for high performance double-pane low-e (Florida)	M	New window technologies: 2nd gen low emmissivity (low-e) coatings; high insulation technologies (HIT) with triple or quadruple panes, vacuum spaces and aerogels	Low-e and double pane windows are standard; HIT windows account for <1% in US due to cost of US$ 30-50/m^2 higher than standard; retrofitting possible
Improved insulation	**12%**	L	Improved insulation products or practices to avoid loss of thermal insulation R-value; thermal bridging and air leakage are major factors	Lack of consumer and builder education and 3rd party oversight; for retrofit adding sufficient insulation and effective air sealing could be expensive
Radiant barriers	up to **10%** of cooling energy; much higher impact when combined with airtightnes	L	Materials with high reflectivity (>0.9) and low emmissivity (< 0.1) – reflect heat radiated by hot surfaces (e.g., keeps the heat out or in)	Lack of education: when combined with envelope airtightness impact is significantly higher; adding more insulation is considered more cost effective; retrofits might be more attractive – insulation harder to add
Phase change materials (PCM)	can save **35%** on the energy used for air conditioning;		PCMs provide thermal mass to light structures, moderating temperature fluctuations and reducing heating and cooling energy consumption. PCMs absorb heat and slow down the temperature increase within a room, reducing peak temperatures and delaying the peak loads. As temperatures drop, the absorbed heat in the PCMs is released, warming the rooms and reducing the heating loads. PCMs are generally incorporated in the building envelope as boards/panels or other forms.	High first cost; unproven long-term performance; new technology

Technology	Potential savings	Cost (unsubsidized) low, medium or high	Brief description	Barriers to broad implementation
Thermal energy storage materials (TES)	**10-20%** of cooling energy		TES systems store a sizeable quantity of "cool" thermal energy at night to meet cooling needs during the day. When the building requires cooling during the day, water passes through the TES tank and circulates around the building. The thermal storage media could be PCM materials or chilled water.	Technology commercialized, but very limited market penetration; higher first cost and lower efficiency for ice-based systems, space constraints for water-based systems
Lighting				
Compact Fluorescent lamps (CFL)	Up to **80%** of lighting energy	L	CFL lamps are smaller, consume 4 -5 times less energy to produce the same amount of light and last approx. 10 times longer than conventional incandescent lamps.	Higher first cost (CFLs ~ several dollars premium; dimmable CFLs ~12 cost premium); more common in Europe, less in US
Occupancy sensors for lighting control	**5-75%** of lighting energy for individual spaces	L	Devices that automatically switch on/off lighting based on space occupancy.	Payback uncertainty, commissioning challenges and false triggering
Photosensor-based lighting controls	Daylighting can save up to **30%** in lighting energy	H	Photo-sensor based devices that allow for continuous dimming (combine daylighting with electric lighting) to adjust lighting output.	High cost, complex installation, commissioning , lack of evidence that technology works and reduces energy use, limited retrofit opportunities
Heating, ventilation and air conditioning (HVAC)				
Air-source heat pump	Up to **60%** of heating energy in moderate climates	H	Avoiding use of electric resistance heating is the primary basis for energy savings: climates where the length of the heating season & the range of outdoor temperatures make it possible to meet heating requirements w/little or no electric resistance back-up.	Higher first cost versus electric resistance heating
Condensing boilers and furnaces		M-H	Condensing boilers and furnaces achieve 90-95% efficiencies versus non-condensing boilers at 80-85%; require stainless steel heat exchangers and special venting.	High cost (US$ 750-1,500); lack of information
Condensing water heater	**16%**	M-H	Condensing water heaters achieve energy factor of 0.86 (residential) to 0.95 (commercial), versus conventional non-condensing water heaters.	High first cost; space required
Dedicated outdoor air systems (DOAS)	>**10%** of total space heating;	M-H	DOAS condition the outdoor make-up air separately from the return air: effective ventilation and dehumidification. Saves energy by reducing total ventilation airflow, the energy to condition ventilation air, decoupling temperature and humidity control.	Limited application: perception of higher cost even though this might not be the case

Technology	Potential savings	Cost (unsubsidized) low, medium or high	Brief description	Barriers to broad implementation
Displacement ventilation (DV)	**30-70%** reduction in cooling equipment energy use and 35-50% increase in ventilation energy consumption	?/H?	A cooling technology that uses a low-velocity air stream vs. turbulent jets. DV reduces energy consumption relative to conventional mixing ventilation reducing thermal envelope loads in cooling climates and increasing economizer operation in moderate climates.	First cost premium not well understood – perceived high; technology not well understood
Electric heat-pump water heater (HPWH)	**40-70%** less than electric resistance water heaters; 30% less than gas-fired water heaters	H	Uses vapor compression to move heat from the surrounding air to the hot-water storage tank via a heat exchanger. Sometimes integrated with the hot-water tank.	High first cost; noise; poor reliability of early HPWH equipment
Heat and energy recovery ventilation (ERV)	Reduces annual cooling by **~33%** while ventilation energy increases by **25%**; highly dependent on climate	H?	Uses the exhaust flow to provide conditioning of the outdoor air: during cooling season the cooler indoor air pre-cools the incoming air; during the heating season the warmer indoor air pre-heats the incoming outdoor air.	Perception of higher cost; Perception of greater maintenance due to moving parts
Heating-only absorption heat pump	In heating mode can save **40%** energy, when compared to conventional furnaces and boilers.		Thermally activated heat pump (e.g., heat input rather than mechanical input); simpler than the reversible counterpart; can be used for space heating, water heating or both.	High first cost; some safety issues; limited commercial availability
Modulating (variable speed/capacity) compressors	**20%** of annual AC energy	?	Ability of modulating compressors to meet partial compressor loads better than single capacity compressors, hence reduce energy consumption by reducing loading; multiple technology approaches.	Longer simple pay-back periods (e.g., >10years)
Radiant ceiling panels	**15-20%** of cooling energy, with larger savings in warm, dry areas	?	«Chilled beam» systems – chilled water flows through pipes in the ceilings, cooling the room through natural convection and radiation (passive panels, no forced air). Each heat transfer mode accounts for ~1/2 of the cooling capacity of passive radiant cooling panels.	Perception of higher first cost; unfamiliar with technology; requires upfront coordination; potential condensation problems – a DOAS is needed to manage latent loads and avoid condensation in many climates
Commercial combined heat and power (CHP)	**4%-30%** of building primary energy consumption	M-H	Integrated system that uses «waste» thermal energy produced in the power-generation process to supplement space-heating, water heating, dehumidification.	System complexity; space requirement; noise/vibration; uncertainties on future utility rates; uneconomical performance in all but highest utility rates areas

Technology	Potential savings	Cost (unsubsidized) low, medium or high	Brief description	Barriers to broad implementation
Residential combined heat and power (micro-CHP)	Est. **55%** of waste heat could be recovered , displacing ~**50%** of annual space and water heating primary energy consumption	?	Integrated system that uses «waste» thermal energy produced in the power-generation process to provide heat for household space-heating, water heating, dehumidification.	High first cost; complexity; poor economics based on energy-cost savings
Variable-speed / ECPM	**50%** savings relative to single-speed motor	H	ECPMs offer variable-speed capability at no additional cost while achieving benefits of improved efficiency and reliability.	High cost, low volume
Water-cooled condensers	**20-40%** reduction in cooling energy consumption	?	Uses water (instead of air) to transfer heat from the refrigerant.	Maintenance issues; liability concerns from biological growth, most notably legionella; cost
Appliances & office equipment				
Electronics with low standby power	Low but can add up	?	Electronic devices can continue to provide some functionality when off, while decreasing the power draw in the off mode.	Cost?
Enabling power management for office equipment	Can achieve **36%** reduction in energy consumption by all office equipment in US	?	Low power sleep mode after a period of inactivity; on-mode power draw for most devices is at least one order of magnitude greater than sleep-mode power draw - significant energy savings potential.	Network connectivity issues, software incompatibility, central power management, lack of awareness
Heat pump dryer	**50%** less energy for drying the clothes	H	Uses a vapor-compression cycle to pump heat from the dryer's exhaust flow to the air entering the dryer.	First cost (payback 15 years); commercialized in Europe, not US; concerns about reliability of new, unfamiliar technology
Horizontal axis washing machines	**35-55%** lower energy consumption than the new, 2007 US efficiency standard for clothes washers	M	Horizontal-axis washers use a smaller volume of heated water than vertical-axis washers.	First cost (US$ 500?); some people in US prefer top-loading washers for ease of loading
Non-biomass cooking, space heating, and water heating		?	Biomass-based cooking and heating generally has much lower site energy efficiencies than conventional building equipment.	In developing countries first cost and availability of gas and electricity

Technology	Potential savings	Cost (unsubsidized) low, medium or high	Brief description	Barriers to broad implementation
Services				
Retro-commissioning	**5** to **20%** of building HVAC, lighting, & large refrigeration system energy consumption	M	Service performed in existing buildings to identify and fix potential problems so that building systems function properly. The tests can uncover energy savings opportunities.	First cost (typically US$ 2.50-3.50/m²), perceptions of expense, lack of awareness of benefits and practical concerns
Ongoing commissioning	**5-20%**	M	Similar to retro-comissioning but carried out regularly instead of once.	Lack of awareness about energy waste; uncertain first cost
Duct sealing	Sealing can reduce leakage by about **80%** and heating and cooling energy needs by up to **35%**	L	Duct leakage increases HVAC energy consumption because the heated or chilled air that leaks into unconditioned spaces increases the run time of the heating or cooling equipment. Aerosol duct sealant systems can be used to patch holes and cracks in existing ducts using an adhesive-aerosol spray.	Additional costs for sealing a leaky duct system (US$ 0.40-0.50/ft² for a commercial building), very little awareness of the prevalence and energy impact of duct leakage
CLEAN ENERGY				
Geothermal heat pumps	**20-50%** depending on climate	M	Systems that exchange heat between buildings and the ground (ground-coupled heat pumps) or underground water (water-source heat pump).	High first cost, and some ground conditions are unsuitable
Solar thermal heating	Not known **40-80%** of water heating energy	M	Liquid is heated by being pumped through a collector, usually placed on the roof, and passed through heat exchangers that transfer the collected energy for water or space heating.	First cost and solar hot water systems may not be as efficient as other high efficiency options such as indirect boiler hot water heating and high efficiency on-demand gas water heaters
Solar photovoltaic	Not known **50-80%** of electrical energy, depending on climate	H	Converts sun energy into electricity that can be used on site, or sent back into the grid (where infrastructure exists). The 2 largest segments are grid-connected distributed power application (62%) in developed countries and PV applications (primarily off-grid applications) in developing countries (21%).	Cost is still high, if non-subsidized, but has decreased by a factor of 7 over the last 20 years and are expected to decline further with increasing production volume
Wind turbines	Not known Dependent on site wind characteristics	H	Wind turbines convert the kinetic energy in the wind into mechanical power, and a generator converts this mechanical power into electricity. Utility-scale turbines range in size from 100 kilowatts to several megawatts. Larger turbines are grouped together into wind farms, which provide bulk power to the electrical grid. Single small turbines, below 100 kilowatts, are used for homes, telecommunications dishes, or water pumping.	Relatively new technology, not fully penetrated; the energy balance/payback period for wind turbines is favorable, compared to competing technologies

Financial information and mechanisms

Summary

- Real estate has become more significant as an investment class
- Short-term financial judgments have become more important as commercial owner-occupation has declined
- Energy is typically a small proportion of cost for most decision-makers in the building value chain, so tends to be overlooked in financial decisions
- The cost of energy efficiency is typically overestimated and needs to be assessed project by project
- Data is often lacking to assess the cost/value equation
- A more sophisticated risk management model may be necessary to deal with building energy costs
- New business models can help increase the focus on energy efficiency and stimulate investment

Financial considerations are critical to property development and investment in general, but they appear to be limiting progress on energy efficiency. Development and investment projects will normally be based on detailed financial analysis and will only go ahead if projects promise to yield acceptable rates of return. This is true of major development projects and smaller investments in specific improvements of individual buildings, including energy efficiency projects.

Financial pressures have become more powerful, especially in the US, because of the rise of real estate as an investment class alongside equities and bonds and a decline in the number of owner-occupied buildings. Owner-occupiers are in the best position to make long-term investment decisions about their buildings.[29] They will tend to have a longer term perspective and stand to benefit directly from energy savings. This applies both to owners specifying a new building that they will occupy as well as to existing owner-occupiers considering retrofitting. But leasing, rather than owning, is becoming more popular among corporate building users. Investors' time horizons are likely to be shorter. This increases the importance of their investment calculations of the property's residual value when they sell compared with operational returns during their ownership. In any case, energy costs are often hidden in operational costs and not considered by most investors.

Attention to energy efficiency is also hampered by the fact that energy costs are a small proportion of total occupancy costs, especially in commercial properties. For example, the budget for energy in a medium-sized office building in the US typically equals approximately 1% of total business costs, while salaries represent about 80% (see figure 5.11). Energy therefore tends to receive too little attention from developers, investors, owners and occupiers. This is made worse by uncertainty and lack of information about the energy efficiency value equation – decision makers may find it difficult to get adequate information about potential returns from energy-saving investments. This chapter explores these issues and describes the potential for new business models and relationships to address them

A. Real Estate as an investment class

Real estate investment in commercial buildings is part of mainstream investment practice. The aim is to generate a return on invested capital, just as with any other investment. Professional investors and investment managers are involved; the asset class is divided into sub-sectors such as retail and office buildings.

Residential buildings constitute the most significant share of global personal wealth. People in many countries own or aspire to own their own house. But self-occupied homes cannot be considered a typical investment asset. A home is more than an investment and very few homeowners would sell purely for financial reasons. Buy or sell decisions are likely to be based more on non-financial considerations rather than yield considerations. This section therefore concentrates on commercial property investment.

Real estate investment has become an important part of most asset managers' portfolios, alongside equities, bonds and other assets. It now accountants for 14% of global investment assets (see figure 5.8).

> "Banks play a role too… it would be important to consider the ecological quality of a building in the financing by simply…reducing the interest when people can prove a certain ecological quality."
>
> Architect, Germany

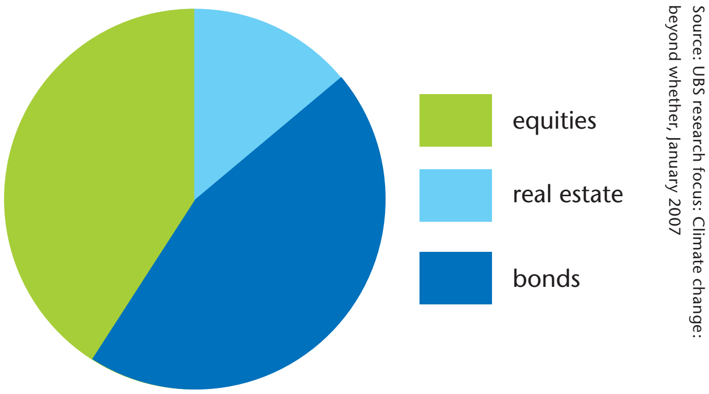


Figure 5.8: Global asset allocation

Real estate is attractive because it provides a steady income flow and has a low correlation to other asset classes (i.e., it does not tend to move in line with either bonds or equities). It has also proved to be an effective hedge against inflation.

These investments are becoming global. Cross border investment is growing strongly and stands at about 40 % of total real estate investment in Europe and the US[30] and 60% in China.[31]

Investment categories
It is necessary to distinguish between direct and indirect investment. Direct investment means that an investor buys (all or a share in) a specific building. This gives the investor control of the asset and direct access to the income stream from rentals. But risks are difficult to diversify and the investment horizon must be long, especially because the market can be illiquid – it can take a long time and significant management time to sell a commercial property.

Indirect real estate investment is possible through investment funds that hold a portfolio of properties (known as real estate investment trusts or REITs). They may be private or publicly traded, the latter being attractive because of their liquidity.

Valuation
Investors are primarily interested in the future income stream generated by the investment and the risk-adjusted return achieved over the period it is held. It is difficult to evaluate property investments as a whole, because each piece of real estate is unique. The investment value of a building is determined by factors such as rental income, costs of operating, maintaining and repairing the building, and the disposal value.

In general, energy costs are hidden in the operational costs and are not considered by most investors to be significant or material in the investment decision. Energy is more significant in some sub-sectors, such as supermarkets and hospitals, where owners and operators will have greater sensitivity to energy costs compared to the commercial office sub-sector.

“Investors and developers would gladly invest in sustainable building if it is made clear that construction of sustainable buildings generates high asset value in the future and also contributes to profitability.”

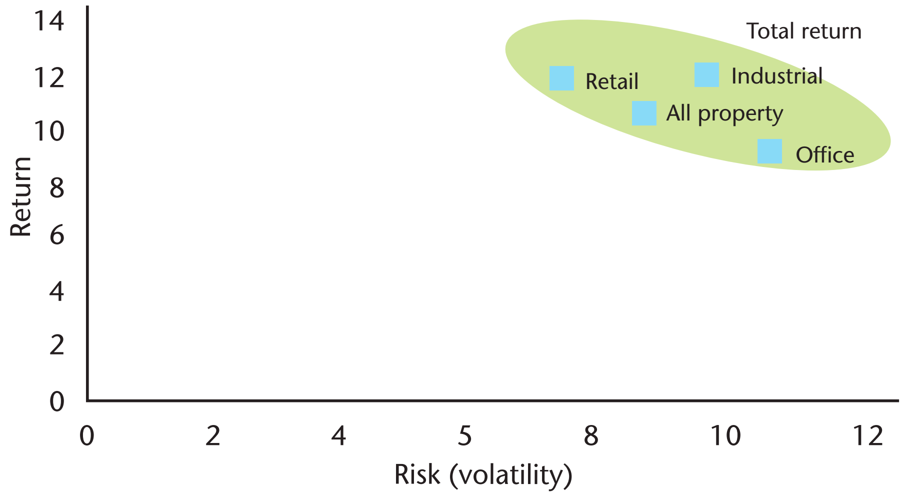
Academic, Japan

Over a 10-year perspective the residual value of a building (its value when sold) is important and can constitute approximately 60% of the overall value of the property. As indirect property investments have a turnover of typically 6-10 years, residual value is more important than for direct owners who tend to hold assets longer. The shorter the time horizon, the more speculative becomes the investment and the more important its residual value compared to operating costs (including energy) and returns.

There is a famous saying that three factors determine the value of a building: “location, location and location”. Location does explain a large part of the value because that is the key determinant of demand, especially for retail properties and certain kinds of commercial buildings (e.g., financial institutions that want to be at the heart of the financial center of a city).

Despite this, real estate markets are very heterogeneous and the performance of sub-sectors varies, as shown in figure 5.9 (for the UK). This diversity applies to geographic markets (countries, regions, cities, even parts of cities) and market types (commercial versus residential, commercial sub-sectors such as retail, offices, hotels).

%, average annual returns, period 1981–2004



Source: Investment Property Databank (IPD).

Figure 5.9: Direct market return in UK

B. Value of "green" buildings

There is emerging evidence that an energy-efficient building can command a premium, and this may grow as awareness of the link to climate change and expectations of rising energy costs leads more people and organizations to attach more value to energy efficiency.

One US study[32] found that professionals expect greener buildings to achieve an average increase in value of 7.5% over comparable standard buildings, together with a 6.6% improved return on investment. Average rents were expected to be 3% higher. The chart (figure 5.10) shows that the REITs in the US considered to have the highest green credentials outperformed the index over several years.

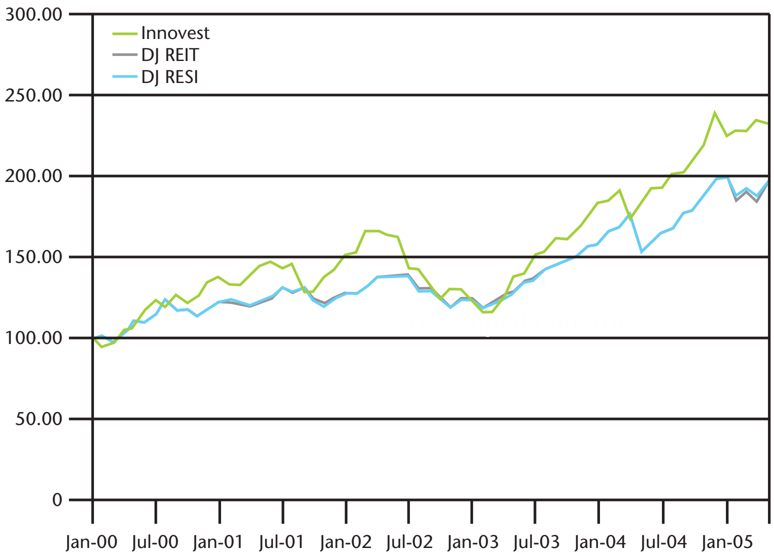


Figure 5.10: Outperformance of green REITs, Innovest

The relative insignificance of energy in building decision-making clearly represents an important barrier to the recognition of energy-efficient value. But there are signs that *values*-based considerations could overcome a purely "rational" economic approach, in both commercial and residential property. The growth of sustainable development, or corporate responsibility, has led many companies to focus on energy and greenhouse gas emissions from their properties, regardless of the relative insignificance of these factors in short-term financial terms. The headquarters of the New York Times and Bank of America are two current examples in the US, while elsewhere companies such as Swiss Re are committed to high energy-efficiency standards.

A similar development could emerge in residential property if building energy becomes more prominent in the concerns of private individuals. If this were to happen it would follow the trajectory of other consumer issues such as child labor and other supply chain issues, organic food and nutritional issues, and environmental impacts of products in production, use and disposal. All these issues have become prominent concerns for values-based consumers – which has prompted retailers and other consumer-oriented companies to respond (e.g., Wal-Mart's efforts since 2005 to improve its green credentials). Building energy efficiency could follow the same pattern.

This could have a significant effect on the property market, with energy-efficient homes commanding a premium, and the presence of "green buildings" potentially increasing the attractiveness (and therefore property values) of whole neighborhoods.

Socially responsible investment (SRI) has been a powerful force in raising public companies' awareness of their social and environmental impacts – and stimulating them to act on issues ranging from child labor to product recycling (as mentioned in the previous section).

SRI has recently emerged in the property sector, demonstrated by Innovest's focus on green REITs. If this trend grows on a similar scale to equity SRI it could represent significant pressure on real estate investment trusts REITs and other significant property-owning companies (e.g., developers, owners such as insurance companies) to address energy efficiency.

C. Energy cost significance

Energy is typically a small proportion of total operating costs for buildings. Real estate managers at the EEB's financial hearing in Zurich in March 2007 said that energy costs were too low to be a driver for energy efficiency. For example, in a high-quality office building in Germany, heating and electricity made up less than 5% of the total running cost of the building - about 1.1 of out of every 23.3 Euros spent (see figure 5.11)

They also said that energy prices rose by 40% between 2001-2006, but the overall cost only increased by 10% due to market liberalization, professional procurement, hedging, improved energy efficiency in equipment and better energy control systems.

But the investment case for energy-saving technology is not clear cut. Investment would drive down energy costs, but could increase maintenance costs and thus reduce the potential cost savings.

The demand for aesthetically higher quality office buildings will tend to further decrease the importance of energy cost. Most occupiers demand well-appointed offices with excellent service standards in high-quality buildings. Companies move to such premises, vacating offices that are not state-of-the-art. These buildings may have higher operating and energy costs, but the energy proportion decreases relative to the total.

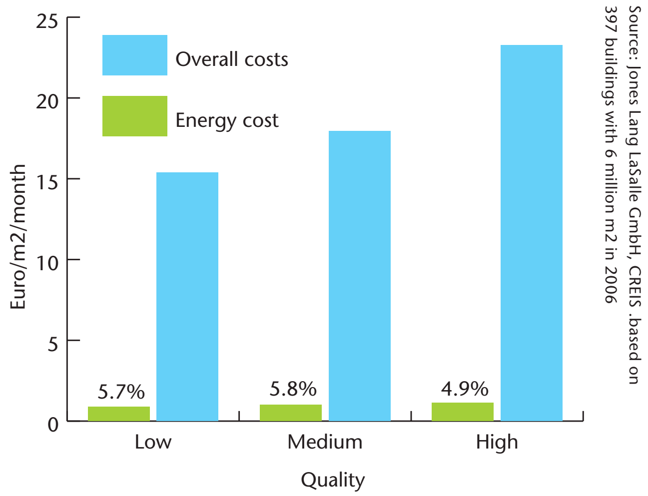


Figure 5.11: Average values of total costs by quality of fittings (EUR/m² /Month)

Energy costs are more significant for direct investors. Energy efficiency is part of the due diligence for the procurement of new properties by those who will own and operate them. For other investors, energy costs are not important. In most countries they are passed on to tenants, and are therefore not relevant to the building owner.

D. The cost of achieving energy efficiency

EEB market research commissioned has found that perceptions of the cost necessary to achieve greener buildings are likely to be significantly higher than the actual cost (see Chapter 4). The average perception was that a 17% premium would be necessary to reach a "certified" level of sustainability, but cost studies on actual properties have come up with much lower figures. The Fraunhofer Institute has shown that the energy demand of new office buildings can be reduced by 50% compared to the building stock (limiting primary energy use to 100 kWh/m² for most buildings) without enhancing building construction costs compared to the average.[33]

The US Green Building Council (USGBC) has performed numerous studies and concluded that the cost of reaching certification under its LEED standards system is between zero and 3%, while the cost of reaching the highest level of LEED (platinum) comes at a cost premium of less then 10%. These figures are supported by a study of 40 offices and schools that found cost premiums substantially lower than the estimates (16% for the USA). (See figure 5.12)

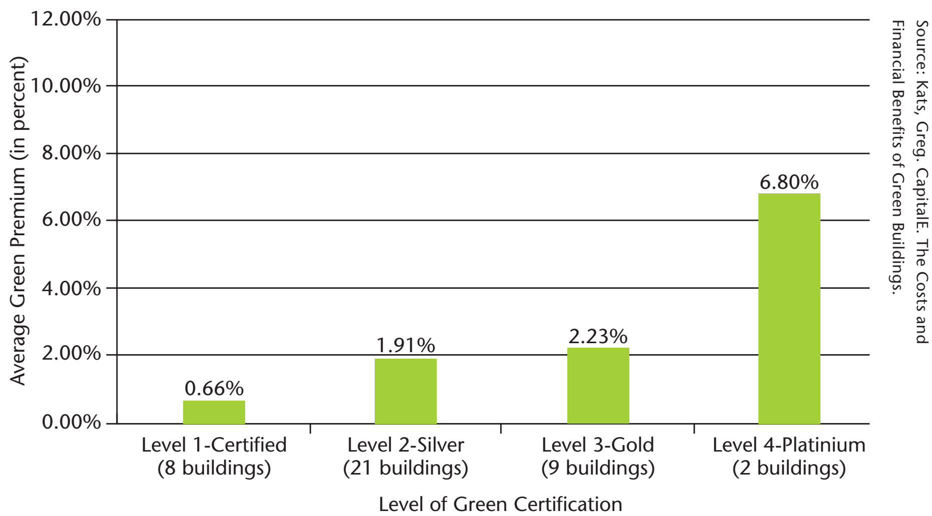


Figure 5.12: The green cost premium

Table 5.4 summarizes the relationship between LEED criteria and cost. It shows that the average cost to reach 18% improvement in energy efficiency, incorporating green power, is only 1%. Incorporating on-site renewable energy gains an efficiency of 48% at only a 2% premium.

	Certified	Silver	Gold
Energy efficiency	8%	30%	37%
On-site renewable energy	0%	0%	4%
Green power	10%	0%	7%
Total efficiency gains	**18%**	**30%**	**48%**
Related cost premium	**1%**	**2%**	**2%**

Source: USGBC data, CapitalE analysis.

Table 5.4: Costs of green certification

A more comprehensive study of a broad selection of buildings by Davis Langdon Adamson (a construction management firm) confirmed these broad conclusions. It found that location and climate are more important than the level of energy efficiency as an influence on ultimate cost. The study looked at over 600 cases in 19 US States. It found that the cost variations between LEED and non-LEED buildings are not significantly different when considering the impact of location and climate, especially for heating and cooling costs. The principle findings on cost were as follows:

- There is a very large variation in the cost of buildings, even within the same building program category
- Cost differences between buildings are due primarily to building program type
- There are low cost and high cost green LEED buildings
- There are low cost and high cost non-green buildings.

The conclusion is that building developers and owners considering a green building should be aware that the costs can be influenced more by local factors and conditions than by sustainable design requirements.

As the report says:

"Comparing the average cost per square foot for one set of buildings to another does not provide any meaningful data for any individual project to assess what – if any – cost impact there might be for incorporating LEED and sustainable design. The normal variations between buildings are sufficiently large that analysis of averages is not helpful."

The cost of retrofitting energy efficiency was studied by the International Energy Agency in the European Union. It concluded that cost-effective energy savings of 28% could be achieved from refurbishment of the high-rise building stock (1 in 6 residential dwellings in the 28 European countries studied are in high-rise buildings). This would yield a 1.5% reduction in Europe's total primary energy demand. As much as 80% of heating energy was saved in the least efficient buildings, with an overall 28% energy saving. The study also states that energy efficiency improvements would be best carried out as part of general refurbishment projects.[34]

E. Energy cost information and analysis

While energy costs are a relatively small part of total occupancy costs, they can still be a significant factor in motivating energy efficiency action. But profitable opportunities for energy savings are often overlooked because of inadequate cost information. Despite real estate managers' stated interest in energy efficiency, a study in 2006 found that only two thirds of companies tracked energy data and only 60% tracked energy costs.[35]

Where data was collected, it was used mostly by facilities managers, rarely by real estate managers and seldom passed on to property evaluators. In the US, only 30% of real estate managers or facilities managers claimed to have included energy efficiency requirements into requests for proposals. Despite these findings, the study surprisingly suggested that energy costs are the most important driver for energy efficiency, both currently and in the future.

The EEB market research confirms these findings in all six regions. Three of the four attitudinal segments defined in the research (skeptical participant, unengaged, uninformed enthusiast) may be characterized by inaction in pursuing energy savings.

Research by the Green Building Finance Consortium indicates that owners and developers often do not provide appraisers with sufficient data to allow a thorough assessment of the costs and benefits of energy efficiency strategies. Too much reliance is placed on "first cost", even though life-cycle cost assessments and return on investment calculations are more relevant.

It is clear that energy managers and investment decision-makers do not speak the same language.

The situation stems in part from the fact that energy management is considered as primarily a physical need rather than a financial opportunity. By working together to develop a methodology and language for valuing energy projects alongside other investments, both energy managers and investment decision-makers can ensure that the gap is closed.

Energy managers and investment decision-makers need to develop a common methodology and language for valuing energy efficiency projects in a similar manner to other investments. A financial risk management model[36] would identify:

- *Energy consumption elements* directly affected by changes within the facility that are measurable, verifiable and controllable (intrinsic volatilities). This includes the energy volume risk, asset performance risk, and energy baseline uncertainty risk.
- *Energy consumption risks* outside the facility that could be hedgeable (extrinsic volatilities). These include energy price risk, energy security, labor cost risk, interest rate risk and currency risk.

With such a risk analysis framework in place, energy-efficiency experts and investment decision-makers could exchange the information they need to expand investment into energy efficient buildings projects.

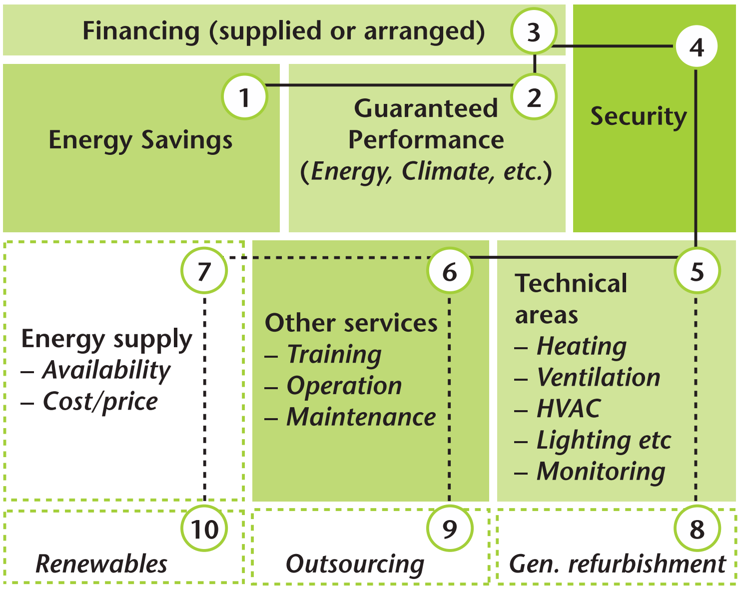
Accurate and robust analysis demands a high level of understanding of the physical aspects of energy efficiency, which enables physical performance data to be translated into the language of investment.

However, while there is a general recognition that energy efficiency practices and products are becoming more widespread in the market place, there is limited data on how these factors impact the value of buildings.

The financial effectiveness of capital improvements that target energy demand reduction is usually assessed in terms of simple payback times and do not typically reflect a property investor's valuation methods. Lawrence Berkeley National Labs has shown[37] that substantial increases in property resale value can be derived using more relevant real estate valuation methods that employ net operating income, a relevant capitalization rate, and a calculated return on assets. As an example, a dollar of annual energy savings drops to a dollar of increased net income. Therefore, at a market capitalization rate of 5% (typical in mature and desirable markets) investment to achieve a US$ 1 energy saving would imply a US$ 20 gain in resale potential value – thus changing the outcome of a typical simple payback calculation.

F. New business models and financial instruments

Appropriate commercial relationships can increase the focus on energy costs by altering commercial relationships, removing the split incentives problem and introducing more effective incentives for reducing energy use and costs. Energy performance contracting (EPC) is one example.



Source: IEA DSM. Task X. Performance Contracting – Summary Report. May 2003.

Figure 5.13: Fundamental structure and service links of energy performance contracting

An EPC is an arrangement between a property owner and an energy service company (ESCO) that covers both the financing and management of energy-related costs. It involves a variety of mechanisms to help property owners use the knowledge of energy professionals to reduce their energy costs. Specifically, first-cost and performance risk considerations are taken on by the ESCO. Figure 5.13 illustrates how this relationship wraps up a variety of services while guaranteeing energy supplies and savings.

The energy service industry has its origins in the late 1970s and early 1980s when energy prices rose dramatically. While the effectiveness of ESCOs is well documented, miscalculation of financial and technical risks has caused many failures of these firms.

ESCO's generally act as project developers, installers and operators over a 7-10 year time period. They assume the technical and performance risk associated with the project. The services offered are bundled into the project's cost and are repaid through the operational savings generated, with the ESCO's profit coming from a proportion of cost savings or a fixed fee based on projected energy savings. The savings are illustrated in figure 5.14 (E is the cost of energy, O is the operating cost, M is the maintenance cost) in the stages before, during and after the contract where the savings transfer to the property owner.

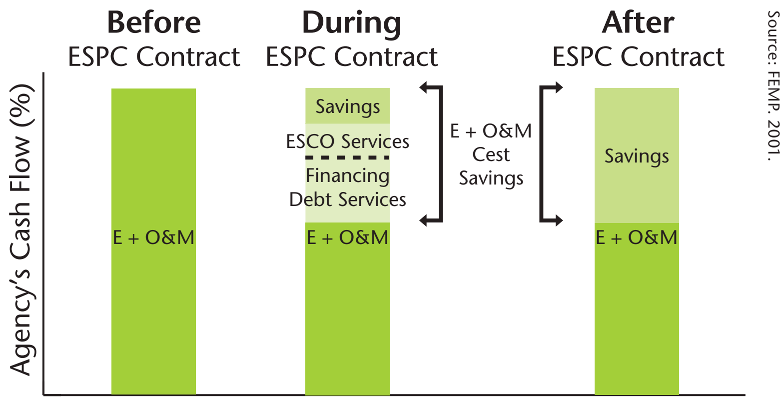


Figure 5.14: Illustrated ESCO (ESPC) Savings by Stage of Contract

As an additional service in most contracts, the ESCO provides any specialized training needed so that the customer's maintenance staff can take over at the end of the contract period.[38] ESCOs have placed great emphasis on measurement and verification and have led the way to verify, rather than estimate, energy savings.[39] One of the most accurate means of measurement is the relatively new practice of metering, which is direct tracking of energy savings according to sanctioned engineering protocols.[40]

But standards for measurement and verification need to be developed, and there are several other barriers to increased use of EPC. In particular, procurement rules and contract arrangements need to be developed, along with guarantees and securities relating to the contracts and suitable financing arrangements.

A Lawrence Berkeley National Labs 2003 research study on International ESCOs found that the bulk of activity today is in the US, but ESCOs exist in varying degrees in other countries - ranging from just a few in Belgium, Thailand and South Africa to over 50 in Brazil, Germany, Korea and Switzerland. Hong Kong has seen an emergence of ESCO's to serve the growing Chinese marketplace. The total amount of ESCO activity is estimated to be US$ 3billion, with two-thirds of that in the US (adjusting for estimated growth projections from 2001 information).

In Japan, ESCO's have grown significantly during this decade, with the recent emphasis on performance contracting, as the charts show below. The retrofit markets for environmental load decrease and energy savings are forecast to grow by 90% and 60% respectively during 2000-2015.

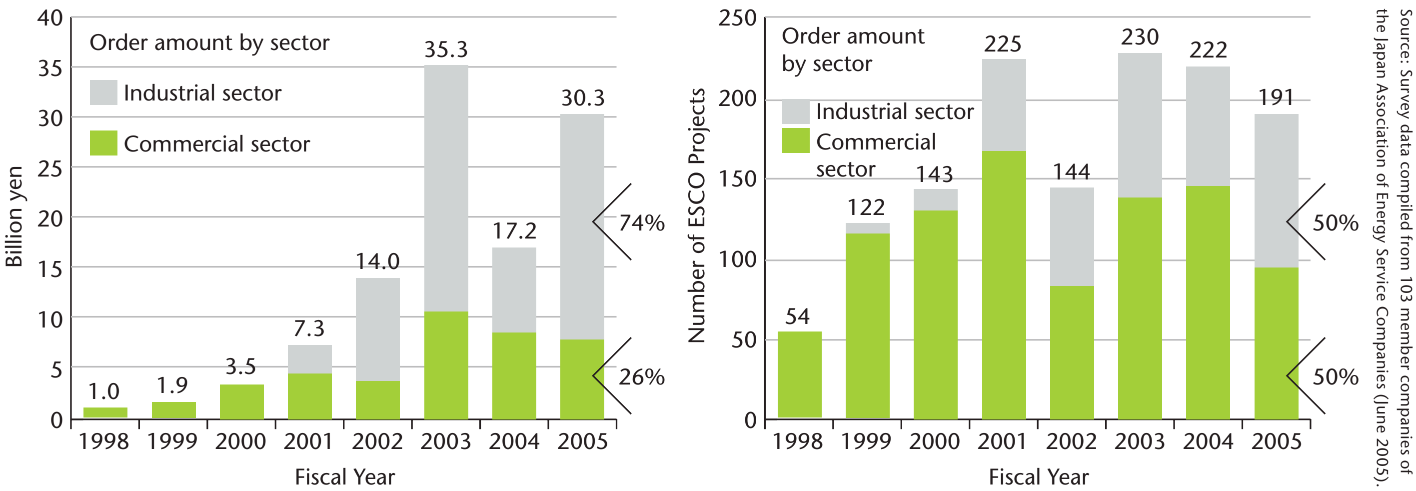


Figure 5.15: ESCO growth in Japan

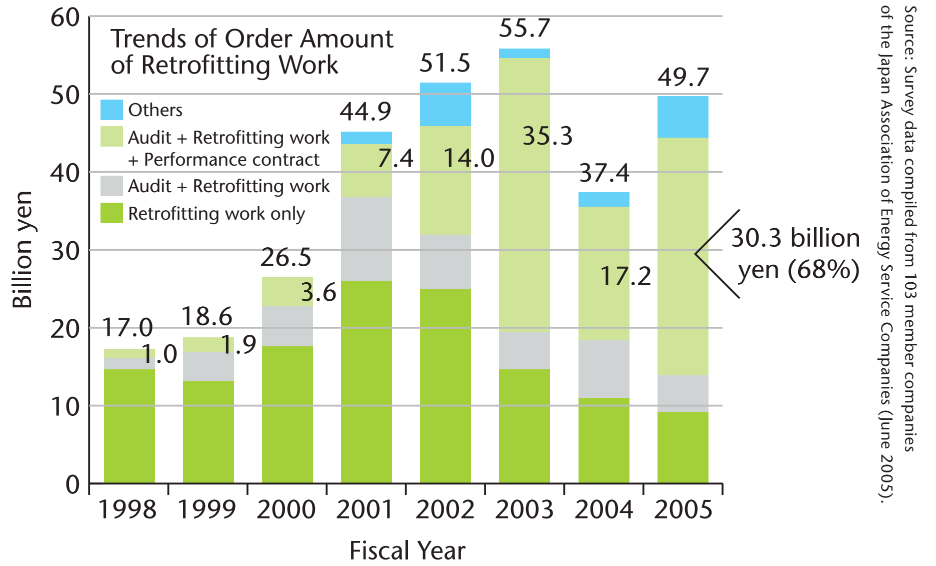
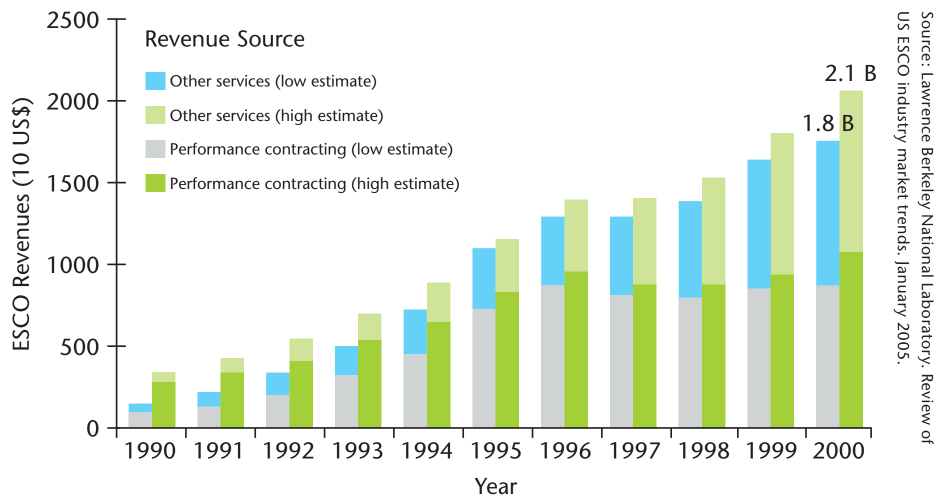


Figure 5.16: ESCO retrofitting work in Japan

The United States ESCO industry is widely seen as a successful model for delivery of energy efficiency technologies and services. The industry's 24% annualized growth rate during the 1990s slowed to 9% from 1996 to 2000 based on relative saturation and maturity of performance contracts as well as the uncertainties created by electricity restructuring and retail competition.

In the US market, electricity savings are the most critical component of energy savings, accounting for over 80% of the total site energy savings. Electricity savings reported in a study by Lawrence Berkeley National Laboratory (2005) was estimated at 23% of the total electric bill baseline for comprehensive upgrades, including lighting and non-lighting retrofits.[41]



Note: Total market estimate (1990-2000) US$ 16.5-20 billion.

Figure 5.17: Aggregate ESCO industry activity

In Europe, ESCOs are not as widespread as they are in the US or Japan. Those that do operate in Europe tend to supply energy-efficiency activities as part of a broad service offer. Energy efficiency can be provided by energy suppliers and installers (usually from the building sector). Energy savings contracts with result guarantees will most likely remain separate and specific offers linked to supply and maintenance contracts. Therefore energy demand reduction activities will remain diluted in energy services, with few players completely focused on such activities. The financial and technical risks associated with stand-alone energy efficiency ESCOs in Europe can only be mitigated if regulations enable project finance through third party investments, and the integration of ESCO mechanisms are facilitated by financial organizations.

Financial instruments[42]
Several new and emerging financial mechanisms are supporting growing interest in high-performance buildings in the United States. Financial incentives are playing a key role in helping energy-efficient buildings make business sense. New tax breaks and emerging markets for renewable power and energy efficiency can help firms overcome internal financial hurdle rates and are expected to promote further investment in energy-efficient buildings.

Reducing initial costs
Tax incentives at the federal, state, and local levels can help overcome initial cost barriers to energy efficiency upgrades or development. The Energy Policy Act of 2005 (EPAct 2005) provides a federal tax deduction of US$ 0.30-1.80 per square foot for energy-efficient commercial buildings, depending on the technology and energy savings. A growing number of cities and states are offering tax credits for commercial buildings that meet certain energy efficiency or sustainability standards. EPAct 2005 also established a 10-30% tax credit for commercial and industrial clean energy projects and states and municipalities have established similar incentives to promote renewable (e.g., solar and geothermal) or efficient (e.g., combined heat and power) energy sources.

Renewables can deliver revenues
Expanding market-based energy regulations are also creating financial opportunities for high-performance buildings. More than 20 states have adopted renewable portfolio standards requiring electric utilities to meet a percentage of demand with renewable energy sources. In many cases, states allow third parties (e.g., commercial and industrial facilities) that generate renewable energy to register and sell renewable energy credits (RECs) to utilities seeking to meet their mandated targets. The value of RECs in these compliance markets can range from US$10-200 per megawatt hour (MWh) or more, depending on the state and energy source, and can be an important revenue stream that, when combined with energy cost savings, can offset installation and operational costs for renewable energy systems.

A market for efficiency credits?
More than 10 states have also developed energy efficiency resources standards that set utility requirements for energy efficiency and are expected to create a market for energy efficiency credits (EECs). In 2007, Connecticut became the first state to launch a market for trading in energy efficiency, where EECs will be valued between US$ 10 and US$ 31 per MWh. As the market develops and utility efficiency requirements become more stringent in 2008 and 2009, commercial and industrial facilities are expected to benefit from demand for EECs and generate revenue through qualifying efficiency projects (e.g., combined heat and power generation and lighting and HVAC upgrades).

Behavior

Summary

- The behavior of a building's occupants can have as much impact on energy consumption as the efficiency of equipment
- User behavior is influenced by economic, social and psychological factors that affect both buying equipment and using energy
- Energy use is determined by information/awareness, energy cost, plus social, educational and cultural factors
- The rebound effect limits potential energy savings by substituting new consumption for some of the energy saved

Energy is not merely a functional product. Its use has important symbolic and behavioral aspects that can have as much influence as equipment on energy consumption. In many people's minds, energy "rationing" is a symbol of hard times whereas energy consumption is a sign of prosperity. Saving energy therefore carries ambiguous connotations. In developing countries using energy can be a symbol of progress and affluence. In the developed world, it is a commodity that is taken for granted and whose insignificance can lead to thoughtless waste.

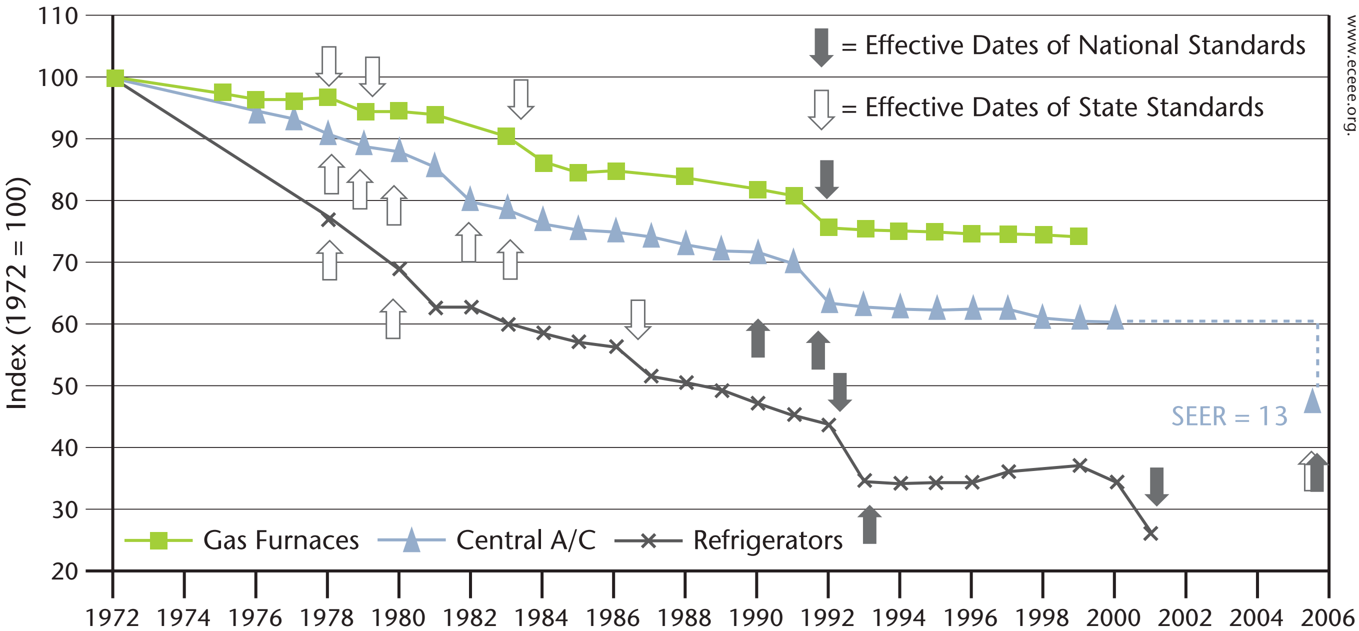
Conventional development based on economic growth is associated with growing individual comfort and social recognition through consumption. This can clash with saving energy.

A. Influences on energy behavior

Behavior is influenced by economic, social and psychological factors. Poor people may not be able to afford high energy consumption. Wealthy people may use it as a sign of affluence. Some cultures are more frugal than others. People with little education may be ignorant of energy options and issues. Older people use energy differently than younger generations. Women and men may have different approaches.

Energy needs evolve according to standard of living and lifestyle. Basic needs come first: heating, cooking, lighting. Then people address comfort, acquiring electrical appliances, and finally leisure, with products such as electronic goods.

Economic development therefore tends to be accompanied by rising energy consumption by consumers, which stabilizes as saturation of equipment occurs. It may then begin to decrease due to the development of energy-efficient equipment. These factors can be seen in figure 5.18, which shows improved efficiencies for heating, air conditioning and refrigeration equipment in the US.



Source: Nadel, S. American Council for An Energy Efficient Economy (ACEEE). European Council for an Energy Efficient Economy (ECEEE) 2003 Summer Study. www.eceee.org.

Figure 5.18: Energy needs of domestic equipment over time

Lifestyle or habit may increase energy consumption. For example, people tend to prefer individual houses rather than apartments. Houses are also getting larger, with fewer people per household. (In the EU, the number of households increased twice as much as the population between 1960 and 1990[43].)

Other factors accounting for reduced energy efficiency are the increasing number and specialization of electrical appliances for leisure, work and cooking.

There are two separate aspects of energy consumption behavior: buying equipment and using energy. They are closely linked – people buy more appliances but at the same they buy more energy-efficient equipment. They take care switching off certain devices (such as the TV) and at the same time keep other devices on (those connected to the outside world such as modems and phones, as well as those with programs such as alarm clocks).

B. Buying energy-efficient equipment

Despite the difference in price between standard and energy-efficient equipment there has been a market transformation over the last decade in developed countries. Figure 5.19 shows a switch in Europe to buying more energy-efficient appliances during the 1990s.

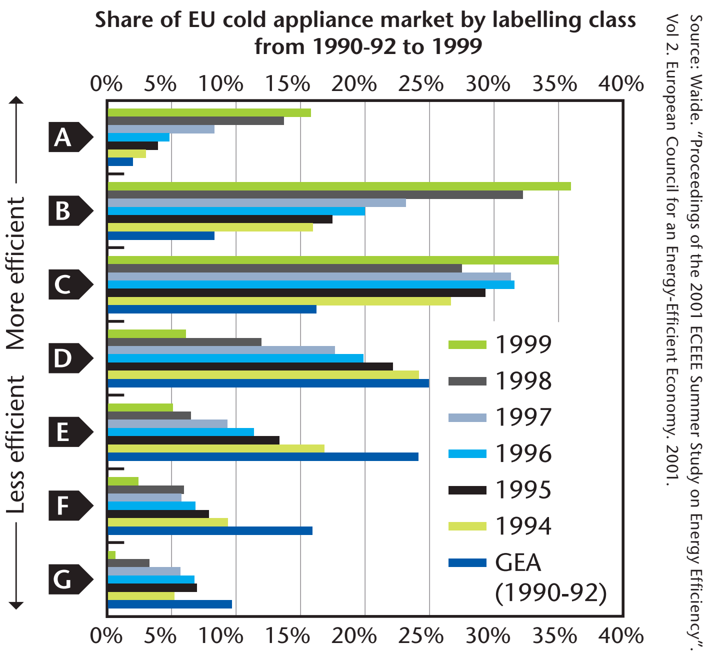


Figure 5.19: Growing preference for energy-efficient appliances

"The information from the market to consumers is asymmetrical. There's a lot of information they don't have, because the impression transmitted from the mass media…is that there is not an alternative solution."

Architect, Spain

The flip-side of this is the trend towards buying more equipment as people become wealthier – dishwashers, power showers, garden equipment, extra TVs and other consumer electronics. This tends to offset increasing product efficiency, leading experts to predict consumption due to consumer electronics to increase significantly.[44]

C. Using energy

Several factors influence energy-saving actions:

- Availability of **information** on energy consumption and price (labels, energy consumption measurement devices, advice on energy efficient behavior and equipment)
- Energy **cost** (as a share of total household income)
  - In developing countries, where energy is a significant cost (about 20% of household income) energy tends to be used very carefully
  - In developed countries, where energy may be only 5 to 10% of household income, people tend to be careless about consumption
- **Cultural, educational, social factors** – table 5.5 shows the very different approaches people adopt depending on age, gender and level of education. Energy-saving behavior appears to be associated most with higher education levels and the generation that grew up in the 1940s and 1950s.
- **Environmental concern** (a belief that energy is valuable and becoming scarce and therefore must not be wasted). Behavior studies show an increasing environmental awareness in developed countries (for example 70% of French people say they care about saving energy, 10% higher than three years previously). Favorable environmental attitudes are linked with social level (medium age, highest level of education, family life). But many people do not adopt energy-saving action despite understanding the potential benefits.

Sex	Education	Age				
		20-34	35-49	50-64	65+	All
Male	Left education at/ before 15	31%	37%	41%	38%	38%
	Left education 16-19	35%	46%	43%	42%	42%
	Left education 20+	40%	47%	49%	44%	44%
Female	Left education at/ before 15	39%	38%	42%	42%	41%
	Left education 16-19	40%	48%	48%	45%	45%
	Left education 20+	43%	52%	57%	48%	49%

Source: Delft University of Technology 2002 (covering EU 15 countries)

Table 5.5: Likelihood of action to save on heating and air conditioning

"You can design a very, very energy-efficient house, but if the people living and using the building are not aware how to operate it and how to behave it will still not be a very energy efficient building."

NGO, International

D. Behavioral barriers to energy savings

Barriers to the purchase of energy-efficient equipment

Buying energy-efficient equipment may be limited due to:

- **Lack of information** on equipment performance (labels, advertising campaigns). This is a major limit in developing countries, but consumers in developed countries tend to be well-informed about energy-efficient equipment through advertising campaigns, energy labels and other measures.
- **Lack of concern for energy efficiency** - energy efficiency is not the first driver for consumers, who tend to choose new equipment according to other criteria (technical performance, comfort, design, technical capability). For example, sales of plasma TVs have increased significantly in developed countries, even though most consumers know that they use three to four times as much energy as standard TVs or even LCD TVs.
- **Cost difference** between standard and energy-efficient equipment. When buying new equipment, users will consider the immediate investment cost instead of the total cost including operation over the whole product lifetime. For example, lighting and the relatively low uptake of low-consumption lamps for many reasons (aesthetics, color of lamps and price).

Barriers to the rational use of energy

Several social, cultural and psychological factors (standard of living, lack of environmental concern, cost, lack of information) prevent users from making energy savings, as shown in table 5.5. The figures emphasize that people generally understand the point of saving energy, and know what to do. Many are also not put off by the cost or the practical effort. But they prefer to be comfortable and equate lower energy use with lower comfort levels.

	Completely	Rather yes	Neither yes nor no	Rather no	Not at all
Doesn't want to lose comfort	3.5%	32.2%	5.2%	29.8%	29.3%
Would be a drop in the ocean	2.4%	23.1%	3.7%	26.4%	44.5%
Doesn't have financial means	4.7%	23.3%	5.2%	30.4%	39.4%
Requires too much effort	1.9%	19.4%	4.8%	30.8%	43.1%
Doesn't know what is necessary to do	3.3%	15.7%	4.7%	33.4%	42.9%
Doesn't see the utlitiy	0.5%	3.5%	0.4%	23.5%	72.1%

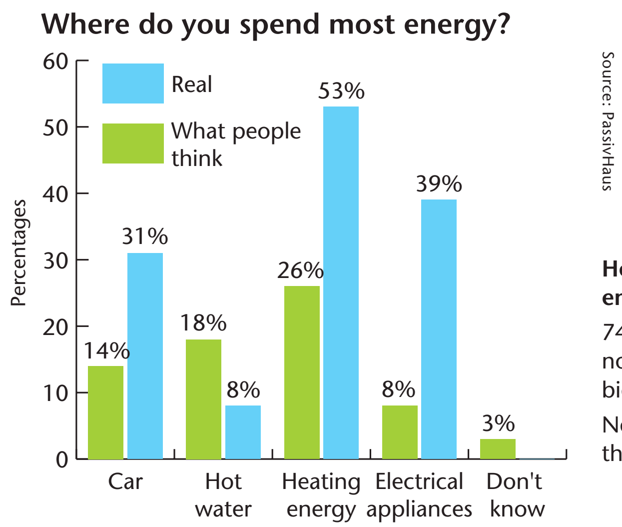
Source: SEREC, Belgium 2004 (1,000 households).

Table 5.6: Reasons for not doing the utmost to make energy savings

Perception is important. People may not have an accurate understanding of the scale of effort needed to achieve energy efficiency and the potential advantages in terms of energy consumption. In other words, they may feel too much effort would be required for too little return.

These barriers to a rational use of energy are linked to 3 issues: lack of awareness and information, habit, and the rebound effect.

- The **lack of awareness and information** - Energy being invisible, its waste is invisible as well, and very often people do not have the feeling that they waste energy, which prevents them from behaving efficiently. The example of appliance labeling (quoted earlier in this section) shows that when people are repeatedly informed, they are more likely to buy energy-efficient equipment. Research also shows that people significantly underestimate the amount of energy they use for heating. In one study in Germany,[45] three-quarter of those questioned did not know that heating was their biggest energy use. They estimated it accounted for 26% of their energy consumption, compared to an actual figure of 53%. (See figure 5.20.)
- **Habits** – Culture and education affect people's habits towards energy use. Figure 5.21 shows huge differences in behavior towards energy savings, which can be explained partly by habits (people forget that ovens consume more energy than microwaves).



Heating – an underestimated energy guzzler

74% of German respondents did not know that heating is their biggest energy guzzler.

Nearly 30% did not even know their monthly heating expenses.

Figure 5.20: Perceived and actual energy use

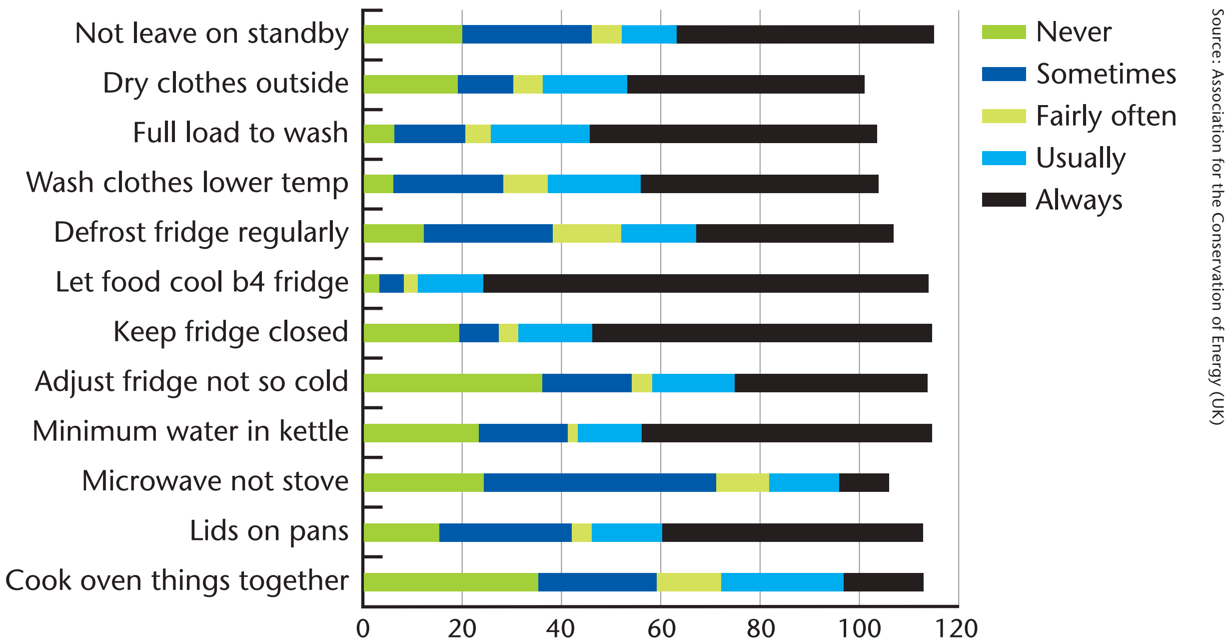


Figure 5.21: Responses to energy-saving actions

- **The rebound effect** – The rebound effect is the reduction of potential energy savings because of higher energy use in response to those savings:
  - Direct rebound effect: improvement of energy efficiency leads to an increase of energy use due to the decrease in the effective price (e.g., a more efficient car is driven further)
  - Indirect rebound effect: the low effective price of energy leads to demand for additional energy (e.g., the money saved is used to buy other cars or other consumer goods)
  - Economy wide: the overall economic impact of the decrease of energy service price.
- The **mechanism** is widely recognized but the magnitude of the effect varies, for example:[46]
  - Space heating: 10-30%
  - Space cooling: 0-50%
  - Lighting: 5-20%
  - Water heating: 10-40%
  - Automobile: 10-30%

E. Key issues

Several studies have shown that as much energy efficiency can be achieved through behavior as through energy-efficient equipment, even though it is difficult to measure the precise impact. Changing people's behavior is a challenge. They need to become concerned, as individuals but also as part of a general movement involving all stakeholders. The challenge is to affect behavior permanently.

Consumers tend to want more user-friendly technologies, and economic incentives such as bonuses for reducing energy use. But energy-efficient behavior can become almost automatic when trends in lifestyle, energy efficient technology and behaviors coincide.[47]

Consumer needs can be addressed through several types of policy instruments: information, economic instruments, administrative instruments and physical improvements.

Information and education
Information includes advertising campaigns on energy efficiency, energy labeling of appliances, advice on energy efficient equipment or behavior, education at school. In developed countries, information campaigns on energy labeling have supported the transformation towards more efficient equipment (A+ and A++ labels in Europe) as described previously.

Public advertising campaigns are not enough on their own to push people to act so other tools are needed to change behavior:

- Some people are not sufficiently motivated to change their behavior
- Some wait for others to lead
- Some believe that their own behavior is not significant enough.

Knowledge of energy consumption (communication, training)
Individual information is not sufficient: advice and help are necessary to change knowledge into behavior, for example through feedback, with tools such as consumption measurement devices. Expert advice, for example through audits, may be necessary to help people become aware of possible energy savings and measure the impact of their behavior.

Technical devices that provide consumers with information on energy consumption – especially with immediate feedback - may cut energy consumption by between 4 and 20%.[48] Direct feedback enables consumers to see the direct link between actions and their impact. But behavior does not necessarily change immediately, as this study concluded:

> The relationship between advice and action, and the need for reinforcement, vary with the type of advice. In some cases, the energy efficiency action will follow directly from being given expert advice; in other situations, the action will depend upon having the message reiterated and reinforced. For instance, more reinforcement is needed to achieve a behavioral change than is required for an application for a grant.
>
> Feedback has a further role. There are numerous ways in which a household can improve its energy efficiency – and more are being identified each year. The conscious competence model is not, therefore, a single cycle, but an iterative process. The consumer will gain most by repeating the cycle several times, almost endlessly![49]

Comfort remains a significant factor for consumers, even when they have clear energy-saving information. A study in Japan confirmed this even though the energy saving potential was as significant as 12%. Even with information, consumers chose actions to save energy with the smallest cost to their comfort. The study concluded that we should consider the balance between energy-saving value versus the perceived loss of comfort when selecting energy-saving methods, and adopt the methods with the highest energy-saving effects and the smallest reductions in comfort.[50]

The Prius effect

The potential of direct, real-time feedback on consumer behavior is demonstrated in a different field by what is sometimes known as the "Prius effect". The Toyota Prius hybrid car provides a display that illustrates the use of the electric motor and the level of fuel consumption. One screen option shows whether energy is being taken from the electric motor or the gas engine (or both), or if the battery is being recharged. An alternative screen depicts the vehicle's current fuel consumption as well as recent performance in five-minute time bands, and a cumulative consumption figure. Anecdotal evidence suggests this information encourages owners to drive in ways that are more fuel-efficient, for example accelerating more slowly and braking more gently. A parallel in the home would be an indicator showing real-time fuel usage, which could encourage people to turn down thermostats or adjust air conditioning to achieve acceptable comfort levels with lower fuel usage.

Chapter 6

Conclusions and next steps

Technology available today can achieve dramatic improvements in building energy efficiency, but market failures and behavioral barriers are blocking progress towards the EEB vision of zero net energy.

The challenge in this first phase has been to understand those impediments. The next phase will address how to overcome them, developing a roadmap with practical measures which businesses can implement.

Complexity and segmentation (chapter 3)

One of the key findings concerns the complexity of the building industry and the market. Each sub-sector (e.g., hospitals, retail, apartments, detached houses) may have its own particular characteristics requiring different approaches for different segments, geographies and sub-sectors. At the highest level, the most significant segmentation is between:

- New and existing buildings
- Commercial and residential
- Developed and developing countries
- Hot, cold, dry and humid climates.

The project will develop sector-specific analysis in the second phase. At this stage the conclusions are generally concerned with the building market as a whole.

Use less, make more, share (chapter 2)

There are three key elements to achieving zero net energy:

- Use less energy
- Make more energy (locally)
- Share surplus energy (through an intelligent grid)

The most significant gains in the medium term are likely to come from using less energy.

Risks and opportunities (chapter 2)

There are market and operational risks for businesses, and potential opportunities. There will be substantial market demand for energy efficiency but the timing and the value proposition are uncertain. Businesses that make an early entry into the energy efficient building market could achieve first-mover advantages.

Barriers (chapter 4)

The EEB's perception research found high levels of awareness of building energy as an issue, but low levels of specific knowledge and involvement. The research identified three key barriers to implementation:

- Lack of information about building energy use and costs
- Lack of leadership from professionals and business people in the industry
- Lack of know-how and experience as too few professionals have been involved in green building work.

Levers to achieve change (chapter 5)

Appropriate policies and regulations are necessary to ensure the right conditions are in place for the market to work effectively. Three aspects are particularly important: technical regulation specific to buildings, measures to improve information flow, financial and other incentives. Given an appropriate policy framework, there are three broad business levers that can help to remove the barriers to building energy efficiency:

- *Adopt a holistic approach*. This will deliver value by capitalizing on the interdependency of the building industry and is essential to integrate individual technologies and innovations. The sum of the parts can be greater than the whole.
- *Make energy in buildings more valued* by developing incentives, new commercial relationships and financial mechanisms, and clearer information about building energy performance.
- *Educate and motivate* building professionals and users to encourage behaviors that will respond more readily to market opportunities and signals and maximize the potential of existing technologies and innovations.

Next steps

In its second phase, the EEB project will explore how these levers can be developed, using a combination of “top-down” and “bottom-up” methods.

The “top-down” qualitative approach is based on international scenario exercises carried out in China, Europe, India, Japan and the USA. Scenarios are being developed to identify possible routes to energy efficiency, given the barriers identified in this report. They include consideration of different policy, technology and financial measures in light of differing assumptions about key issues such as energy and carbon costs.

The project is also carrying out “bottom-up” analysis to quantify these scenarios and look for effective policy, behavior, and technological solutions to guide markets toward an energy efficient vision. The modeling work aims to identify the impact of policy options on specific sub-sectors of the property market, and to roll up these sub-market impacts in comparison to global energy consumption and carbon emissions.

The modeling work is based on an international building energy database constructed by this project, which provides the data and insights into energy characteristics by sector and sub-market across the geographic markets covered by EEB. This includes energy end use and energy sources, but also financial and non-financial purchasing and operational criteria. The analysis ranks building subsystem and operation alternatives against purchasing criteria defined for each sub-market. It identifies the mix of available solutions that best match the building purchasing expectations to provide the expected adopted solution, given the decision-maker’s local decision criteria.

The result of this work will be a comparison of available policy options for policy-makers, as well as recommendations on technology combinations and standards needed for business and others involved in building energy efficiency.

The EEB will then develop a preliminary action plan that will be validated through engagement with stakeholders. In the final phase the plan will lead to a call for action by all those involved with the building industry.

Notes

1. Quotes are from EEB Qualitative Market Research, 2007, unless otherwise stated.

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10. These two figures are from Stern, N. *Stern Review: The Economics of Climate Change.* UK Treasury. 2007.

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