DEDICATED TO MAKING A DIFFERENCE

Facts & Trends

Energy Efficiency in Buildings

Business realities and opportunities

Summary Report

World Business Council for
Sustainable Development

Contents

About this report

This report summarizes the first year's work of the Energy Efficiency in Buildings (EEB) project – a WBCSD project co-chaired by Lafarge and United Technologies Corporation. It presents a picture of the challenge of energy use in buildings and a preliminary, high-level approach to addressing that challenge. The next phase of the project will develop those ideas. (See page 34 for more details of the project. The full report and background information are available at http://www.wbcsd.org/web/eeb)

The urgent challenge of energy efficiency

Buildings are responsible for at least 40% of energy use in most countries. The absolute figure is rising fast, as construction booms, especially in countries such as China and India. It is essential to act now, because buildings can make a major contribution to tackling climate change and energy use.

Progress can begin immediately because knowledge and technology exist today to slash the energy buildings use, while at the same time improving levels of comfort. Behavioral, organizational and financial barriers stand in the way of immediate action, and three approaches can help overcome them:

- ***Encourage interdependence*** by adopting holistic, integrated approaches among the stakeholders that assure a shared responsibility and accountability toward improved energy performance in buildings and their communities
- ***Make energy more valued*** by those involved in the development, operation and use of buildings
- ***Transform behavior*** by educating and motivating the professionals involved in building transactions to alter their course toward improved energy efficiency in buildings.

The project summarizes these findings in this, its first year report on facts and trends having to do with energy efficiency in buildings. This report combines the findings from existing research and stakeholder dialogues during hearings, workshops, and forums with a breakthrough market research study that measures the stakeholder perceptions of sustainable buildings around the world. The report sets out to establish a baseline of current facts and trends that will be used in the coming months in scenario planning and modeling approaches to assess the needed and prioritized actions for change to affect buildings' energy consumption. In the final year (by mid-2009), the project will seek to gain commitments to actions by the various stakeholders involved with the building sector, including those of the project itself.

The EEB project covers six countries or regions that are together responsible for two-thirds of world energy demand, including developed and developing countries and a range of climates: Brazil, China, Europe, India, Japan and the United States. The project has brought together leading companies in the building industry[1] (shown on final page) 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.

Many organizations, both public and private, are working on building sustainability. This project aims to complement them by providing a business perspective and developing practical action for property developers, regulators, energy providers and suppliers of products and services to the building industry.

This report aims to stimulate the widest possible debate about the route to achieving the EEB vision of zero net energy use in buildings. Please participate in the EEB blog at www.eeb-blog.org or send your thoughts to the project director, Christian Kornevall, at kornevall@wbcsd.org.

[1] For the EEB project, the "building industry" covers all buildings and all those involved in the value chain – from architects and property developers to occupiers.

The vision: Zero net energy for buildings

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

NGO, China[2]

Summary:

- Urgent action is needed to reduce buildings' energy use, thus addressing climate change and energy use.
- We can dramatically improve energy efficiency today with existing technologies.
- Businesses that engage early with energy efficiency for buildings can gain a market advantage.

The EEB vision is a world in which buildings consume zero net energy. It is ambitious, but ambition is necessary to achieve the progress needed to address climate change and energy use.

Progress must be made now if we are to vastly improve the energy efficiency of both new and existing buildings. Examples exist of where this is being and can be achieved – see EEB around the world on pages 5, 20 and 24. And there are many ambitious goals; for example, the UK government anticipates dramatic energy reductions to achieve its goal that all new homes in England will be carbon-neutral by 2016.

There are three main approaches to energy neutrality:

- Cut buildings' energy demand by, for example, using equipment that is more energy efficient
- 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.

Efficiency gains in buildings are likely to provide the greatest energy reductions and in many cases will be the most economical option. A study by McKinsey[3] estimated that demand reduction measures with no net cost could almost halve expected growth in global electricity demand. The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report estimates that by 2020 CO_2 emissions from building energy use can be reduced by 29% at no net cost.

About the EEB vision

- *What is zero net energy?*
  It means buildings as a whole (but not every individual building) would generate as much energy as they use over the course a year.
- *Why energy, not carbon?*
  Using more non-fossil fuels (solar and wind) will address climate change and energy security, but cutting energy consumption is also vital.
- *Why energy used on site, not primary energy?*
  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.
- *What is meant by energy efficiency?*
  Efficiency involves reduced energy consumption for acceptable levels of comfort, air quality and other occupancy requirements, including the energy used in manufacturing building materials and in construction.

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[2] Quotes are from the EEB project perception research unless otherwise stated.

[3] A cost curve for greenhouse gas reduction, McKinsey Quarterly 2007 Number 1.

The business opportunity

The need for much-improved energy efficiency presents risks and opportunities for companies in the building industry seeking to enter this market. The EEB Project's view is that early entrants can gain first-mover advantage, but there are risks, especially with regards to the timing of market entry.

Market risks

The timing and pace of rising demand for energy efficiency is uncertain and poses the most significant risk for market entrants. Demand is expected to grow as people become more aware of the importance of energy use in buildings. The value proposition will continue to develop, given the right market structures and instruments. The key question is how fast these changes will occur.

Operational risks

Businesses need the skills to devise attractive, energy efficient propositions at appropriate cost levels. The project's perception research found that there is a widespread lack of personal and corporate know-how in the market and a general reluctance to innovate (see page 12).

Strategic assessment[4]

There are potential first-mover advantages for companies entering the energy efficiency market. Subsequent competitors will face barriers to entry in the form of specialist know-how, which should result in a lower level of competition than in the mainstream market. This in turn will tilt the balance of power in favor of suppliers rather than buyers, due to the relatively low number of suppliers with the necessary expertise. Energy efficient property could lose value if demand for office and retail sites falls because of a rise in working at home and on-line shopping.

"I expect industry will see this as an opportunity rather than something that we will impose."

EU Energy Commissioner Andris Piebalgs
speaking at the EEB Brussels Forum

[4] The factors in this assessment are based on Michael Porter's Five Forces – see http://www.quickmba.com/strategy/porter.shtml.

Energy efficient buildings around the world

Västra Hamnen (Western Harbor), Malmö, Sweden

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.

Alarming energy growth

"Buildings and construction are one of the sectors causing emissions that are really a problem for climate change."

Journalist, *International*

The WBCSD identified buildings as one of the five main users of energy where "megatrends" are needed to transform energy efficiency. They account for 40% of primary energy[5] in most countries covered by this project, and consumption is rising. The International Energy Agency (IEA) estimates that current trends in energy demand for buildings will stimulate about half of energy supply investments to 2030.[6]

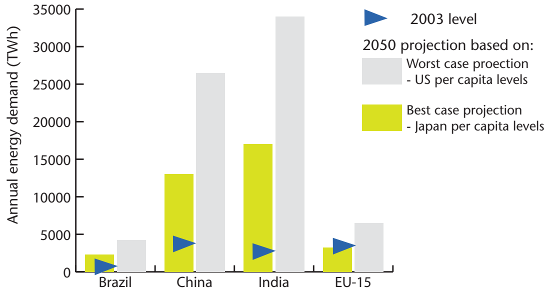
Summary:

- Building energy use will grow rapidly without improvements in energy efficiency.
- The building market has many segments with widely varying characteristics.
- Building energy use is driven by demographics, economic development, lifestyles, changes in energy sources and technology.
- The vast majority of energy consumption occurs while a building is occupied.

If building site energy consumption in China and India grows to current US levels, China's and India's consumption will be respectively about four and seven times greater than they are today. Figure 1 shows a projection based on current population forecasts combined with current energy use per capita based on Japanese and US levels – what could be considered the best and worst case scenarios. (The arrows show consumption levels in 2003.) This highlights the fact that energy consumption will grow dramatically without action to improve energy efficiency substantially. The construction boom, especially in China, is increasing energy demand significantly, but economic development and other factors are adding to the challenge because they also increase buildings' energy needs.

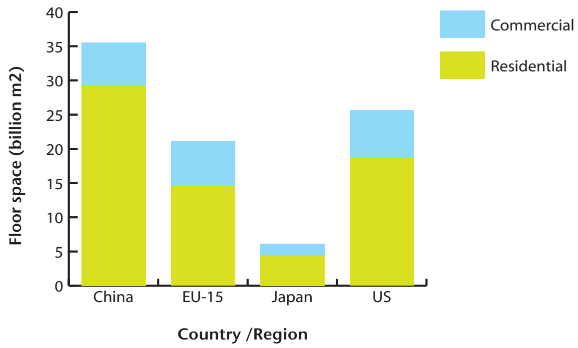
[5] Primary energy includes the energy required to generate, transmit and distribute electricity, as well as energy directly consumed on site.
[6] IEA, *World Energy Outlook* 2006.

Figure 1: Best and worst case projections of site energy demand[7]



The scale of current property stock in several countries or regions, broken down into commercial and residential occupancy, is shown in Figure 2.[8] The property market in China is particularly notable and is growing rapidly; China is adding 2 billion square meters a year, equivalent to one-third of Japan's existing building area.[9] This means China is building the equivalent of Japan's building area every three years.

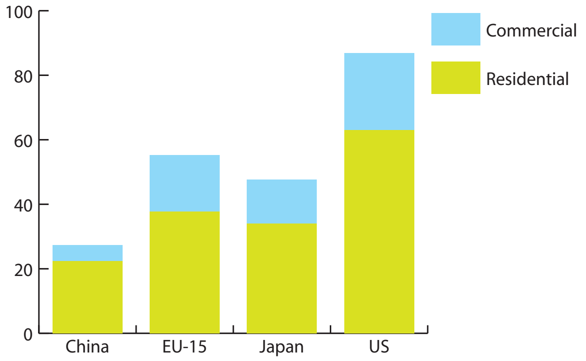
Figure 2: Existing building floor space (2003)[10]



[7] IEA and TIAX analysis, US Census 2006.
[8] Data for India and Brazil are not available in comparable format. We will work to add this data subsequently.
[9] Chinese Ministry of Construction representative at the EEB China Forum.
[10] Annual Energy Outlook (2006). US Energy Information Administration; IEA "Light's Labour's Lost – Policies for Energy efficient Lighting" (2006); Price et al. "Sectoral Trends in Global Energy Use and Greenhouse Gas Emissions", Lawrence Berkeley National Laboratory (2006); Yamashita, "Residential Statistics in Japan", Institute of Energy Economics Japan, (2001).

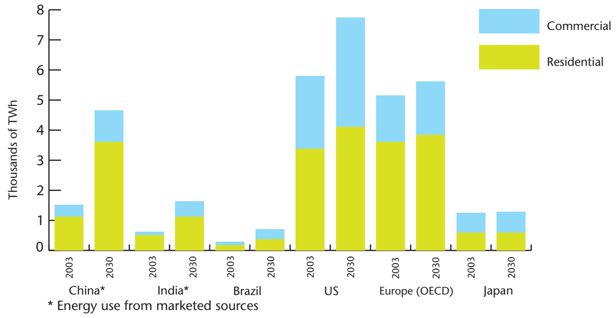
There are large differences in space per person between regions (see Figure 3), especially the much greater residential space per capita in the US. The differences are less marked in commercial buildings, except for China, which currently uses much less commercial space per capita than other regions. This has significant implications for energy use, assuming that space demands in China move toward those in Europe and Japan, if not the US.

Figure 3: Building floorspace per person (2003)[12]



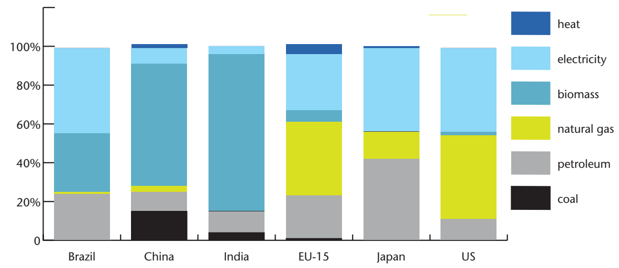
Energy use for buildings in the US is substantially higher than in the other regions, and this is likely to continue (see Figure 4). Consumption in China and India will grow rapidly, however, and China's building energy consumption will be approaching Europe's by 2030, while India will have overtaken 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 in Brazil will grow, but will remain relatively small in 2030 compared with other regions.

Figure 4: Building energy projection by region – 2003/2030[11]



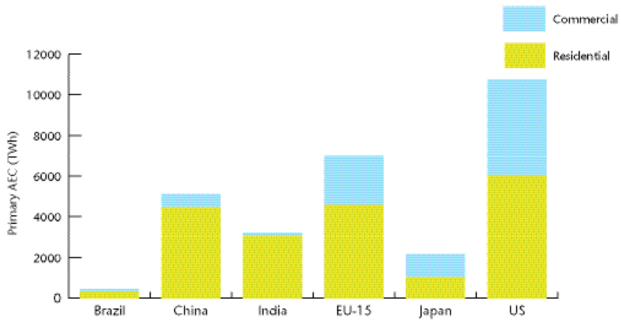
This report and this project focus on the energy demands of buildings (site energy). The sources of energy vary widely (see Figure 5), with a significant amount of coal and biomass burned on site in China and India, but with a much higher share of electricity being used in other countries. This variation contributes to large differences in primary energy consumption (see Figure 6) 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 6 also emphasizes the scale of primary energy demand by US commercial space.

Figure 5: Site energy sources (2003)[13]



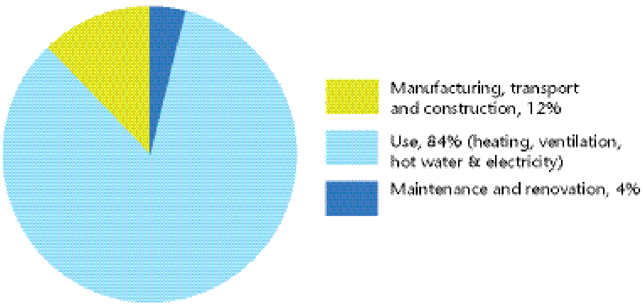
[11] International Energy Outlook 2006, US Department of Energy.
[12] Annual Energy Outlook (2006). US Energy Information Administration; IEA "Light's Labour's Lost – Policies for Energy efficient Lighting" (2006); Price et al. "Sectoral Trends in Global Energy Use and Greenhouse Gas Emissions", Lawrence Berkeley National Laboratory (2006); Yamashita, "Residential Statistics in Japan", Institute of Energy Economics Japan, (2001), US Census (2006).
[13] IEA "Energy Statistics and Energy Balances". (2003); IEA "Energy Technology Perspectives 2006: Scenarios and Strategies to 2050."

Figure 6: Primary energy (2003)[14]

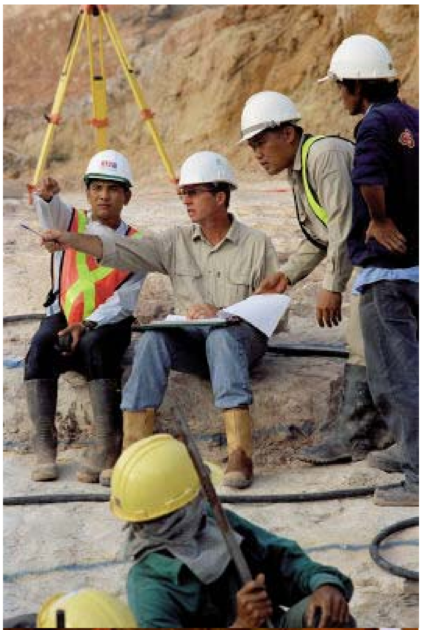


More than four-fifths of site energy use typically occurs in the operational phase of a building's life, as Figure 7 shows. The proportion of energy embodied in materials and construction will rise if operational energy efficiency increases and if building life spans shorten.

Figure 7*:* Life cycle energy use[15]



End uses vary by sector, region and climate. For example, refrigeration is a major user of energy in food retailing, while non-food retail uses substantially more energy for lighting than other sectors do. Food service and food sales are high-intensity sub-sectors, but the large amount of office space means this is likely to be the greatest overall energy user. Energy use varies among 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 hotter states.



[14] IEA "Energy Statistics and Energy Balances". (2003); TIAX analysis based on IEA "Energy Technology Perspectives 2006: Scenarios and Strategies to 2050."
[15] Building & Environment, Vol. 32, No. 4, pp. 321–329. (1997).

Segmenting the building market

The EEB Project is developing a database of information on the nature of each sub-sector and its energy-use characteristics that will be used in the next phase of the project to build scenarios. The major division by property type is between commercial and residential. But there are significant differences between commercial sub-sectors (such as offices, retail, banking and hotels). These other attributes are also important:

- New versus existing buildings
- Rural versus urban
- Developed versus developing countries
- Climate variations - humidity and rainfall as well as temperature

Energy use in buildings

Energy efficiency factors in buildings vary according to geography, climate, building type and location. The distinction between developed and developing countries is important, as is the contrast between retrofitting existing buildings and new construction. In all cases there are different standards of building quality. It is vital that energy efficiency permeates all levels and is not restricted to high-end properties.

This complexity means it is impossible to develop a single solution for all markets and all cultures. Instead, the EEB project aims to identify approaches, market factors and policy initiatives that will together achieve the needed results. These will be developed in the next stage of the project's work.

Climate change will increase site energy demand as people seek to maintain comfort levels in more extreme conditions. The other main drivers are:

- Demographics
- Economic development
- Lifestyle changes
- Technology and the spread of new equipment

A complex sector

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

Architect, *Brazil*

Summary:

- 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 save the most through energy efficiency.

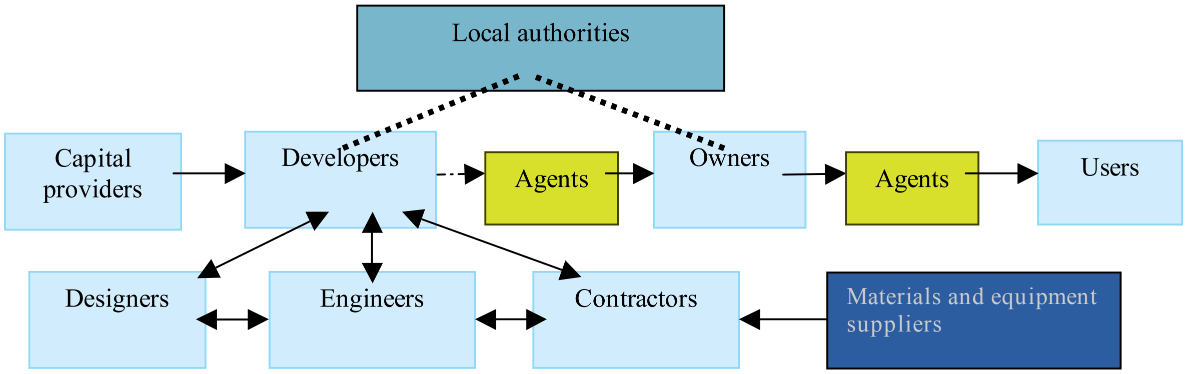
The building market is diverse and complex. The commercial relationships between the many specialists involved are intricate and critical in sparking action on energy efficiency.

The sector is characterized by the fragmentation within sections of the value chain and non-integration among them.

Even the largest players are small and relatively local by international business standards, with the exception of materials and equipment suppliers.

Figure 8 illustrates the most significant commercial relationships in the building supply chain. The complexity of interaction among these participants is one of the greatest barriers to energy efficient buildings.

Figure 8: The complex value chain



Local authorities influence the value chain through enacting building policies for their areas. These rules are often a compromise between high levels of energy performance and cost considerations.[16]

Capital providers*,* such as lenders or investors, are overwhelmingly concerned with the risk and return equation. They often consider only a short time period, which can reduce energy use to a relatively minor factor in decision-making.

Developers are the primary actors in commercial construction and are frequently speculative, which inevitably results in a short-term focus on buildings' financial value. Speculative developers will only be interested in energy efficiency if it is a significant factor in the buying decision. On the other hand, developers who hold property to receive income from tenants have a longer term view, which may make energy-saving investments attractive. But developers may not be able to reap the benefits of such investments, as energy cost saving goes to the occupier even though the developer incurs the investment cost. This weakens the incentive for energy efficiency investments.

[16] "Who Plays and Who Decides," Innovologie LLC, US DOE, page xiii.

Developers ***commission designers (or architects), engineers and construction companies*** who have expertise in technical aspects of construction, including energy efficiency. But their influence on key decisions may be limited, especially if they do not work together in an integrated fashion.

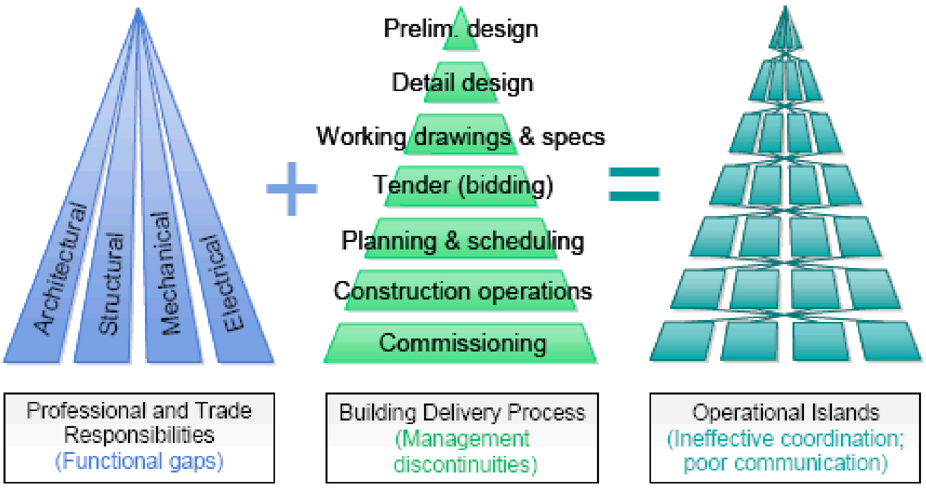
The role of ***agents*** can be important. They often stand between developers and tenants and between owners and occupiers. Typically, their financial interests are short-term.

Owners may rent their buildings, making their interests different from those of end users. Some owners buy to sell (and make a capital return); others buy to lease (as an investment) or occupy. The last group is most likely to consider investments that may have paybacks over several years.

End users are often in the best position to benefit from energy savings, but they may not be in a position to make the necessary investments. This also depends on the financial arrangements among owners, agents and users, which may include a fixed energy fee regardless of consumption.

Figure 9 illustrates the decision-making "islands" that are typical in commercial developments. 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 because of the functional gaps and management discontinuities. There are often lengthy delays between the design stages, due to problems with planning permission, project financing or signing up of anchor tenants for commercial property.

Figure 9: Players and practices in the building market[17]



More vertical integration in the supply chain can improve energy efficiency in buildings. But fully integrated design/build projects are perceived to be more costly to implement.[18] Many property developers believe competition rather than cooperation results in lower bids in a tendering process.

The isolated roles and ineffective coordination between participants have two important consequences:

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

[17] Seminar proceedings Aus-PeBBu Industry seminar, presenter Lee Siew Eang, Melbourne, 24 June, 2004 .
[18] "Who Plays and Who Decides," Innovologie LLC, US DOE.

Barriers within the industry

"I think the real estate agents don't know anything about energy efficiency. And I think the bank is a barrier, because they're not demanding it for their loan."

NGO, *US*

Summary:

- Building professionals tend to underestimate the contribution of buildings' energy to climate change and to overestimate the cost of saving energy.
- Know-how and experience are lacking in these professions.
- Our research found four key deficiencies: personal know-how, business community acceptance, corporate conviction and personal commitment.
- There is a lack of leadership on building sustainability.

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. Awareness is high in most countries covered by this project, but there are significant barriers preventing widespread involvement.

The EEB project commissioned research that identified 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.

Technical details

Lippincott Mercer designed qualitative and quantitative research (carried out by GfK) on behalf of the EEB project. It was designed to gauge current levels of support among opinion leaders, policy-makers and the business people who finance, design, build and occupy buildings. It measured:

- Perceptions of "sustainable" or "green" buildings, including an exploration of that terminology
- The level of understanding and level of maturity of this concept
- The readiness to adopt sustainable building practices and the constraints faced by professionals such as investors, architects and contractors.

The research covered eight countries – Japan, China, India, Brazil, the US, Spain, France and Germany – and investigated perceptions and attitudes about building sustainability in general.

Qualitative research was conducted 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 with 45 people between October 2006 and January 2007. The interviews covered attitudes toward 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 between November 2006 and February 2007, using a telephone questionnaire.

The research did not include private landlords or homeowners.

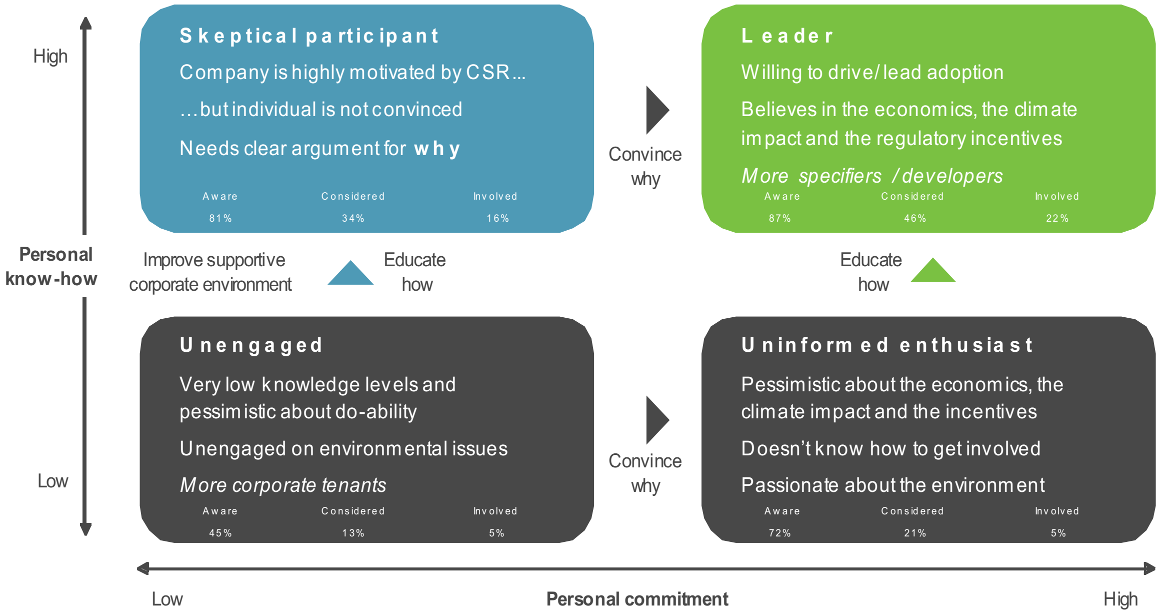
Attitudinal segments

The research identified four broad attitudinal segments among building professionals (see Figure 10). The segmentation is based on personal know-how 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. (These figures relate to the "purchase funnel" in Figure 13.) The boxes also indicate the key requirements to move groups toward the "leader" quadrant.

An unengaged respondent:

> *"I don't even know if the projects we finance are sustainable – I just care about the risk."*
>
> **Financier**, *Europe*

Figure 10: Segments among building professionals[19]



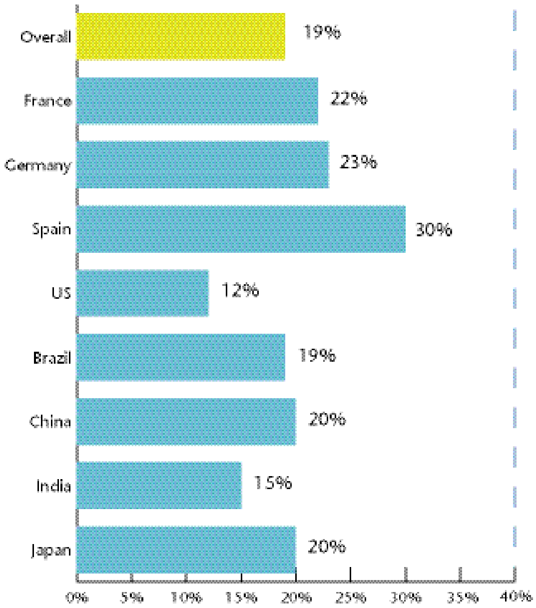
[19] Source of figures 10–15: Lippincott research.

Professionals' knowledge of sustainable building issues

People recognize that sustainable buildings are important for the environment but underestimate buildings' contribution to greenhouse gas levels (see Figure 11), which is actually about 40%.

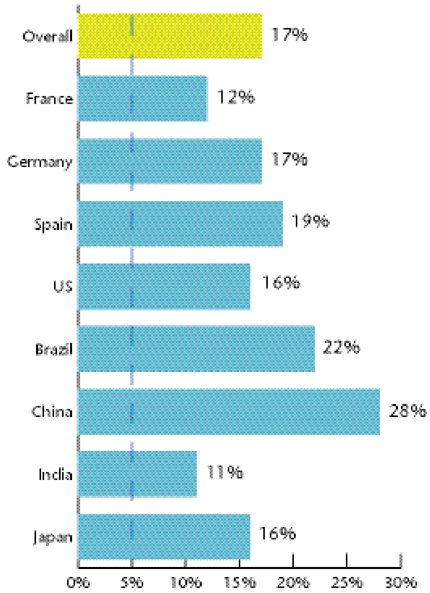
They also generally overestimate the cost premium (see Figure 12), which is likely to be under 5% in developed countries, although possibly higher in China, Brazil and India.

Figure 11: Estimates of buildings' contribution to total emissions



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

Figure 12: Estimates of cost premium for "a certified sustainable building"



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

Awareness and involvement[20]

Awareness of environmental building issues is relatively high in all markets. But in most markets the numbers drop sharply on questions about involvement in green building activity. Typically only a third of those who said they were aware of green buildings had considered involvement, and only a third of that smaller group had actually been involved (11% of the total). Figure 13 shows the percentages of respondents who are aware, have considered it and have been involved. It also indicates the percentages at each of these stages. For example, in France 32% of those who are aware have considered sustainable building, and 30% of those who have considered it have been involved, which means only 8% of respondents have direct experience.

Overall, only 13% of respondents have been involved in green/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 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."

Politician, US

Figure 13: Awareness and involvement of building professional

	Aware	Considered	Been involved
France	83%	27%	8%
Germany	98%	67%	45%
Spain	87%	28%	9%
US	83%	43%	16%
Brazil	82%	27%	9%
China	79%	28%	10%
India	64%	13%	5%
Japan	13%	5%	3%

Question: "What is your level of awareness of green/sustainable buildings?"
(Figures rounded to the nearest full number, those between the blue columns represent the proportion of the previous column number and have been rounded using the actual non-rounded number).

[20] The results in Japan are particularly interesting – 13% awareness of green/sustainable buildings compared to an average for other regions of 84%. This is odd given that its building energy use is the lowest of the developed countries.

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.

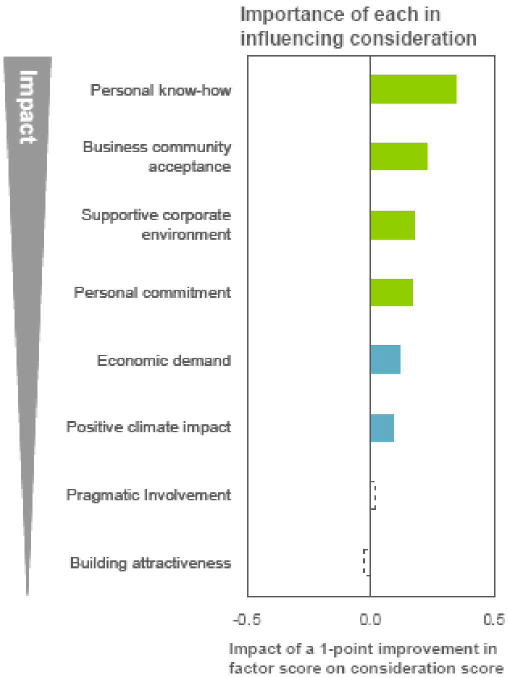
"The biggest barrier is that investors have the final decision-making authority on buildings and, under current circumstances, they are pursuing profit maximization. Sustainable building option conflicts with profit maximization."

Academic, *Japan*

The quantitative research identified eight factors that influence decision-makers about sustainable buildings (see Figure 14). 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":

- ***Personal know-how*** – whether people understand how to improve a building's environmental performance and where to go for good advice
- ***Business community acceptance –*** whether people think the business community in their market sees sustainable buildings as a priority
- ***A supportive corporate environment*** – whether people think their company's leaders will support them in decisions to build sustainably
- ***Personal commitment –*** whether action on the environment is important to them as individuals.

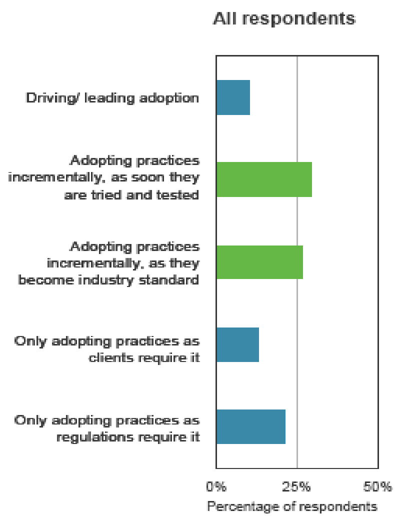
Figure 14: Factors influencing adoption of sustainable building practices



Leadership

Figure 15: Lack of leadership

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



Source: WBCSD EEB Market Research, 2007

When asked about their responsibility in driving change, very few decision-makers saw their task as leading the move to sustainable building (see Figure 15). The answers suggest some willingness to adopt new practices, but also hint at the conservatism for which the building industry is renowned.

Achieving change, based on sound policies

"It is necessary for the State to determine that greener buildings must receive more financial aid. Then the market will move into this."

Architect, *Spain*

Summary:

- Technology is available, but businesses need to be supported by appropriate policies and regulations.
- Three approaches can help to break down the barriers: a holistic design approach, financial mechanisms and relationships and behavioral changes.

The knowledge, technology and skills are already available but are not being widely used to achieve dramatically lower energy use in buildings. The previous pages have shown that progress is hampered by barriers in the form of industry structure and practices, professionals' lack of know-how and support and a lack of leadership.

Policy and regulation

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 2006 review for the UK government. He concluded that several types of interventions by governments are necessary to correct this market failure:

- 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.

Businesses in the building industry need a supportive policy and regulatory framework to achieve dramatic improvements in energy efficiency. This is supported by the project's research findings on industry leadership, which reveal that many building industry professionals only adopt new practices if they are required by regulation (see page 11).

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.[13] The study identified policies that were both successful in reducing emissions and cost-effective. Table 1 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 1: Effective policy instruments

[21] UNEP SBCI, Quoted at the Brussels Forum.

Governments in the countries covered by this project have introduced building codes and other relevant policies, as Table 2 illustrates. But more needs to be done to encourage improved energy performance.

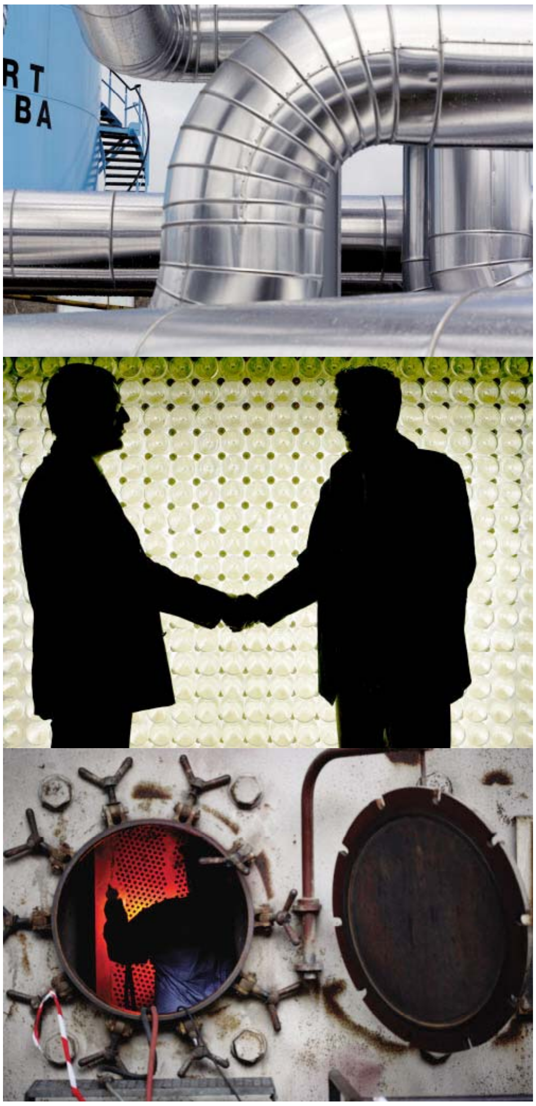
It is not the role of this project to define policy details but to identify key areas where policy initiatives can help influence holistic design, financial decision-making and behavior.

Examples of government action in addition to building codes	
Brazil	Measures to improve the efficiency of lighting equipment
China	Mandatory energy labeling for domestic appliances, broadening and updating voluntary energy labelling
European Union	Building "energy passport" required by the Energy Performance in Buildings Directive
India	Efficiency standards and new mandatory energy labeling for new appliances and equipment
Japan	*Top Runner* efficiency standards for equipment
US	Energy efficiency programs for utility companies

Source: IEA, "World Energy Outlook 2004."

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

- Urban planning (see page 22)
- More-effective building codes to enforce minimum required technical standards
- Information and communication, to overcome the lack of know-how and to highlight 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) and LEED (US) and the building "energy passport" (EU)
- Incentives, including tax incentives, to encourage energy efficiency in building equipment, materials and occupant consumption
- Energy pricing to make energy more valued by users, to decouple utilities' revenues from the volume of energy supplied and to encourage 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
- Enforcement, measurement and verification to make sure policies and regulations (including building codes) are effective and support market measures such as trading.



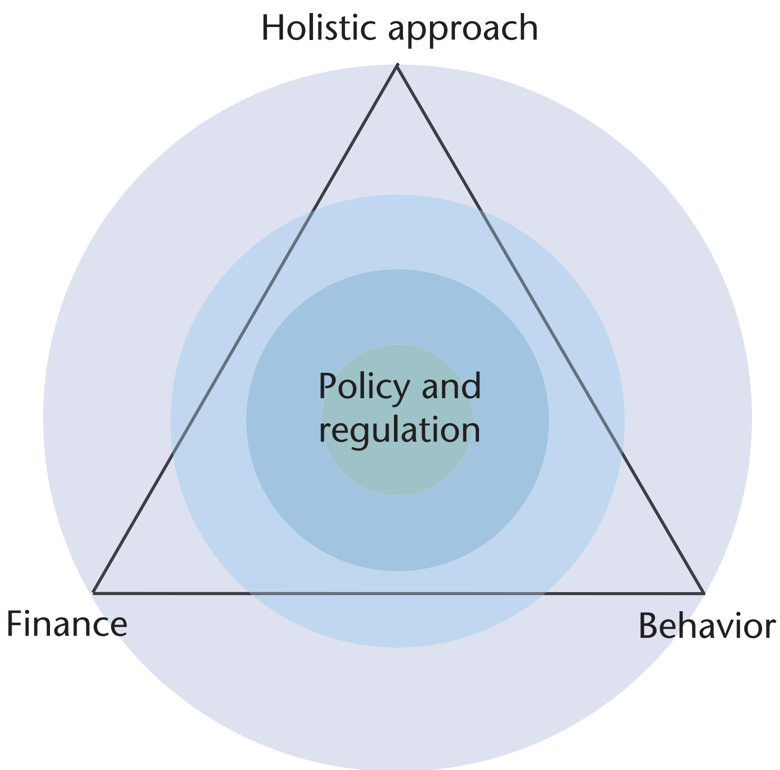
Policy as a supportive framework for business levers

Given a supportive policy framework, there are three approaches that can help break down the barriers: a holistic design approach, financial mechanisms and relationships, and behavioral changes. These can change the ways that the market and individuals respond, increasing the market value of energy efficient buildings, and they will enable the isolated "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 operations.
- 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 16 illustrates.

Figure 16: Three approaches in a supportive framework



Energy efficient buildings around the world

TERI RETREAT, Gurgaon, India

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 m€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.

Encouraging interdependence with a holistic approach

"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*

Summary:

- Energy efficiency in buildings should begin at the neighborhood or city planning stage.
- The holistic approach must consider energy use over the whole life cycle of the building.
- Holistic design combines different components and technology in the building in an integrated approach rather than focusing on individual elements.
- The building "envelope"[22] is critical to energy efficient design, which also needs to integrate shade, orientation, daylight, ventilation and appropriate materials.
- Design should include on-site energy generation from renewable and otherwise wasted resources.

A holistic approach begins with master planning, takes the whole life cycle into account and embraces integrated building design processes.

This approach is essential to maximize the potential of individual technologies and innovations. It begins at the community planning level to gain efficiencies on a larger scale than can be achieved in individual buildings and to integrate other energy uses, such as transport. Master planning considers the community in its entirety as well as single buildings. Some new urban centers are being created from scratch with an entirely sustainable plan, like Dongtan near Shanghai, China, and Songdo, Korea. But many existing and rapidly growing cities have little room to maneuver due to existing constraints. In that case, master planning has to be implemented within the existing urban environment.

[22] The envelope is the structure that encloses the internal space and separates it from the exterior.

Within individual buildings, efficiency is improved with a greater degree of collaboration between specialists from the earliest stages of the design process. Integration helps to adopt approaches, technologies and materials that can significantly lower energy use in buildings in economically attractive ways. Costs can be minimized with this holistic approach to integrated design and innovation.

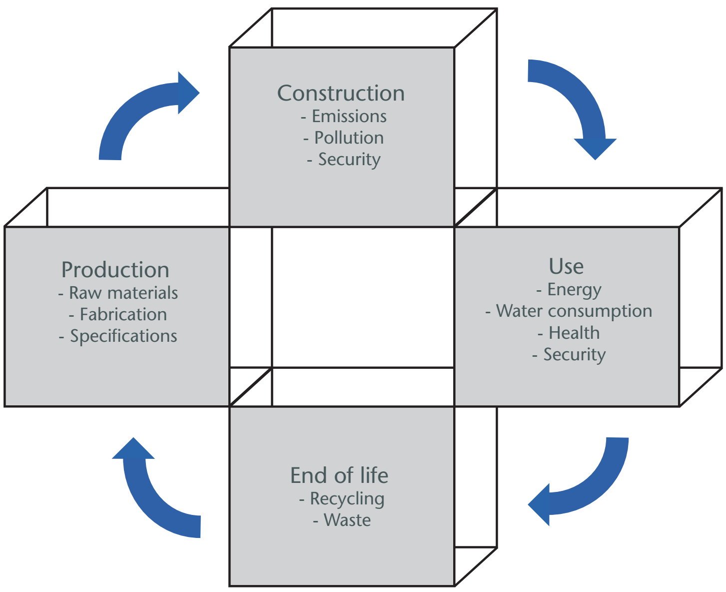
Lifespan and embodied energy

A holistic approach considers impacts during the life of a specific building or component rather than focusing on only one phase, such as construction, use or disposal.

Such a life-cycle approach can be applied to a specific material or component, a single building element (wall, window or equipment), an entire building or even a city. In practice, it is helpful to narrow the scope of the variables to be optimized. For example, the UK Building Research Establishment focuses on energy, material and water consumption, and 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 sector's environmental footprint needs to be addressed at every phase, depicted in Figure 17.

Figure 17: Sources of environmental impacts in each phase of the building life cycle



About 84% of total building energy is typically consumed during the use phase, assuming a building life of more than 50 years. The building lifespan is important, as the impact of embodied energy (used in the extraction, processing and transport of building materials and in construction) will be more significant if the building lifespan is shorter. The challenge in reducing energy demand of buildings during the use phase is to avoid increasing the energy use in other phases.

The lifetime of buildings has been decreasing, and this trend needs to be reversed to spread the embodied energy over a longer period. The life of a building can be prolonged by using high-quality construction systems and building materials, anticipating and designing out maintenance and repair, and designing in flexibility so that changes of use are practical during the building's lifetime.

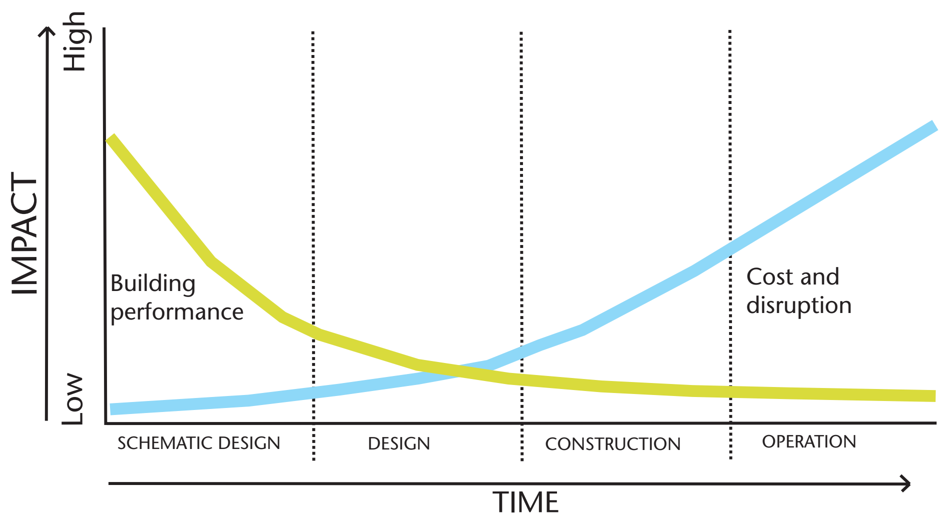
Integrated building design

Many professionals are involved at different stages of a design project, and many factors need to be taken into account: climate, building shape, comfort levels, materials and systems, occupant health and security. Most projects follow a sequential approach, finalizing one stage before moving to the next, with fee structures aligned to this linear approach and compartmentalization. Designers need to be able to carry out extra iterations, revisiting earlier stages, to optimize the many factors and introduce cost-effective innovations at an early stage.

An Integrated Design Process (IDP) involves all participants in the early design phase of the project. Multi-disciplinary workshops bring together owners, architects, engineers and others. They cooperate across the different specialties rather than working in the traditional "silo" approach that involves little communication between specialists and results in buildings with sub-optimal performance.

IDP can achieve improved building performance with lower costs and fewer disruptive changes during the later project stages. Figure 18 shows that the earlier in the process that IDP occurs, the greater the impact on building performance and the lower the impact on costs.

Figure 18: The benefits of early integration



Source: Solidar, Berlin Germany

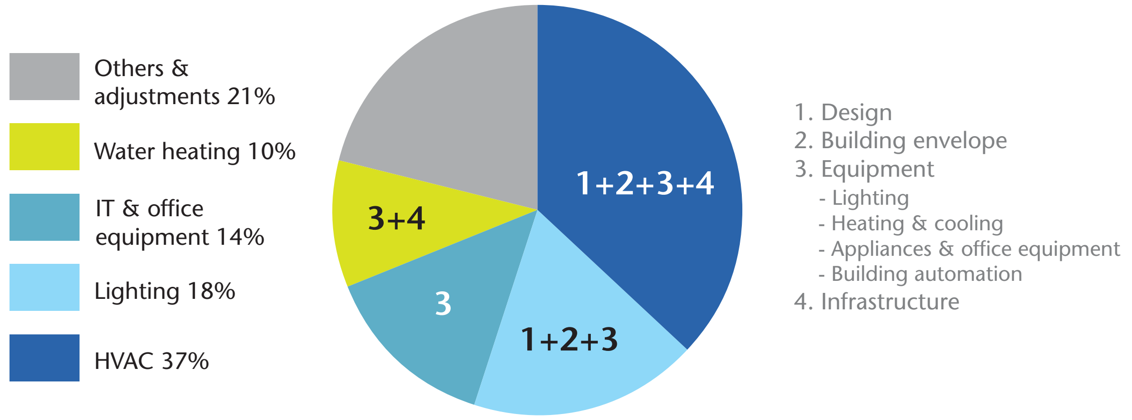
Design components

Building performance depends not only on the performance of individual elements but also on how they perform as integrated systems. 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, how much heat is transmitted through "thermal bridges" (which breach insulation and allow heat to flow in or out) and how much natural light and ventilation can be used.

Considering equipment and infrastructure is also important, while the design brings together all the influences on energy efficiency.

Figure 19 illustrates the inter-relationships among these four main influences on energy efficiency and the key energy consumers. 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).

Figure 19: Design impacts on energy use[23]



(Percentages of total energy are for US buildings)

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, as well as new and renovated buildings.

There are five key elements for PassivHaus:

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

[23] 2004 DOE Buildings Energy Databook.

Energy efficient buildings around the world

Council House 2, Melbourne

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.

The technologies used include:

- Undulating high thermal mass concrete ceilings which improve air circulation, cooling and natural light and reduce energy demands 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/m€/year. Compared to the previous Council building (c1970), this equals savings of:

- 82% electricity consumption
- 87% gas consumption
- 72% mains water supply.

Financial savings of 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.

Providing financial information and mechanisms

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

Academic, *Japan*

Summary:

- Energy is a small proportion of cost for most decision-makers in the building value chain.
- The cost of energy efficiency is typically over-estimated.
- Reliable data are often lacking.
- A more sophisticated risk-management model may be necessary to assess building energy investments.
- New business models can help to increase the focus on energy efficiency and drive investment.

Financial considerations are critical to property development and investment, but they appear to be limiting the advance of energy efficiency. This is true of major development projects as well as smaller investments in 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. 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. On the other hand, investors' time horizons are likely to be shorter. This increases the importance for 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.

There is some evidence that an energy efficient building can command a premium, and this may increase as awareness of climate change and expectations of rising energy costs leads people and organizations to attach more value to energy efficiency. A McGraw-Hill study[24] reported 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. In the US, buildings with high energy performance are becoming more attractive financially because of markets for renewable energy (in 20 states as of mid-2007) and energy efficiency credits (10 states).

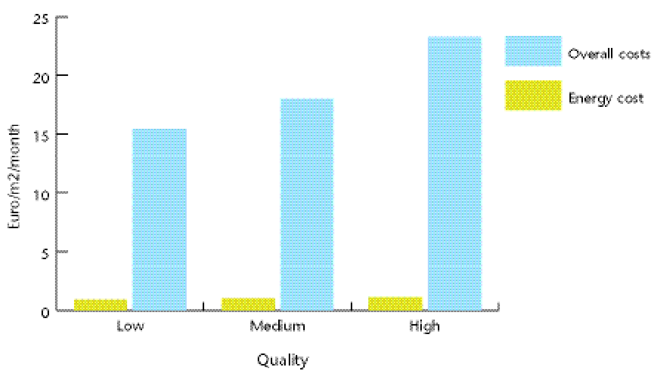
Energy cost significance

Energy is typically a small proportion of total occupancy costs for buildings. Real estate managers at the EEB's financial hearing in Zurich said that energy costs were too low to be a driver for energy efficiency (see Figure 20). For example, in a high-quality office building in Germany, heating and electricity made up less than 5% of the total operating cost of the building, including rent and maintenance (about €1.1 of out of every €23.3 spent).

The demand for higher quality office buildings will further decrease the importance of energy costs. High-quality buildings have higher operating and energy costs, but the energy proportion decreases relative to the total, as Figure 20 shows.

Figure 20: Energy and total costs by quality of fittings[25]

Based on 397 buildings with 6 million m^2 in 2006



[24] McGraw-Hill Construction: Green Building SmartMarket Report 2006.

[25] Jones LaSalle GmbH, CREIS.

The cost of achieving energy efficiency

EEB research (reported on pages 6 and 7) found that perceptions of the cost necessary to achieve greener buildings are likely to be significantly higher than the actual cost. The average perception was a 17% premium, but cost studies on actual properties have shown much lower figures. For commercial properties, the Fraunhofer Institute has shown that the energy demand of new office buildings can be reduced by 50% compared with the existing building stock without increasing construction costs.[26]

The US Green Building Council has performed numerous studies and concluded that the cost of reaching certification under its Leadership in Energy and Environmental Design (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 than 10%. These figures are supported by a study of 40 US offices and schools that found cost premiums substantially lower than professionals' estimates revealed in this project's research (16% for US).[27]

A more comprehensive study by Davis Langdon Adamson, a construction management services firm, confirmed these broad conclusions but with an important caveat: location and climate are more important than the level of energy efficiency to the ultimate cost. The survey looked at more than 600 projects in 19 US states and examined the impact on cost of location and climate. Figure 21 shows the additional cost necessary to meet the relevant LEED level.

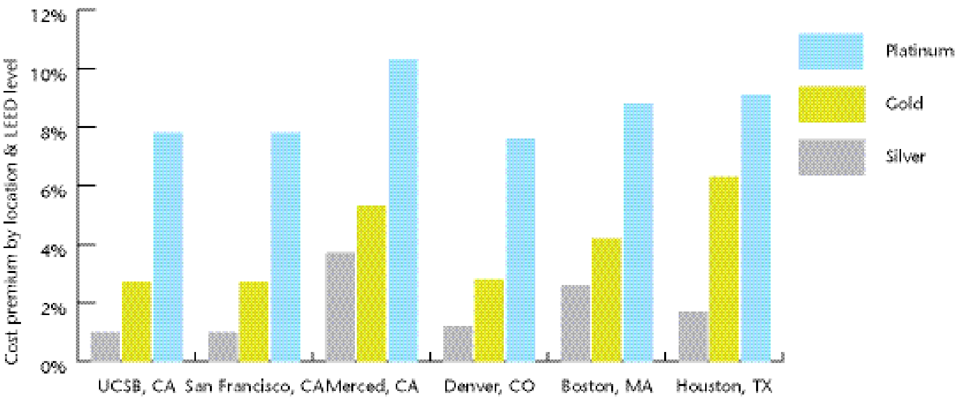
This analysis shows that variations between cost premiums in different locations can be more pronounced than the cost differential between different levels of environmental performance.

Retrofitting energy efficiency in existing buildings can also be cost-effective. Research for the IEA on high-rise apartments in the European Union concluded that substantial energy savings could be achieved in hot and cold climates, with significant net cost savings.[28] As much as 80% of heating energy was saved in the least efficient buildings, with an overall 28% energy saving. The study showed that retrofitting was most cost-effective when carried out as part of general refurbishment.

Information

While energy costs are a relatively small part of total occupancy costs, they are the most important to gain energy efficiency. Profitable opportunities for energy savings are often overlooked because of inadequate cost information. Despite the stated interest of real estate managers in energy efficiency, a study in 2007 found that only two-thirds of the companies tracked energy data and only 60% tracked energy costs.[29] Only 30% of real estate managers or facilities managers claimed to have included energy efficiency requirements in requests for proposals.

Figure 21: Cost premium by location and energy efficiency level



[26] Herkel and others, Energy efficient office buildings – Results and Experiences from a Research and Demonstration Program in Germany, Building Performance Congress 2006; see www.enbau-monitor.de.
[27] Greg Katz, CapitalE, *Economic Costs and Benefits of Green Buildings.*
[28] IEA Information Paper, High-rise refurbishment: The energy efficient upgrade of multi-storey residences in the European Union.
[29] CoreNet Global 2007.

Research by the Green Building Finance Consortium in the US 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," the initial investment required, rather than life-cycle cost assessments and return-on-investment calculations.

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 would[30] identify:

- Energy consumption elements directly affected by changes within the facility (intrinsic volatilities), which 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), which includes energy price risk, labor cost risk, interest rate risk and currency risk.

Such a risk management framework would allow energy efficiency experts and investment decision-makers to exchange the information they need to expand investment into energy efficient buildings projects.

Energy Service Companies (ESCOs)

Appropriate commercial relationships can increase the focus on energy costs and avoid the split incentive problem. ESCOs are one example.

ESCOs engage in energy performance contracting – an arrangement with a property owner that covers both the financing and management of energy-related costs.

Initial investment and life-cycle cost considerations are taken on by the ESCO. These companies generally act as project developers for a wide range of tasks and assume the technical and performance risks associated with the project. An ESCO develops, installs and finances projects designed to provide energy at a contracted level and cost, usually over 7–10 years. Its compensation can be linked directly to the amount of energy that is actually saved.

[30] See *Energy Policy* 34 (2006) 188–199. "From volatility to value: analysing and managing financial and performance risk in energy savings projects", by Evan Millsa, Steve Kromerb, Gary Weissc and Paul A. Mathew.

Changing behavior

"Culture and Ethics are important considerations."
Prof Jiang Yi, *Tsingua University speaking at the EEB Beijing Forum*

Summary:

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

Energy has important symbolic and behavioral aspects that can have as much impact on consumption as energy efficient equipment does.[31] In many people's minds, energy "rationing" is a negative 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; social recognition can come from consumption, which clashes with saving energy. In the developed world, it is a commodity that is taken for granted and its insignificance can lead to thoughtless waste.

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.[32]

Buying and using equipment

There are two separate aspects of energy behavior: buying efficient equipment and using energy efficiently.

In Europe and the US the market for appliances has changed over the last decade. Despite the price premium for energy efficient equipment, there was a switch during the 1990s to buying more energy efficient appliances.[33] The flip-side of this is the trend to buying more equipment as people become wealthier: dishwashers, garden equipment, extra TVs and other consumer electronics. [34]

Barriers to energy efficient buying and use

The transition to using energy efficiently is difficult because it requires widespread changes in habits, ranging from turning off appliances when not in use to buying more energy efficient appliances. The balance between technical solutions for energy efficiency and human actions for energy efficiency needs to be weighed system by system.

Energy-saving actions can be influenced by several factors. Cost is important, especially energy cost as a share of total expenses, but information must be available to stimulate action. Cultural, educational and social factors, including concern for the environment, also influence people's attitudes.

People may fail to buy energy efficient equipment due to:

- ***Lack of information*** on equipment performance
- ***Lack of concern*** for energy efficiency – consumers tend to be more concerned with criteria such as technical performance, comfort and aesthetic design
- ***Cost difference*** between standard and energy efficient equipment – for example, there has been relatively low uptake of low-consumption lamps, possibly due to their higher price.

Several social, cultural and psychological factors prevent users from making energy savings, as shown in the Table 2. 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 effort. But 36% do not want to lose comfort; 25% think their action would be just a drop in the ocean; another 25% say they cannot afford it, and 22% say it is too much effort.

[31] Anna-Lisa Linden et al. (2006). "Efficient and inefficient aspects of residential energy behaviour: What are the policy instruments for change?"
[32] *Revue Durable*, 2002.
[33] Waide (2001). Proceedings of the 2001 ECEEE Summer Study on Energy Efficiency, Vol 2. Paris: European Council for an Energy efficient Economy.
[34] Pers. Comm. with Gavin Killip, Environmental Change Institute, Oxford, mentioning the "40% House" report made with Brenda Boardman.

Perception is important. People may not have an accurate understanding of the effort needed to achieve energy efficiency and the resulting 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 energy efficient behavior are linked to three issues:

- ***Lack of awareness and information*** on energy consumption and cost – people are often not aware that they are wasting energy – which prevents them from behaving efficiently.
- ***Habit*** – people are in the habit of leaving lights on, not adjusting heating and using ovens even though they consume more energy than microwaves do.
- ***The rebound effect*** – the reduction of energy savings because the saving leads to additional activity through either greater use of the same product or for another energy-using action, such as driving a more efficient car further, or leaving lights on because they are energy-saving bulbs – is widely recognized but its magnitude varies, for example:[35]
    - Space heating: 10- 30%
    - Space cooling: 0-50%
    - Lighting: 5-20%
    - Water heating: 10-40%
    - Automobile: 10-30%.

Removing the barriers

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.[26] This emphasizes the importance of lifestyles and behavior in energy consumption.

The challenge is to affect behavior permanently. Information and education are key elements to change knowledge into action. This includes advertising campaigns on energy efficiency, energy labeling of appliances, advice on energy efficient equipment or behavior, education at school and the use of information technologies such as consumption meters. Expert advice, through audits, may be necessary to help people become aware of possible energy savings and measure the impact of their behavior.

Technical devices to measure energy consumption and provide immediate feedback help households to cut energy consumption by as much as 20%.[37] Direct and immediate feedback reveals the link between actions and their impacts. Well-informed consumers choose actions to save energy with minimal impact on their comfort. Perceptions of comfort are important; there must be a balance between energy-saving value and any perceived loss of comfort.[38]

Table 2: Reasons for not having done the utmost to make energy savings (Belgium, 1000 households)

	Completely	Rather yes	Neither yes nor no	Rather no	Not at all	Total
Doesn't want to lose comfort	3.5%	32.2%	5.2%	29.8%	29.3%	100.0%
Would be a drop in the sea	2.4%	23.1%	3.7%	26.4%	44.5%	100.0%
Doesn't have financial means	1.7%	23.3%	5.2%	30.4%	39.4%	100.0%
Requires too many efforts	1.9%	19.4%	4.8%	30.8%	43.1%	100.0%
Doesn't know what is necessary	3.3%	15.7%	4.7%	33.4%	42.9%	100.0%
Doesn't see the utility	0.5%	3.5%	0.4%	23.5%	72.1%	100.0%

35 UKERC, IEA, International Resource Group.

36 Anna-Lisa Linden et al. (2006) "Efficient and inefficient aspects of residential energy behaviour: What are the policy instruments for change?"

37 EPRI, 2005, In-Home Display Units, Tools for Conservation and Demand Response.

38 ACEEE Summer Session Proceedings, 2006, "Effectiveness of Displaying Energy Consumption Data in Residential Buildings: To Know Is to Change" by Tsuyoshi Ueno, Central Research Institute of Electric Power Industry; Kiichiro Tsuji, Osaka University; and Yukio Nakano, Central Research Institute of Electric Power Industry.

Conclusions and next steps

Technology available today can achieve dramatic improvements in building energy efficiency, but market failures and behavioral barriers are blocking progress toward the EEB vision of zero net energy. The challenge in this first phase has been to understand those impediments. In the next phase the project will explore ways to overcome them and develop a roadmap with practical measures that businesses can implement.

Complexity and segmentation

The building industry and the market are highly complex. Different approaches will be needed for different segments and sub-sectors. Each sub-sector (e.g., offices, hospitals, retail, apartments, detached houses) may have its own particular characteristics, and the project will develop sector-specific analyses in the next phase. At this stage the conclusions are concerned with the building market as a whole.

Use less, make more, share

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, long-term gains will come from using less energy.

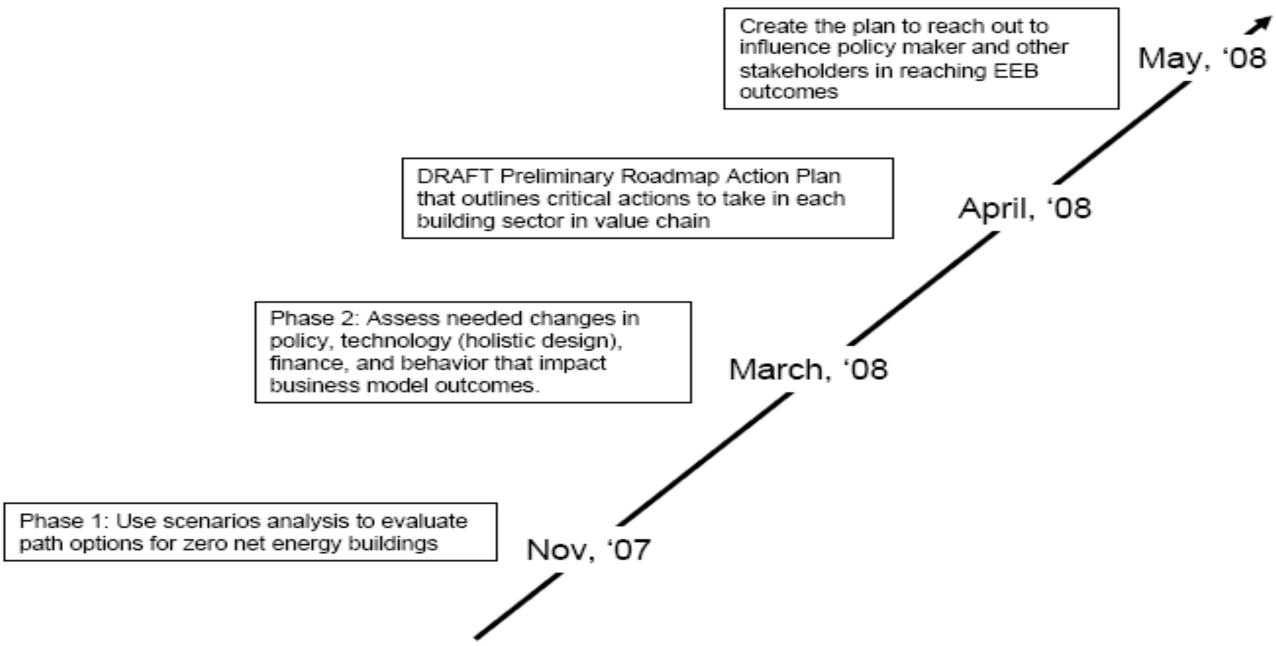
Risks and opportunities

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

Barriers

The EEB's perception research found high levels of awareness of the issue of sustainable building but low levels of specific knowledge and involvement. It 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 sustainable building work.



Levers for change

Appropriate policies and regulations are necessary to ensure that the right conditions are in place for the market to work effectively. Given an appropriate policy framework, there are three broad business levers that can help remove the barriers to building energy efficiency:

- ***Adopt a holistic approach***. This is essential to integrate individual technologies and innovations.
- ***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 in order to encourage behaviors that will respond more readily to market opportunities and maximize the potential of existing technology.

Next steps

In its next phase, the EEB Project will explore how these levers can be developed. First, the group will create scenarios to evaluate paths toward zero net energy. These will help identify changes needed in building industry approaches, finance and behavior that will create the necessary levers. The EEB will then develop a preliminary action plan that will be used to influence policy-makers and stakeholders. These steps are shown in the illustration above. In the final phase the plan will lead to a call for action by all those involved with the building industry.



Acknowledgements

This report was developed by representatives of the project's Core Group companies, led by Bill Sisson of UTC and Constant van Aerschot of Lafarge, with editorial support from Roger Cowe of Context. The project director is Christian Kornevall of the WBCSD. We are grateful for support and assistance from many people, especially those who hosted and helped to organize events in California, Frankfurt, Zurich, Beijing and Brussels. The main contributors to this report from the project's core companies are:

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About the project

Lafarge and United Technologies Corporation chair the project and the companies shown below make up the Core Group. They 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 professionals and opinion leaders, as well as 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 four areas of policy, innovation, 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. 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. A second Forum took place in Brussels in July 2007, concentrating on how to drive investments in energy efficiency in existing buildings.

EEB Core Group companies

Company profiles

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 CO2 emissions, on track to keeping its voluntary commitment of reducing the group's worldwide CO2 emission 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, 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 impact. From 1997 to 2006 the company reduced its energy consumption, measured in BTUs, by 19 percent 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.

CEMEX works together with its customers and communities to provide integral sustainable building solutions which contribute to lower the overall Greenhouse gas (GHG) emissions, these solutions consists of: financing, design, planning support, as well as our products. Offering our customers practical and readily applicable products, that are: economically feasible, can be used in a mass scale, are durable, have better insulation properties, and additionally provides comfort and reduces energy consumption for heating and cooling.

CEMEX also contributes to reduce the GHG emissions in our cement production facilities; from 1990 to 2006 we have achieved an 11% reduction in our CO2 emissions. Our target is to reduce them up to 25% by 2015.

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 CHG emissions at least 15% from the 2004 level. We are also committed to growing revenues from products that create energy efficiency and/or significantly reduce greenhouse gas emissions for our customers.

The EDF group is an integrated European energy supplier that has a long-standing 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 €3 billion investment out of a €40 billions 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, 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. Leading positions in Europe In Europe, the Gaz de France Group : - operates the longest natural gas transmission network, - manages the largest natural gas distribution network, - ranks among the leading suppliers of natural gas.
THE KANSAI ELECTRIC POWER CO., INC.	Kansai Electric Power Company is actively promoting comprehensive measures strategically to reduce greenhouse gases, as a leading electricity utilities. Achieving more efficient energy use in demand side is one of the important elements of such measures. For corporate customers, Kansai has introduced equipments such as 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 are typical devices that use electric power late at night (off-peak), Kansai is further popularize 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.
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 voluntary start managing its GHG emissions, reducing 25% in electricity consumption per m2 for the aggregated Sierra portfolio in the last five years and consequently GHG emissions.
TEPCO	TEPCO, the largest electricity supplier and one of the most excellent 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 over 30% of energy consumption and CO_2 emissions than that of usual building. Main driving technologies for the energy efficient buildings are heat pumps and thermal storage, which will continue to play the main role to reduce world-wide CO_2 emissions.

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