Buildings Guide
Upgrade to ultra-low-energy buildings

bigEE

# A Strategic Approach enables Energy-Efficient Buildings

## The key to energy efficiency


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# Index

A Strategic Approach enables Energy-Efficient Building .......... 3
It's really worth it: the potential for energy savings in buildings .......... 6
Regional differences and building types .......... 8
How integrated design can bring higher energy savings at lower costs .......... 10
What will all this cost? Are energy-efficient buildings really cost effective? .......... 12
A strategic approach is the key to high energy savings at low cost. .......... 15
References: .......... 17

# A Strategic Approach enables Energy-Efficient Buildings

A Strategic Approach to integrated building design is the key to achieving high-energy savings at low or no extra capital cost in buildings. Energy-efficient buildings can be achieved through a holistic design with energy-efficient technologies and intelligent building management. Examples of holistically planned Ultra-Low-Energy and (nearly) Zero and Plus-Energy Buildings already exist and it has been shown that these can be achieved economically. A step-by-step path is needed in implementing these integrated design processes, to effectively reach energy efficiency in new building projects and the building sector overall. This strategic approach is ultimately the key to comfortable, competitive and energy-efficient buildings as well as a sustainable development.

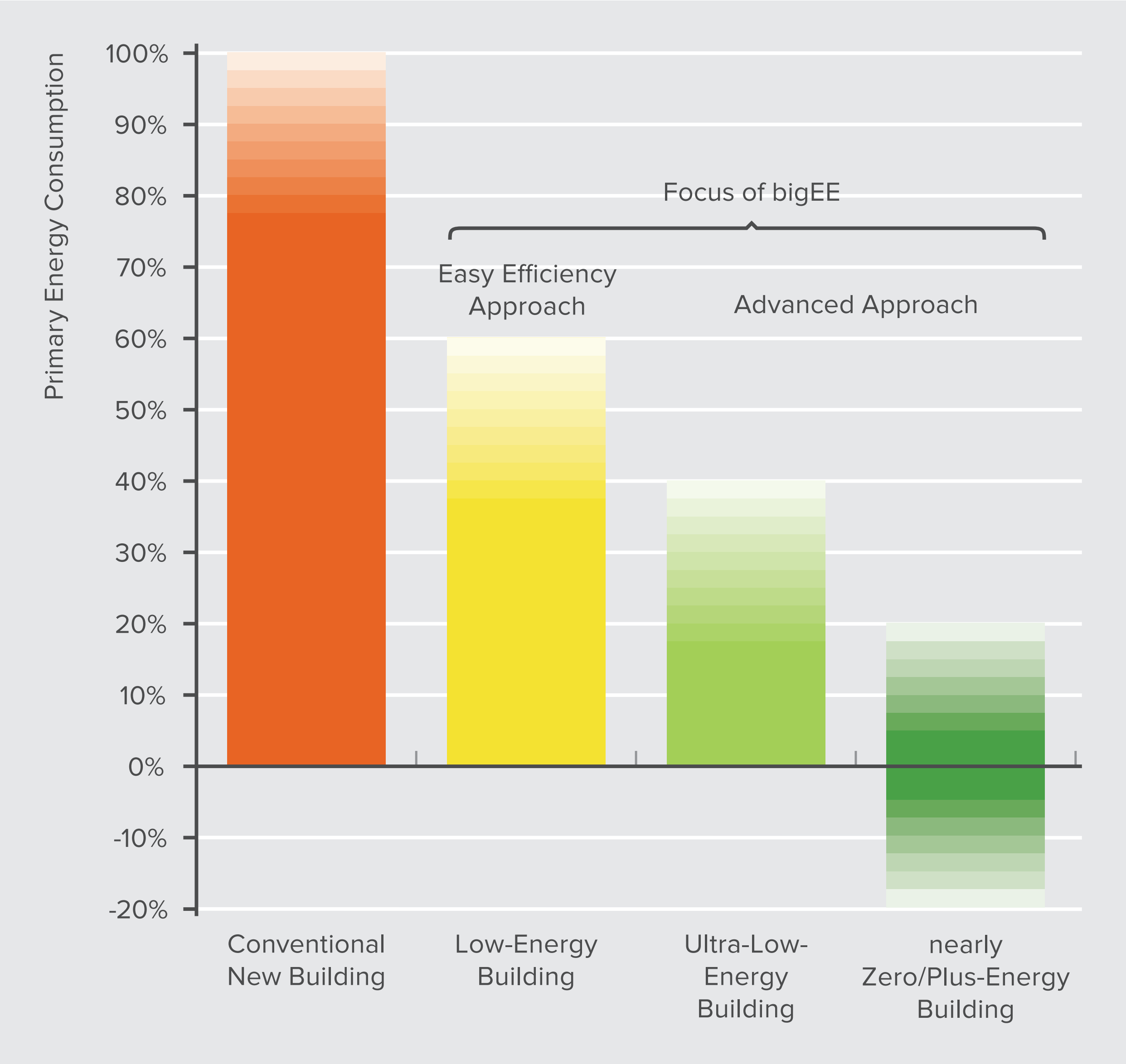


**Figure 1: The steps to energy efficiency through a Strategic Approach for new residential buildings**

Source: Developed by Wuppertal Institute for bigEE (2012)

Figure 1 displays the three energy-efficient building concepts that bigEE recommends (1) Low-Energy Buildings, (2) Ultra-Low-Energy Buildings and (3) (nearly)Zero and Plus- Energy Buildings.

The choice between these three concepts will depend not only on an investor's ambition but also on the cost and benefit situation, the design and building skills, material, and technologies available in a country. bigEE will present – adapted to either new or existing – residential, service sector and industry buildings.

- Details on the strategic approach to be followed to realise each of these three concepts in the section "Strategic Approach"
- Detailed recommendations for achieving these concepts in four major climatic zones and for different types of buildings in the section "Recommendations"

- Already existing buildings of different types that are model examples of good practice for the three concepts located in different climatic zones in the section “Building Examples”, with ample details on construction, building systems, energy savings and cost-effectiveness for these examples

In this document, you will find further information on:

- how Integrated Design can bring higher energy savings at lower costs through the Easy Efficiency and Advanced Efficiency Approaches mentioned in Figure 1,
- whether energy-efficient buildings are really cost effective,
- general principles of how the Strategic Approach works.

To begin with, we touch on the potential energy savings worldwide and for an individual building. We will also see why pushing the boundaries to achieve maximum achievable efficiency in buildings is so important.

# It's really worth it: the potential for energy savings in buildings

Energy efficiency in buildings is crucial for sustainable development, mitigating climate change and limiting resource use and a low-risk worldwide energy system.

Approximately 40% of global final energy demand and one third of the energy-related $CO_2$ emissions are related to buildings (IEA 2008). Early and comprehensive use of energy efficient design and technology can substantially reduce both energy usage and emissions. Further energy savings can be made in appliances used in buildings – see the bigEE Appliances Guide.

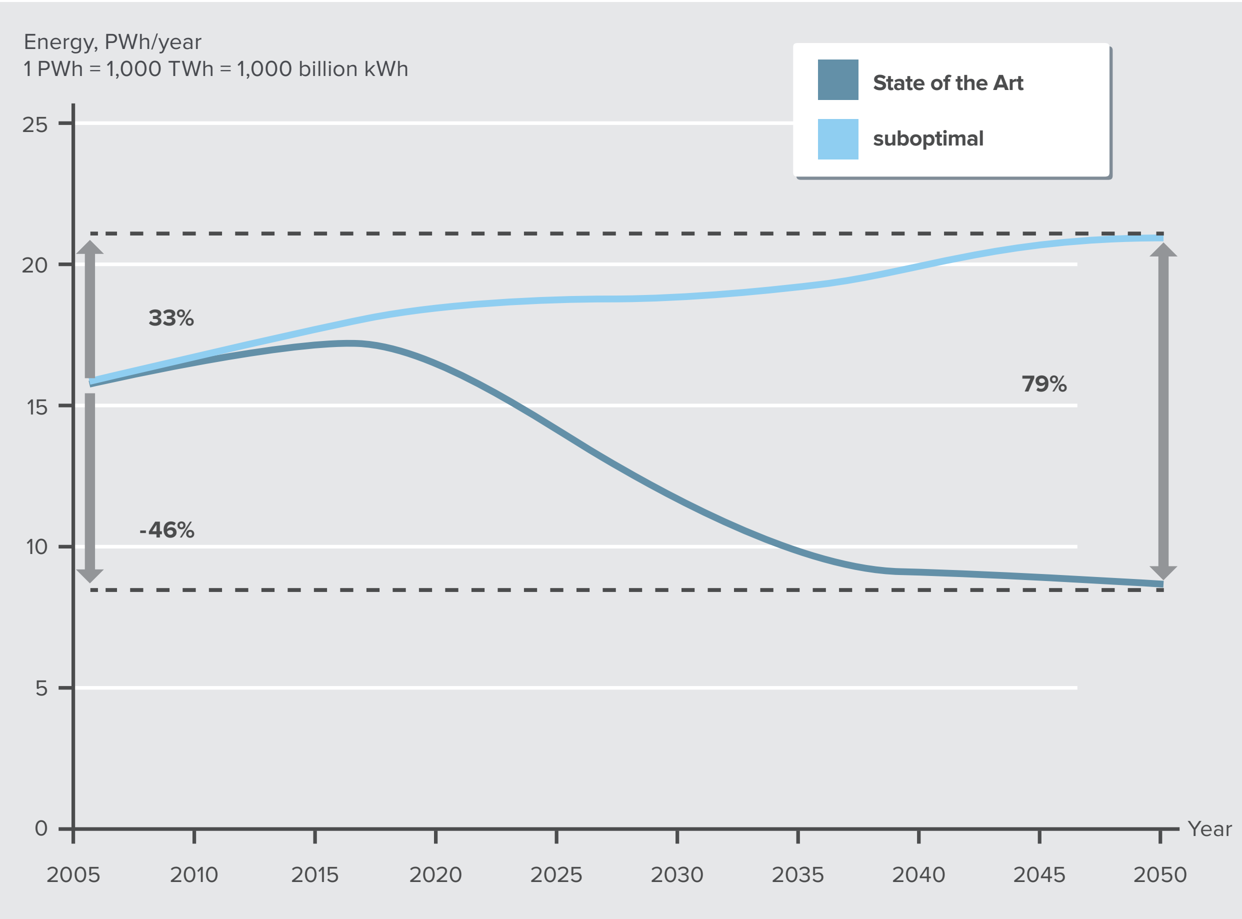


**Figure 2: World Space Heating and Cooling final energy use, 2005 - 2050, suboptimal and state-of-the-art energy efficiency scenarios.**

Source: GEA (2012)

Most recent scenarios (GEA 2012) show that **state-of-the-art energy-efficient renovations** and **new buildings** could result in **worldwide final energy demand savings** for heating and cooling energy use of 46% in 2050 compared to 2005 or 60% of the energy consumption expected in 2050 for the suboptimal scenario. This translates into an absolute decrease in energy consumption from 15.7 PWh (15,700 TWh) in 2005 down to 8.5 PWh (8,500 TWh) in 2050, despite growth in the building stock. Such a **transition** will only be achieved with early, comprehensive and systematic implementation of state-of-the art energy efficiency measures in design, construction and technology in both new and existing buildings.

Both paths are visualized in Figure 2 above, the **state-of-the art** scenario in dark blue (representing adequately refurbished existing buildings and Ultra-Low-Energy new buildings) vs. the suboptimal development path in light blue (representing sub-standard new build and refurbishment of the building stock). If left unchecked, the overall difference in 2050 will add up to an implementation gap of 79%. These energy savings potentials apply equally to both new buildings as well as the building stock. To **achieve these goals**, Ultra-Low-Energy buildings need to become the widely accepted and practiced standard.

# Regional differences and building types

## The energy efficiency targets and priorities for new buildings and renovations differ among the world regions.

In Western Europe, North America and Pacific OECD, the focus should be on the renovation of the large existing building stock. New buildings are clearly the main challenge in Centrally Planned Asia, South Asia, Latin America, Middle East, Africa and Non-OECD Pacific Asia. These regions are characterised by rapid rates of new construction and increasing energy demand for cooling. In Eastern Europe and the former Soviet Union there is equal potential for both new and existing buildings (GEA 2012).
These regions however, each require their own approaches to reaching Ultra-Low-Energy and eventually (nearly) Zero-/Plus-Energy Buildings and must deal with the existing building stock and new buildings in different ways. The most important factor determining the approach for achieving energy efficiency is the climate. This as well as other factors including the availability of local construction materials, efficient technology, know-how in the industry, existing policies as well as the price of energy will determine the path taken to reaching these goals.

**Energy efficiency in new buildings**
New Ultra-Low-Energy buildings, that need **60 to 90% less primary energy** for heating and cooling than conventional new buildings, can be constructed cost-effectively in most parts of the world. Conventional new buildings in OECD countries and China with existing building energy codes already save about 50% of energy compared to the existing building stock. These improvements, however, are neither enough to create a building standard with low lifetime costs nor to reach long-term climate change mitigation targets. Much higher energy savings can be achieved through proven high-efficiency building concepts worldwide.

**Energy efficiency in the building stock**
Retrofitting existing buildings can also bring significant improvements. The existing building stock provides the larger potential for cost-effective energy savings compared to new construction not only in OECD countries but increasingly also in countries like China (GEA 2012).

However, it is also a bigger challenge to holistically retrofit the walls, roofs, windows, and heating and cooling systems of existing buildings to highest energy performance levels and to ensure the savings through optimal operation.

Every year, many existing buildings undergo renovation for maintenance or beautification anyway. These opportunities should be utilized to improve energy efficiency by adding thermal insulation or shading and using more energy-efficient windows, heating, and cooling systems, instead of just replacing paint, styles, or windows as they were before.

They should always be at the least as stringent as the energy performance level leading to least life-cycle costs.

The operational goal for energy efficiency in existing buildings thus has two dimensions: Achieving very energy-efficient and comprehensive, “extensive” retrofits whenever a building is renovated, and increasing the rate at which buildings undergo such “extensive” renovations. Extensive energy-efficient renovation measures can achieve **primary energy savings of 50 to 90%** (GEA 2012).

# How integrated design can bring higher energy savings at lower costs

Buildings are extremely complex. Each component can be improved upon but none can bring about high energy efficiency in buildings on their own. There are combinations of different options for improving energy efficiency in buildings.

Comprehensive packages are much more effective than single actions or measures. On the policy side measures must be tailored to the regional characteristics (e.g. climate zones) and combined to address all relevant actors and barriers to energy efficiency. On the technology side, it is also important to apply packages of energy efficiency improvements because a sequence of measures is less cost effective than a package implemented all at once. This is because fixed costs occur each time technologies are implemented or retrofitted.

These packages of energy efficiency improvements in buildings can be improved through passive and active options as well as user and energy management related aspects. Once in place passive options, such as building form and orientation, shading, and thermal insulation, usually improve the performance of a building without the need of operational energy. Active options focus on energy-efficient technologies and equipment that requires operational energy, e.g. heating and cooling systems. It is important to emphasize the order in which these options must be considered.

***The sum of the whole package is greater than the sum of the single components.***

At first glance they all seem independent of each other. However all energy efficiency options are interdependent to some degree and therefore an integrated design approach is indispensible to ensure that the architectural elements and the engineering systems work effectively together. Changing or improving one aspect might have great impact on another. Focusing on individual pieces of equipment or design features generally only brings limited improvements, which are limited to single steps. Analysing the building as an entire system can however lead to altogether different design solutions. This can result in new buildings that use much less energy but are no more expensive than conventional buildings (Levine et al. 2007).  This **integrated design process** can achieve improved building performance at lower costs and ensures fewer troublesome changes during the later stages of the project (Figure 3).

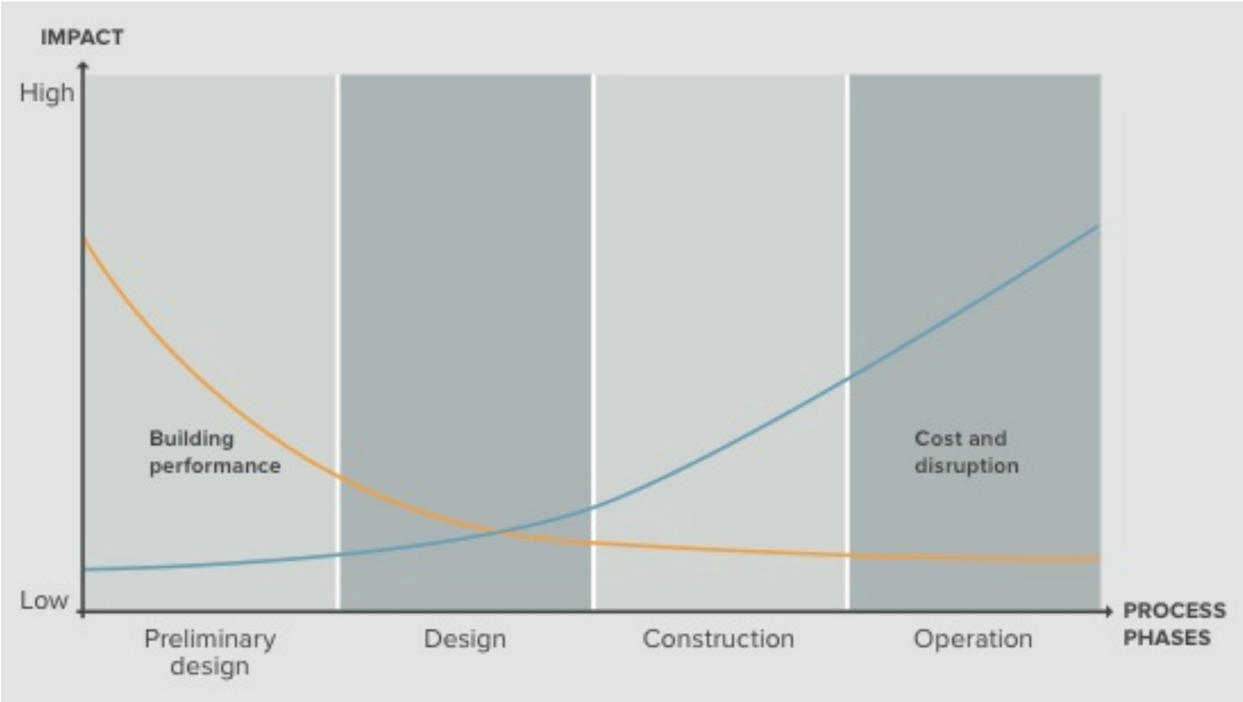


**Figure 3: Benefits of early integration into the design process.**

Source: WBCSD (2007)

In the same way, the energy cost savings potential must be considered. Looking at the cost savings potential of individual measures will give an indication of incremental improvements only. An integrated approach, however, can generate savings that are greater than achievable through individual measures. Relying solely on estimates for individual components may underestimate the overall cost savings potential. Similarly, it is also likely to overestimate the incremental cost of improving energy efficiency compared to the integrated design. Experience from advanced countries has shown that Ultra-Low-Energy Buildings incorporating an integrated approach can be built at competitive prices. These can be profitable investments for the building stock too, if done as part of typical refurbishment cycles and if the energy costs savings during the life cycle are considered (GEA 2012).

To achieve the optimum energy efficiency in buildings a holistic planning is a must. For this to work effectively performance targets need to be defined for the various types of buildings and climates.

# What will all this cost? Are energy-efficient buildings really cost effective?

Increasing energy prices are often considered the most important pre-condition for improved energy efficiency in developing countries (Levine et al. 2007).

**Energy prices** are **high** and are expected to continue **increasing**, as oil and natural gas soon reach their point of maximum extraction rate and as governments try to cope with global warming. These rising energy costs have however changed the balance of building costs. Where traditionally focus was placed on cost savings in the areas of design and construction it is now being placed more and more on cost savings during the operation phase of a building (maintenance and energy costs).

Energy-efficient buildings are often still seen as being more expensive than a conventional building. This is mainly due to high performance building components. A wide range of existing buildings clearly show that buildings can be built at high levels of energy efficiency (80% of energy savings and above) at little or no extra cost (Harvey 2006; Öhlinger 2006).

Additional capital costs for an Ultra-Low-Energy Building (in this case a Passive House) are for example between 3 to 10% in European countries (residential buildings). Total useful energy savings lie however between 25-65% compared to buildings meeting Minimum Energy Performance Standards (MEPS) in these European countries, which often already are Low-Energy Buildings (Passive-On Project 2007).

This additional capital cost can often be offset through the reduced operational energy cost for mechanical heating and cooling as well for electricity systems. Once such low energy demand levels have been achieved, it is also not so expensive to cover them with buildings-integrated renewable energies. In European countries, the discounted payback time for Passive Houses varies from 4 to 19 years (Passive-On Project 2007). The cost-effectiveness will of course depend on the growth rates of energy prices. In some cases, highly energy-efficient buildings **can even cost less** than buildings built according to standard practice (Harvey 2006).

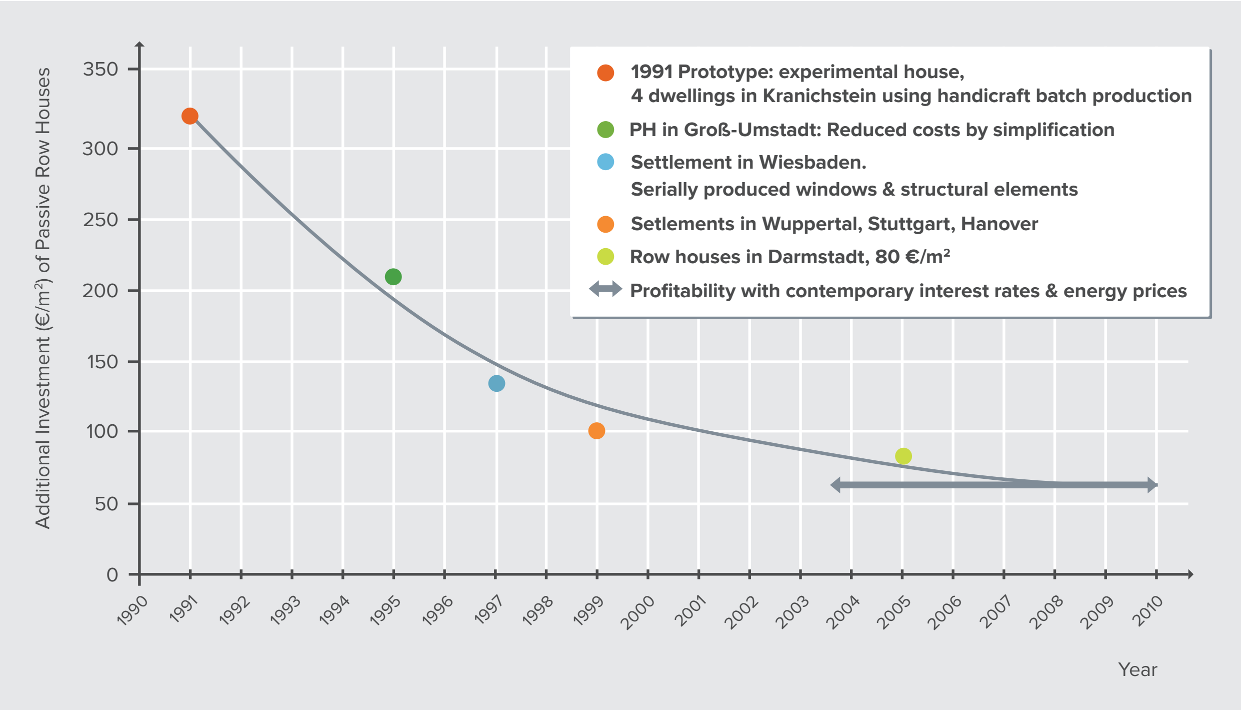


**Figure 4: Learning curve showing the progressive decrease in the incremental cost of meeting the passive house standard for the central unit of row houses in Germany. These compare to costs for conventional buildings of ca. €1250 to 1750 per m2.**

Source: Feist (2005)

With increasing demand for energy efficient building and technologies the market will help to drive these prices down even further (Figure 4). Studies for example, have shown that for residential buildings in Germany, the additional investment can decrease with time (from 8% in 2010 to less than 7% in 2011) (Passive House Institute 2012). Even now at unsubsidised energy prices, at the least the buildings of the easy efficiency approach are globally normally cost-effective unless energy prices to final users are heavily subsidised.– provided the investor uses the windows of opportunity (e.g., if a building or installed system needs renovation anyway).

For direct investors it is clear that energy efficiency will directly affect their future costs in running a building. For other investors this is often not the case. With rising energy prices and operating costs, buyers and building users have however become more savvy and are better able to discount future costs and weigh these against initial investments. The demand for **energy-efficient buildings** will thus be on the rise and can **command a premium**. Market studies have shown that buyers or renters would pay higher prices or higher rents for Passive Houses especially depending on expectations of how energy price levels might increase (Frensch 2008). In addition to this, energy-efficient buildings are also usually much more comfortable to live or work in. Living conditions and productivity are improved through better lighting, more comfortable indoor temperatures, and improved indoor air quality. Buyers and renters of buildings will therefore increasingly **demand buildings** to be more **energy-efficient**, as will governments.

There is however a plethora of **market barriers** very often preventing that buildings are made more energy-efficient than conventional practice or required by mandatory **Minimum Energy Performance Standards (MEPS)** (read more in the background paper 'Why policy needs to assist building and appliance markets to become energy-efficient' that can be found in the bigEE Policy Guide). A **well-designed package** of policies and measures is therefore required to overcome these multiple barriers, combining regulation such as MEPS with information, advice, capacity building and financial incentives or financing schemes to achieve higher energy efficiency levels than MEPS. This will guarantee that developers, designers, builders, investors, and users get the right incentives and achieve these high energy savings through energy efficiency. Especially in developing countries, market failures through energy price subsidies often raise further barriers to energy efficiency in buildings as these are then not economically viable. In such cases, our advice to policy-makers is to gradually **remove** such **energy price subsidies** and use a good part of the monetary savings in the state budget to support energy efficiency improvements and the resulting energy and cost savings, particularly for low to medium income consumers.

The **cost savings** from highly energy-efficient buildings are not limited to a single object as they can also be seen on a national and international scale. The GEA (2012) estimated that on a global scale to reach state-of-the-art energy efficiency by 2050, US$15 trillion of undiscounted additional cumulative investments would be needed. Yet this pales in comparison to the estimated return on investment, which was estimated to be in the region of 57$ trillion for undiscounted energy cost alone. This represents on a global scale a potential return of investment of over 400%.

# A strategic approach is the key to high energy savings at low cost.

To effectively reach these goals of energy efficiency in buildings, a holistic package with a strategic approach is needed to reach to high energy savings at low or no extra cost buildings.

The Strategic Approach follows the premise of **first implementing** load-reducing **“Passive Options”** for building design, **followed by** energy-efficient **“Active Options”** for thermal conditioning and ventilation as needed and then **fine-tuning** building operation through **“User Behaviour and “Energy Management”.**


**Figure 5: Reduce, Select, Optimise: An integrated design process.**

Source: Developed by Wuppertal Institute for bigEE (2012)

This **integrated three-step process** can reduce the primary energy demand of a building to low or even ultra-low levels. Adding on-site renewable energy technologies for heating and cooling can turn the primary energy balance of a building to the positive side, with the building becoming a net producer of energy over the year. Figure 6 presents this path to energy efficiency through a strategic approach with two levels of ambition, the Easy Efficiency Approach and the Advanced Efficiency Approach explained below.

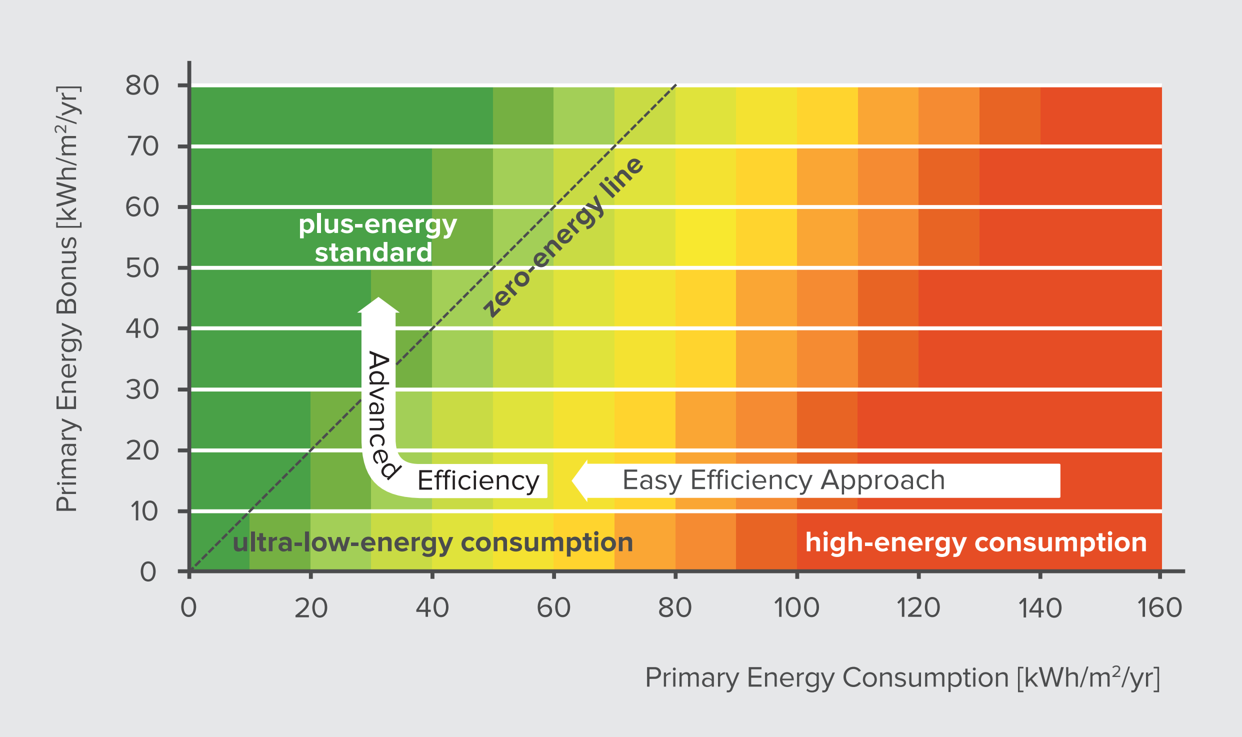


**Figure 6: The path to energy efficiency through a strategic approach**

Source: Developed by Wuppertal Institute for bigEE (2012)

In the short-term, the **Easy Efficiency Approach** should be regarded as the **minimum target.** It focuses on low-cost options, mainly passive options. Although it can already significantly reduce energy consumption, this first step will **not be sufficient** to reach long-term climate protection goals. It is thus necessary to implement and support an **Advanced Efficiency Approach** at the earliest to avoid lock-in effects, which result in new, inefficient houses continuing in use for decades because of long building lifetimes.

Improving energy efficiency in the Easy Efficiency Approach can reduce primary energy demand for cooling, heating, ventilation and domestic hot water by **40 to 60% to achieve a Low-Energy Building.** Improvements in the Advanced Efficiency Approach can reduce primary energy demand by up to **90% to achieve an Ultra-Low-Energy Building.** Further improvements, especially through the use of renewable energies reduce the primary energy demand to nearly 0% or even beyond achieving a (nearly) Zero-Energy Building or a net energy producer Plus-Energy Buildings.

***The key to Energy Efficient Buildings is through a Strategic Approach***

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**bigEE** is an international initiative of research institutes for technical and policy advice and public agencies in the field of energy and climate, co-ordinated by the Wuppertal Institute (Germany). Its aim is to develop the international web-based knowledge platform bigee.net for energy efficiency in buildings, building-related technologies, and appliances in the world's main climatic zones.

The bigee.net platform informs users about energy efficiency options and savings potentials, net benefits and how policy can support achieving those savings. Targeted information is paired with recommendations and examples of good practice.

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