Enlarging the market for low consumption commercial buildings

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Keywords

advanced low energy commercial buildings, building performance, investors' decisions, best practices, building codes

Abstract

In the Europe Union and elsewhere, commercial buildings consume up to 20% of all energy used, causing a rising level of carbon emissions. Despite the presence of building codes, there is little effort and apparent incentives to design and build new commercial buildings with substantially lower energy consumption than required by the codes. This is in the face of a growing body of evidence that low energy buildings are economic to construct, lower cost to operate and more productive.

The paper identifies some recent low consumption non-residential buildings around Europe, which have been operated for a while. The operational results (construction cost, energy consumption and costs, comfort and productivity) compared to the design performance will be presented, along with the technical solutions employed. The paper will discuss the original motivations of the investors, the building occupants and the architects, to create such advanced buildings, and explore whether their expectations have been fulfilled. In particular the paper shows that the traditional power of the architect to drive the game is still strong, but is becoming subordinate to the desires of the developer. Most importantly, it will summarise how architects and developers' experiences may affect their future decisions on other buildings.

By analysing the motivations and the incentives for all players in a very competitive market, the paper discusses ways to motivate the building owners to invest in low energy non-residential buildings. It discusses potential activities to further expand the realisation of cost effective low consumption buildings, reinforcing the potential for the EU industry to be the clear world leader in the design, construction and operation of high-performance building. It will also explore the potential incentives that may exist when the building is a part of a larger, energy efficient wide-area development.

Introduction

In its European Climate Change Programme (ECCP), the European Commission identified with various stakeholders a set of community-level legislative and non-legislative measures to help the European Union meet its Kyoto targets. These measures were identified on the basis of the criteria of cost effectiveness, emission reduction potential, time horizon and political acceptability. The Building Sector was identified as a key sector to improve end-use efficiency, and hence save energy and reduce CO_2 emissions.

In the EU-15 40.7% of total energy demand is used in the residential and tertiary sectors, most of it for building-related energy services. Space heating is by far the largest energy end-use of households in Member States (57%), followed by water heating (25%). Electrical appliances and lighting make up 11% of the sector's total primary energy consumption. For the tertiary sector (see Figure 1) the importance of space heating is somewhat lower (52% of total consumption of the sector), while energy consumption for lighting and "other" (which is mainly office equipment) are 14% and 16%, respectively.

In its Green Paper on energy supply security, the European Commission (EC) called for concrete measures to reduce growth in energy demand, mainly by promoting energy saving in buildings and the transport sector.

The residential and tertiary sectors in the USA also represent about 40% of the total energy consumption, with the major difference that they consume far more electricity than their European counterparts due to the higher cooling requirement. Collectively they represent over 70% of the US national electricity load, and as a result cause proportionally higher greenhouse gases. In terms of efficiency, there is a growing body of evidence that the average building in the USA is significantly less efficient than the average EU building, indicating that benefits outlined in this paper for the EU would even greater in the USA. US homes and buildings contribute not far off 10% of global greenhouse gases, and as such, improving their efficiency has clear global benefits.

According to the EU Green Paper, energy use in buildings could be reduced by at least a fifth by making greater use of available and economically viable energy-efficient technologies. This would represent about 20% of the EU's greenhouse gas reduction commitment. Such savings would also improve the energy supply security and the EU's competitiveness, while creating job and raising the quality of life in buildings. Given the lower average energy efficiency in US buildings, the reductions can be proportionally much greater. The impact of the recent very rapid surge in primary energy prices in the USA is awakening wider interest in energy efficient building. A combination of economic necessity and policies and programmes from states such as California and New York suggest there may be an upsurge in interest in more energy efficient new buildings and retrofits in this vital part of the world energy use.

The Energy Performance of Buildings Directive (EPBD)

Under the principle of subsidiarity, building energy efficiency policies have been left to Member States. This has resulted in a big difference in the type and stringency of building codes, and in particular Southern European countries had very weak and ineffective building codes. The ECCP programme recommended a new Community initiative to substantially improve building efficiency. The new European Directive on Energy Performance of Buildings introduces four major actions to substantially increase the energy performance of buildings across the EU.

The first action is the establishment of a *common methodology for calculating the integrated energy performance of buildings*. Such an approach integrates, in addition to the quality of insulation of the building, heating installations, cooling installations, energy for ventilation, lighting installations, position and orientation of the building, heat recovery, active solar gains and other renewable energy sources. With today's highly insulated new buildings and the trend towards low energy houses, these additional factors play an increasingly large role and shall therefore be included in regulatory provisions.

The second action is to require Member States to *apply the new methodology to minimum standards on the energy performance to new buildings and to certain existing buildings when they are renovated*. This latter is a very important action as new buildings are a small percentage of the total building stock, and this stock is made of many inefficient (old) buildings. The Directive requires that a non-residential building when is renovated is brought to the level of efficiency of new buildings. This is a major action for the energy efficiency improvement.

The third mandatory action is to set up *certification schemes*[1] *for new and existing buildings (both residential and non) on the basis of the above indicated methodology* and to request the public

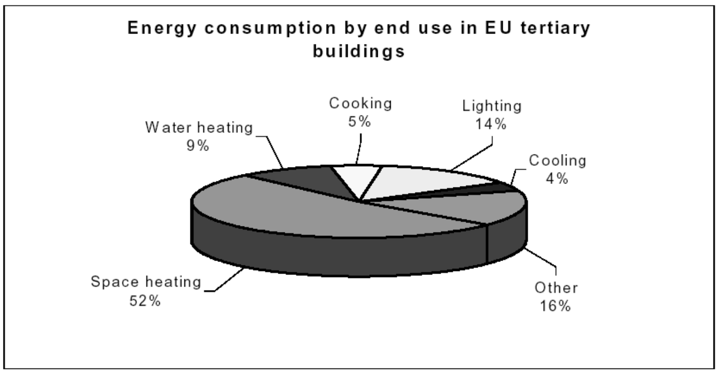

Figure 1. *Energy consumption in the EU tertiary sector.*

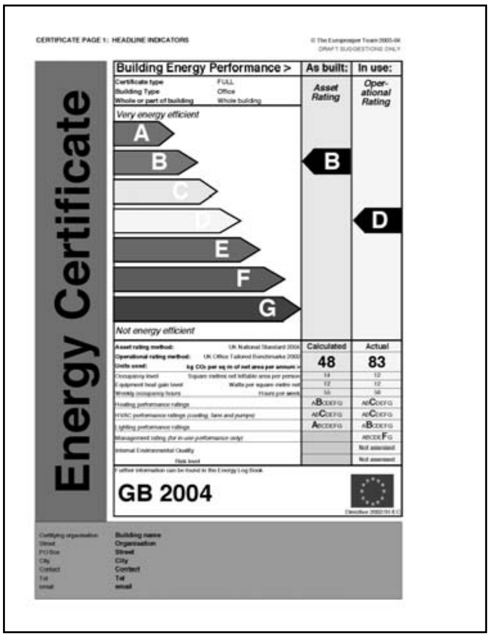

Figure 2. *Example of proposed Building Energy Performance Certificate*

1. One of the main reasons for market imperfections as regards investment in energy efficiency on the rental market is the fact that the owner and renter of a building, dwelling or office have different interests. As the renter normally pays the energy bill, the incentive for the owner to invest in energy efficiency is weak. The best way to make these investments more attractive is to provide clear and reliable information to prospective renters. Clear information will influence the rent that can be asked and therefore will be an incentive for owners to make investments in the energy efficiency of buildings and houses. Therefore, to facilitate the transfer of this information on the energy performance of buildings and apartments, energy certificates for new and existing buildings and dwellings shall be available when these are constructed, sold or rented out.

display of energy performance certificates and recommended indoor temperatures and other relevant climatic factors in public buildings. The certificate format is left to Member States and in some countries it may have a similar look to the well known energy label for residential appliances.

The fourth mandatory action requested to Member States is the establishment of *regular inspection and assessment of boilers and heating/cooling installations*. Heating installations are recognized to be a key issue as regards energy efficiency.

The fifth action is that before the construction of new buildings, the technical and economical feasibility of "alternative" supply systems, i.e. renewable energies, district heating, cogeneration, heat pumps in some cases, must be checked within the planning process.

The GreenBuilding Programme

Among the non-legislative measures identified in the EC-CP, three concern pan-European voluntary programmes for encouraging companies to commit themselves to using energy wisely in order to save money, protect the environment and get public recognition.

One of these measures is the promotion of the European GreenLight Programme. GreenLight has been running since the year 2000. It is a European voluntary programme whereby public and private organisations commit to adopting energy-efficient lighting measures when these are profitable and maintain or improve lighting quality. Major players have joined GreenLight and the programme has now taken off (Berrutto et al. 2002).

A second measure is the introduction of the Motor Challenge programme whereby industries commit to increasing the energy efficiency of their motor driven systems (Bertoldi 2001). This programme was launched in February 2003, after a pilot phase of two years.

Finally, the ECCP proposes a third voluntary programme which consists in the expansion of the GreenLight programme into a GreenBuilding Programme (GBP), covering additional energy end-use technologies rather than lighting alone. The GBP is a new voluntary programme expected to start in early 2005. It is meant to help overcome some of the barriers to energy efficiency – in particular the lack of interest and information – by providing public recognition and information support to companies and public organisations whose top management is ready to show actual commitment to adopting energy efficient measures in buildings.

Participation in the GBP starts with the submittal by the top-manager of an action plan defining the scope and nature of the company's commitment. The company's action plan must be based on the results of an initial energy audit, which identifies profitable energy-efficiency measures, and provides also baseline data for independent ex-post evaluation of the actions carried out. Based on the audit results, the company's action plan must define the buildings at which energy efficiency actions will be undertaken (eligible buildings are those owned or on long-term leases). It must also identify, within the chosen sites, the energy services (space heating, lighting, water heating, ventilation, air-conditioning, office equipment, etc.) and the specific measures to which the commitment applies. While the GBP must be sufficiently flexible to accommodate diverse situations, general requirements will be enforced so that the Partners' commitments have meaning.

If its action plan is accepted by the EC, the company is granted the status of Partner. Partners are expected to report annually on their progress; in return, the EC provides them with public recognition for their effort in protecting the environment. The programme must last at least 5 years to allow Partners to carry out their improvements. The EC renews Partner status every year, upon review of the annual report. If the implementation of the company's action plan is notably weaker than agreed upon, or if the company does not honour its reporting commitments, the Commission reserves the right to terminate the company's participation in the GBP. Also, Partners on their side can withdraw from the programme at any time without penalty.

An implicit goal of the GBP is to transform the way organisations make decisions about investments in energy-efficiency. These decisions have traditionally been low priority, have not benefited from information and analysis, and have had low visibility within an organisation. A critical element of the GBP is to elevate decision-making about efficiency in buildings to senior corporate officials. Partners in the GBP are required to learn how to make profitable building upgrades a priority. They must make decisions based on up-to-date information and proper analysis, and advertise their accomplishment both within and outside their organisation.

The Commission provides support to the Partners in the form of information resources and public recognition. Public recognition takes several forms: articles in the business press and technical magazines; presentation at various fairs and conferences across Europe; regular newsletters; brochure and catalogue of success stories; GBP plaque to allow Partners to show their responsible entrepreneurship to their clients, European award for particularly progressive Partners; etc. The GBP will be complementary to the Building Energy Performance Directive as it will stimulate additional savings in minor refurbishment, as well as anticipating the requirements of the Directive. Moreover the GBP will provide a useful platform for the diffusion of energy services and ESCO services, and important techniques and concepts such as M&V (Measurement and Verification), energy audit, and energy management.

The GBP builds on the lessons learned in two previous EU voluntary schemes: GreenLight and Motor Challenge (http://energyefficiency.jrc.cec.eu.int). The GBP focuses on the existing stock of buildings as it represents the largest potential for improving energy performance in the short and medium term. It ought to be catalysed by the recent building directive, which will raise building owners' interest in energy efficiency. It is expected to start with 100 charter Partners in its first year and 30 more new companies every year as the programme gains public image. The GreenBuilding programme aims at linking business to the efforts of society. It is designed to be flexible and open, so as to be applicable to the great variety of user situations. It is sufficiently precise to ensure that companies that carry out the commitment will achieve a significant part of potential energy savings. It is also adaptable to the large variety of national and European programmes.

Previous experience has shown very clearly that most companies considered any form of corporate commitment with much caution, considering in particular the fear of humiliation if they should fail. Having them define the scope of their commitment turned out to be a better marketing strategy than imposing one on them. In GreenLight, the early versions of the agreement asked companies to commit themselves to carry out at least 50% of all the profitable upgrades. In later versions of the agreement the phrasing was reworded. A company can now join the GreenLight Programme only for a specific site(s). In this case the site(s) has to be clearly indicated in all the communication material relating to the GreenLight Programme. More sites can be added to the company commitment and it is always possible to move from a site partnership to a corporate partnership or vice versa.

The same flexibility will be offered in the GBP, with companies defining their action plan themselves by selecting the cost-effective measures which justify from their viewpoint the allocation of financial and human resources. However, while the GBP must be sufficiently flexible to accommodate diverse situations, general requirements will be enforced so that the Partners' commitments have meaning. For this reason, the GBP contains Modules defining the technical nature of an appropriate commitment for each energy service covered in the programme. The modules are complemented by a "Management Policies" Module containing general principles and proposing tools which can aid in making energy efficiency an element of management priorities, at every step of the life cycle of buildings: building design; choice of components; installation of systems; ongoing operation and maintenance.

Barriers to energy efficient investments in new buildings

Research has shown that there are several reasons why energy-efficient technologies remain overlooked despite their profitability: lack of appropriate information; low priority given by building owners to energy efficiency; requirements for short paybacks; insufficient capital; split incentives; etc.

Energy efficiency has low priority in a building project. The various conditions that affect the energy management of the building are seldom focused, and the actors sometimes have low competence of energy efficiency issues. There is also a lack of coordination between the various professions in building projects. Architect and engineers tend to work on separate issues: architects on the overall conception and design, while engineers on the technical solution for the various services such as lighting, HVAC, control, etc. The building codes have to be made more specific to energy efficiency requirements. Last, but by no means least, there is a plethora of myths surrounding high efficiency buildings in terms of high costs, difficulty, lack of attractiveness, lower resale values etc. despite substantial evidence to the contrary. These are deeply engrained in the market behaviours to the extent that they are frequently never challenged, even by players who would profit from higher efficiency buildings.

The main market mechanisms in a building project are (Burud 2004):

- The project must be attractive in the market.
- The construction costs.
- Building codes.
- Customer attitudes.

All of these mechanisms and a multitude of other factors affect the energy efficiency and eventual energy consumption of commercial buildings.

Low Energy Consumption Buildings

The primary energy consumption of a new office building can be lowered by 70% just by using the energy saving measures available at the market today. This is the result of a theoretical investigation carried out at the Institut Wohnen und Umwelt (IWU) at Darmstadt, Germany. But not only the environment benefits of an energy "efficient office building". An economic assessment shows that high efficient standard is even profitable. So the "efficient office building" meets both ends: the requirements of the environment and the economic interests of the investors (Knissel 2004).

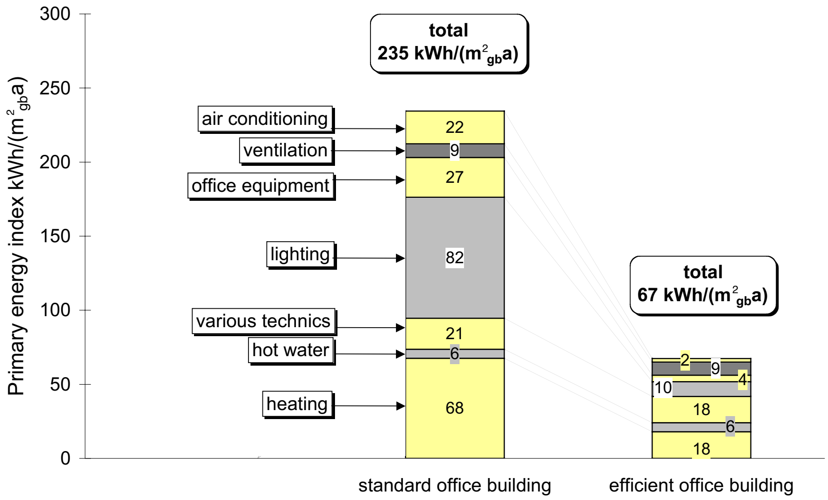

Figure 3. *Calculated cost-effective reduction in energy consumption per end-use (per gross building square metre per year)*

There is a hierarchy and stringent sequence of measures in a office building to be taken in a economic feasible project, otherwise either is not possible to reach very low energy consumption levels or it would be too expensive to achieve then. As an example the following measure and limits should be achieved:

- Low internal heat load through very efficient appliances, electronics and lighting, low stand-by.
- Excellent thermal transmission insulation of walls (U 0,2..0,3 W/m² K), windows (0,6.. 0,8), roofs (0,2), etc.
- Excellent motorized and automatically controlled (> 150 W/m²) exterior shading (g< 0,1).
- Low fresh air supply (n> 0,5) with replacement system.
- Transport of heat and cold in water (not air) systems (some times included in mass: concrete slabs).
- Max winter heating load 10 W/m².
- Max summer cooling load 10 W/m².
- Max lighting load 8 W/m².
- Domestic hot water with waste heat from cooling or solar systems.
- District heating and cooling

Of course this can be reached with various design schemes (interior courts, double facades, etc.) (Brunner 2004).

The primary fuel consumption will be further reduced if the building is being developed as a part of a site plan that incorporates an optimised energy supply plan making maximum use of distributed generation with co-generated generated heat meeting some of the heating and cooling needs. Such an integrated approach can also be a mechanism for optimising investments between the building developer and the wider community.

In simple terms, more efficient buildings need smaller (i.e. lower cost) plant to heat and cool them. If heating and cooling is available as a network utility, even less plant is needed in the building.

This can free up initial capital to create more efficient building shells and create a virtuous cycle that ties efficient buildings to efficient, optimised supplies, at lower investment costs to the developer, the utility and the wider community.

This discussion is probably broader than this paper, but calls out for a rigorous examination of the urban zoning and municipal utility structures. The failure to monetise efficient demand and efficient supply for both the property developer, utility and the wider community is a major market disincentive that needs to be addressed. Europe's best municipal multi-utility energy suppliers in cities such as Frankfurt, Vienna, Mannheim, Copenhagen etc, can be pointers for other parts of the world on successfully capturing the synergies between fuel efficient energy supply and energy efficient buildings. This aspect is almost totally absent from US cities, though it is interesting to see a growing interest in the best of the EU "Stadtwerke" model in major urban redevelopments in places as far apart as California, New York, and South Carolina.

While computer simulations of low energy consumption buildings have shown the potential for many years, more examples are now being built and demonstrated to show the potential. There have been a number of recent efforts to document the actual performance of buildings to demonstrate the lessons learned in these buildings, and a number of papers were presented at the IEECB 04 conference. Several key examples are highlighted below.

Success factors to reduce primary energy demand in advanced office buildings

EXAMPLES FROM THE CITY OF FRANKFURT

Until the year 1990 high rise office buildings have been constructed with a totally closed façade combined with internal heat-, ventilation- and air conditioning- (HVAC) systems. In the past it has been the main guideline that office rooms should be independent of the outside climate and weather conditions. The Frankfurt Fair Tower (next to the Frankfurt fair) constructed at the end of the 90ties, seems to be the last high rise building of this "generation" of office buildings. The façade is closed airtight and there is an air conditioning system with induction air inlet together with a four-rod static heating and cooling device. But there was no central energy management system and users could heat and cool simultaneously in the same room. A black sun shading at the inside of the window sometimes acts like a solar collector, not keeping heat outside, but in contrary heating up the office rooms. At the opening of the building, the design temperature was set to 21°C for summer and winter. All these features cause a very high energy demand for heating and cooling. (Meanwhile some of these mistakes have been corrected). Nevertheless, the supply of energy is rather efficient, by steam transmission from a local CHP station, combined with absorption cooling. This is a good example where the total impact of even sub-optimal energy efficient building is reduced by being a part of a city wide multi-utility energy system, especially in terms of greenhouse gases.

A main factor towards the construction of an energy efficient office building is to implement the aim of a reduced energy demand from the very beginning of the planning, wherever possible including consideration of overall efficiency of the energy supply system. The question, "does this help to reduce energy demand, and/or energy costs" should be raised in every planning step, as the architectural competition, the improvement of architectural proposals as in all other steps of technical planning. This means, that the investor (bank, insurance, investment company) and their representatives should be highly convinced, that an energy efficient building is feasible, can be realized and will be an important factor to reduce future running costs, will make the building more attractive for renting and will be an important factor for the presentation of the company to the public. In all buildings, which will be presented in the workshop this condition has been fulfilled. This is an area ripe for developer education in training them to the challenging questions for their architects, general contractors, and even municipal utility partners.

Figure 4. *The “Commerzbank-Tower”*

Another factor is the commitment of the City towards climate protection. The City should give a signal to investors, that energy efficient buildings are welcome and that the City will offer new supports to reach this aim. In the year 1990 the City of Frankfurt on the Main joined the network of the "Climate alliance of European cities" – (an alliance of more than 1000 cities in Europe) as a founding member. This City network has set up the objective of reducing the CO_2 -emissions by 50% until the year 2010. Therefore, it has attached great importance to ensure that new buildings have a low energy demand. The City of Frankfurt has set up an “Energy Forum – Banks and offices” in year 1992. The city has organized a “Facility Management Forum” later and today the City of Frankfurt – Energiereferat organizes “Benchmarking Circles” for Investors to compare the energy demand of new and existing office buildings, where the possibilities of reducing the energy demand is discussed with the energy managers of several office buildings. (www.energiereferat.stadt-frankfurt.de)

The “Commerzbank-Tower”

Starting in the year 1992 there have been several plans for new high rise buildings. The Commerzbank, one of the biggest German banks, has set up the goal for an energy saving and ecological building as well. It became clear, that the main issue of ecology in office buildings is the energy demand.

An important architectural means to reduce energy demand has been the development of a new façade. The windows can be opened to let fresh air in. If the window is opened, heating, cooling and ventilation devices will be automatically shut off, resulting in a reduced energy demand. The facade has an unglazed wall base, which has better insulation than glazing and reduces heat from the sun. The window consists of two window-panes, whereby the inner one may by opened and between the inner and outer pane air may circulate, thus dissipating heat in summer. Between the window-panes a variable blind can control light and reflect outer heat. In comparison so-called "solar facades" may produce more cooling problems by capturing solar heat than they solve. The window can be controlled individually by the employees and in case of stormy weather all windows will be closed automatically. The energy demand is controlled by a responsible energy manager and subcontracted companies. In the final outcome, it turned out that the highest office building in Europe has been designed with an energy demand 30% less than in the first planning stage. The building owner doesn´t want to call the building a “low energy building”, but the Commerzbank building is one of the most efficient high rise buildings constructed in the early 90ties.

About 8-10 years after the construction of the Commerzbank building, the electricity demand has been analysed in an “energy controlling workshop” organized by the Energiereferat. It turned out, that still there are saving potentials, i.e. due to oversizing of uninterruptible power supplies.

In the year 2003 in the Commerzbank building the local utility MAINOVA AG has organized “Energy Saving Weeks” for the employees of the Commerzbank. The Energy Saving Weeks addresses the change of behaviour of the 2000 employees by motivating them to reduce the electricity demand, i.e. by turning off the light, closing windows, shut down computers and monitors etc. The Energy Saving Week was originally developed in Switzerland and was adopted in Frankfurt by an Energy consultant (www.qualite.de) supported by the “Frankfurt Energie subsidy program” funded by MAINOVA AG and E.ON Energie AG. After the “Energy Saving Weeks” about 9% of the total electricity demand was reduced just by behaviour changes. In absolute terms: The electricity savings in the office areas have been 6400 kWh over the two weeks, which would result in a total annual reduction of about 180 MWh (12.000 Euro). The MAINOVA AG supports the Energy Saving Weeks with a subsidy of 25% of the organizational costs.

The new building of the Helvetia Insurance

The new office building of the Helvetia insurance company in Frankfurt was designed as a low energy office building as one of the important objectives. The outer façade is completely glazed with a triple pane glazing. The type of glazing reduces the transmission of infrared light and is sufficient for daylight use. This type of glazing reduces both heat losses in winter and heat gains in summer. The mean u-value of the façade is u < 0,9 W/m² K. The building has no separate heating and cooling system. Heating and cooling supply are integrated in a system of long tubes distributed in the concrete of the floor and the ceiling. (“Betonkernaktivierung”- thermoactive ceiling) Water flowing through these tubes has only a little temperature difference to the wanted room temperature (+ 3°C in winter, - 3 °C in summer). Due to the big surface of heat exchange and the heat capacity of the concrete this system ensures a smooth, self regulated heating and cooling at a very low level of consumption based on the good insulation of the building. The heat energy demand of the Helvetia building is only 25 kWh/ m² *year compared to a typical value of 150-200 kWh/ m² *year in other office buildings. The electricity demand is 13 kWh/ m² for lighting and 12 kWh/ m² for office equipment. Obviously there are high efficient lighting systems with direct/indirect lighting and the primary energy is only about 120 kWh/ m² *year including office equipment. Some hundreds of measurement devices document the temperature and energy flows in this building. The additional costs for measurements were financed by the “Frankfurt Energie subsidy program”. It should be noted, that this program was structured to be able to support additional investment costs for energy savings. But in the Helvetia building the total investment costs turned out to be lower than for a conventional office building with higher energy demand. Therefore the subsidy was given for a very detailed measurement program of energy flow and comfort parameters. The results of the measurements can be found at: www.helvetia.de/Ueber_uns/Bau

Figure 5. *The building of the Helvetia insurance company in Frankfurt*

The "Ost-Arkade" of the KfW-Bank

Another new office building in Frankfurt, built recently, has a target to have a primary energy demand of only 100 kWh/m² *year (office equipment not included). The building has 10 000 m² with 350 employees and 19 dwellings. This aim was set up by the KfW – Kreditanstalt für Wiederaufbau (German credits bank for reconstruction), which is today the most important federal based subsidy credits bank of Germany. The KfW offers credits with low interest rate for enterprises and private persons for environmental projects, energy saving , CO_2-reduction and renewable energies. Now the KfW has decided to implement energy saving and renewable energy in their own new office building. There is an optimized façade, windows can be opened, efficient lighting systems and efficient office equipment are combined with an effective shading system. There is no active ventilation system, because air can flow through windows to the floors and leave the buildings via an internal atrium space. High comfort can be reached with very low energy demand. Additionally the heat will be delivered from a wood pellets boiler, which will provide 100% CO_2-free renewable energy from wood pellets, not taken into account in the calculation of primary energy. This is the first pellets-boiler in an office building with this size. Additionally there is an ecological concept with use of rain water, no materials with PVC and a photovoltaic plant on the roof. A main success factor was, that the aim of a primary energy demand below 100 kWh/m² *year was set up at the beginning of the planning. Specialized engineer consultants were responsible to survey the planning and to calculate the future energy demand though all planning steps. Air flow and illumination have been simulated with computer tools. Detailed information is available at: www.solarbau.de/monitor/doku/proj15/mainproj.htm.

Figure 6. *Outer view of Ostarkade KfW- Frankfurt am Main*

Summary of the Frankfurt examples

These examples from new office buildings in Frankfurt show that there is no single solution or technology to low energy office buildings, but if the investor wants to have a low energy building, all different building designs of architects can be transformed to a low energy level, if energy efficiency is integrated since the design phase and all buildings components are integrated in the low energy concept. A main success factor is to set ambitious energy demand aims at the beginning of the planning and to control how this aim is reached continuously during planning. New office buildings can have an energy demand less by a factor of 4 compared to the average of existing office buildings with a high comfort level and a representative architecture (Neumann 2004).

OTHER GERMAN EXAMPLES

The International Solar Centre

The International Solar Centre is a unique development in Berlin combining a historic building and contemporary architecture to create 22 200 m² of customised office workspace and the Berlin Energy Forum exhibition area, for companies and organisations active in the growth markets of

Figure 7. *The International Solar Centre (Source Hanseatica 16. Grundbesitz Investitionsgesellschaft mbH & Co. KG)*

renewable energy and energy efficient consumption. The building promotes a sustainable energy economy achieved through an innovative energy concept. The aim of the concept is to realize a low-energy standard, taking particular account of renewable and rational energy conversion technology (Fish 2004).

This concept comprises a high thermal insulation of facades and windows, innovative glazing and shading systems and a natural ventilation system during summertime. For the heating period an energy efficient mechanical ventilation system with heat recovery is activated. About 20% of the heating demand and 100% of the cooling demand is covered by a seasonal heat storage (200 energy piles) underneath the building which is combined with a heat pump and a concrete core heating and cooling system. Photovoltaic panels with an area of 500 m^2 and an electric peak power of 55 kW will produce an estimated 46 MWh per annum. A small fuel cell will demonstrate the possibilities of future domestic energy systems. The aim of the concept is to realize a low-energy standard with a primary energy demand of less than 100 kWh/(m^2a). The characteristic energy values of the building comprise the heating demand and the electric demand for heating, cooling, ventilation and lighting. The energy consumption of the office equipment like computers, printers and photocopier is excluded.

The Post Tower in Bonn

For their new headquarter building in Bonn, Germany, the Deutsche Post AG decided to go for a building concept which ensures a very high comfort and working space quality for each employee and at the same time reaches these conditions with the lowest possible energy input. This building, developed by a design team behind Murphy/Jahn including Werner Sobek Engineers and Transsolar Energietechnik, is not using the well known double facade concept as an add-on but the whole comfort and energy concept relies on this (Auer 2004).

The building is not only 70% but 100% of the year ventilated by the double facade, which excludes an additional central mechanical ventilation system that other examples of well known double facade buildings have installed. The typical office floor uses the double facade as the intake air distribution and the inner sky gardens as exhaust collection, which allows to skip all vertical air distribution shafts, a major point in respect to the building's efficiency. In addition one mechanical floor was saved by this ventilation concept, using decentralized air intake units in the standard under floor convectors. All these savings could be used for covering the additional costs in the facade construction. The comfort and energy concept is mainly based on the use of local natural cooling sources like ground water and night cooling. Through the controlled external skin, every user up to the 40^{th} floor can decide when he wants to open his window and the function of the shading is ensured. As a result of the collaboration of building envelope, building structure and building environmental system, the energy demand of this building is predicted with less than 100 kWh/m^2a for heating, ventilation, cooling and artificial lighting. The building will have complete multi-parameter monitoring system.

The Solvis Zero Emission Factory

This is an example of a factory, which includes production facilities and office space. The design target values for heating consumption of 40 kWh/m^2 and an electrical consumption of 20 kWh/m^2a. for the building facilities are considerably lower in practice. the primary energy consumption being 90 kWh/m^2a. The buildings use low energy equipment (office equipment, lighting, ventilation, etc.), it has a good thermal installation standard and an efficient ventilation plant with heat recovery in the production areas. Thermal insulation in summer in the offices is guaranteed by an external two-part heat protection. A reduction of the g value is achieved by using triple heat protection glass. In addition, the opening parts of the windows are designed as wooden panels with vacuum insulation, so that a reduction of the heat yield in summer is achieved without increasing heat losses. The heat yield in summer is reduced considerably by means of a consistent reduction in internal loads, e.g. by performance management in electronic data processing and by demand-oriented lighting controls. The heating is supplied by a rapeseed oil combined heat and power (cogeneration) plant (180 MWh/a.) ,a collector plant (20 MWh/a.) and by the heat waste from the development department (20 MWh). The electricity demand is also covered by a 60 kW

Figure 8. *Post Tower in Bonn Source: Anja Thierfelder, 2003*

Figure 9. *The Solvis Zero Emission Factory (source Banz + Rieck Architekten)*

PV plant (45 MWh/a.) and by the rapeseed oil chp plant (115 MWh/a). The excellent thermal insulation as well as the consistent planning and implementation of low-energy building facilities means that the new production building of the company Solvis can be completely supplied using regenerative energy sources and in the future will become a zero-emission factory with CO_2-neutral rapeseed oil production. (Riecks 2004)

OTHER EXAMPLES

Wessex Water Operations Centre

The building and grounds occupy a 3 hectare, previously developed site. This 10 000 m², two-storey headquarters building on the outskirts of Bath utilises cutting-edge sustainable design and construction techniques. The building is E-shaped, the three parallel legs being open-plan, naturally ventilated offices, the long spine providing the main circulation route. A 'light' steel frame with exposed pre-cast concrete floor units provides an open, spacious feel to the buildings. The southern façade comprises a double-glazed curtain wall system. Solar shading is provided by steel and aluminium louvres or screens. The building is designed and oriented to 'blend' into the natural landscape to minimise its visual impact and to promote natural ventilation. External solar shading is used to minimise internal thermal gains while providing natural lighting deep into the buildings. The lightweight steel structure is used with pre-cast coffer slabs to provide a resource efficient building with enough thermal mass to benefit from night cooling. Offices are naturally ventilated to minimise the use of mechanical ventilation and cooling. The building is heated by a combination of solar water heating and condensing boilers. The target energy consumption is 33% below current best practice. Overall, the building provides a high level of occupier comfort conducive to quality and efficient working. The energy consumption being monitored for long term evaluation of results.

Figure 10. *Wessex Water Operations Centre*

Discussion

In understanding the actual performance of low consumption buildings, it is important to be certain that the data being viewed are correct for comparison. In many cases there is confusion about whether energy use intensity (EUI) data, usually presented in $kWh_{equivalent}/m^2$, was the delivered (site) energy consumed by the building or the primary (source) energy which included loss and conversion factors for the energy used in the building.

Homes and Buildings are the third (in the EU), and the second (in the USA) cause of greenhouse gases, and it is important to include a Greenhouse Gas Intensity Index (g/m2/year). As carbon emissions gain market value, this will be a powerful design parameter, and will naturally focus at least a part of the building efficiency debate on the efficiency and structure of the energy supply.

It would be very helpful to agree on "conventions and processes" for reporting energy performance data. Reporting delivered $kWh_{equivalent}/m^2$ is most valuable and has less data reliability issues from uncertainty about conversion factors used, though many people argue that primary energy is the better measure. Due to the confusion in comparability of data, when primary energy data are presented, it is most helpful if the conversion factors and assumptions for any other "normalizations" are included. Additionally, it is best to keep thermal and electrical energy intensity data separate as far along the reporting chain as possible, to make it easier to convert to/from primary or delivered as required. However, when the thermal strategy of the building can be met by changing from electrical to thermal services as in the case of cooling, there is a strong case to normalise all energy use to an equivalent energy unit.

The EU energy performance certification process has the potential to be a powerful tool in the financing chain. A well structured document, such as the one being recommended by Denmark and the UK, among others, brings the potential operating cost and competitiveness of the building into a simple, easily understood form. There is a case for making these a mandatory part of the financing approval documents for either a new construction or major renovation. Including them as a part of rental agreements also puts economic pressure into the market. Some Australian cities are moving in this direction, and are finding that more efficient property sells and resells at higher prices, creating the most basic incentive for the developer to build efficiently. The certification also put the potential between "as calculated" and "as used" efficiencies in a simple, transparent way. Again, the EU is showing considerable leadership in this direction, and should follow through and bake it into the commercial transaction.

Conclusions

LOW ENERGY CONSUMPTION COMMERCIAL (OFFICE) BUILDINGS HAVE BEEN CONSTRUCTED AND OPERATED IN THE EU; AND THEY HAVE PROVEN THAT IT IS FEASIBLE TO REACH LOW ENERGY CONSUMPTION TARGETS

There are some very good examples of low energy consumption commercial (office) buildings, especially in Germany. A major result is, that the reduction of consumption of primary energy is not only some percent, but new buildings have reduced consumption by a factor of 3 to 4!

In many cases low energy office buildings have lower investment cost than conventional ones, especially where supply efficiency can be integrated or natural cooling is used. Where the initial cost of the efficient building is greater than the normal market practise, these additional investment costs invariably turn out to be economical within the expected lifetime of the buildings, even on the assumption of constant energy pricing, a totally unrealistic assumption. In some cases, as with the Helvetia Building, the high-performance solution turned out to have even a lower initial cost.

BUILDING OWNERS AND INVESTORS ARE HAPPY

There is growing evidence on both sides of the Atlantic that the occupiers in high-efficiency buildings are happier, and significantly more productive. This aspect has not been explored in this paper, and the writers recommend the data being developed by Intelligent Buildings team at Carnegie Mellon University, Pittsburgh, Pennsylvania, among others, as good further reading. The value of the productivity normally outweighs the operating savings for the pure energy costs Lower energy costs are combined with a good or even better comfort and substantially increased employee productivity. Thus investors and occupants are both happy with these buildings.

WHY ARE SUCH A KIND OF BUILDINGS STILL AN EXCEPTION AND NOT THE STANDARD?

a) A main obstacle is the investor/user dilemma. The experience shows, that most of the low energy buildings have been ordered and are used by the same company. In the "free" market of investment companies for office buildings, the rules are that a building, which is for sale or rent for future users, which are unknown at the time of planning and construction, must cover all possible future requirements. And this should be realized at least investment costs. In this case, energy demand is not a main feature of the planning.

b) Energy demand is not a main argument on the energy market, mostly because energy costs are not known before construction of the building. This hopefully will change with the implementation of the EPBD including energy labelling of office buildings and the demand that energy aspects have to be taken into account from the first step of design, via construction towards facility management of existing buildings. Incorporating energy labelling in contracts will accelerate the changes.

c) The planning process is highly separated and segregated into different planning aspects: The facade mostly is only treated under aesthetical aspects and it is not seen as an integral component of the energy performance of the building. Facade (heat losses, heat gains, shading), lighting, ventilation are treated not in an integrated manner. The new CEN standards (Germany DIN 18599) may help to force engineers and architects towards an integrated planning.

d) Not only economical aspects are important. The construction of office buildings with glass facades give cause for discussion in Germany, that these buildings have rather bad comfort with high temperatures (not only in the hot summer of 2003). Because of this, today architects and investment companies fear that a building will not meet the tenants requirements (thus leading to high energy demand) should be overcome, by showing that this obstacle could be solved, by constructing buildings which will meet all the user needs, have good comfort and are low energy buildings

e) The inertia of the entire construction chain, and the power of the negative mythology around energy efficient buildings is stopping many discussions on potential energy efficient buildings even before they begin. These need to be confronted, challenged and overturned.

THE WAY FORWARD

The authors consider that additional and innovative policy and programmes have to be deployed to make sure that new low consumption buildings become common practice in the building industry and investors' portfolio. Although the EPBD will be a major step in this direction (and very much needed and awaited for a long time!), other additional policies and programmes are urgently needed if we want to contribute to climate change. The author recommendations include:

Information & awareness raising activities

There should be more presentations and documentation of realized projects (www.solarbau.de/) combined with training and education campaigns, visit tours etc. Organizing open "dialog forums" on construction and experience of low energy buildings is essential. (www.ip-building.de/). Particularly important are user and financial testimonials, with maybe less emphasis on the technical and environmental aspects.

The energy productivity proponents be they legislative, technical or non-profit NGO's have to simplify their language and stop trying to turn the construction industry into energy and climate change experts. All the property developer needs to know is that cost to construct is acceptable, that the resale price or rental prices will command a premium, the building will create more value added through employee productivity, and the property will sell faster, or be vacant for shorter times. That it may also attract favourable public opinion and maybe public interest grants and subsidies is gravy.

Training & education

Training and education of architect and engineers to make include energy and comfort consideration in every step of the building design and construction process. They should also be trained to consider aesthetical, functional and energy issues all together.

Supporting industry & companies

The European building industry is a world leader in construction and development of low energy buildings, this industry needs to be encouraged and helped by disseminating the remarkable achievements. Investors and developers that have embraced the concept of low efficiency buildings need recognition. The new European GreenBuilding programme could be a good vehicle for this effort.

Research & Development

There are still a range of new and innovative building technologies, including alternative cooling technologies, renewables and on-site poly-generation. Support to the further development and demonstration of these technologies is needed in large R&D programmes such as FP6 and the future FP7. Also the continuous monitoring of energy performance of new building are needed, to make sure that the initial setting and operating conditions are not changed by the users. Re-commissioning programmes have to be launched to keep these buildings operating at the designed high efficiency. Last but not least international monitoring and benchmarking scheme based on real energy performance of buildings under operation shall be developed.

Innovative Financing Mechanisms

This including the use of ESCO, TPF and Energy Performance Contracting. Banks shall take into account the future energy performance of the building in their economic evaluation of new building project. M&V tools (e.g. the IPMVP new building protocol) shall be common practice in building project financing. Contracts have to include mandatory energy performance certification

City Zoning

City zoning laws that include energy supply and building efficiency aspects – as an example the City of Santa Monica in California is applying higher efficiency standards for new downtown developments that they require elsewhere in the State.

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