Energy efficient office buildings

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SUMMARY
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 an the economic interests of the investors.

TARGET AND PROCEDURE
The possibility to reduce the heating demand of dwellings by more than 80 % was shown in the year 1991 with the construction of the first passive house in Central Europe [Feist 1996], [Feist, Werner 1994]. Up to now more than 1000 passive houses were realised with success.

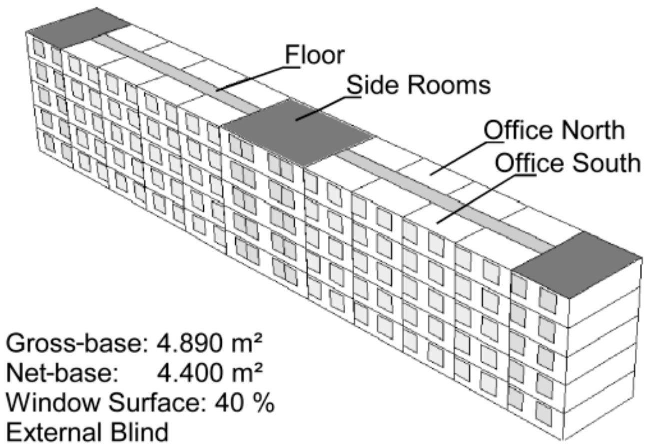

Figure 1: Outline of the examined building

In the investigation introduced here [Knissel 1999] the question was examined, whether such an efficiency increase can be realised in office and administrative buildings as well. So the energy consumption of an example building (Figure 1) was calculated for five different energetic standards. Two of the five variants are shown in the following.

1. Standard office building: The insulation corresponds to the minimum requirements of the thermal protection ordinance (Wärmeschutzverordnung) 1995. Measures to the efficient current use aren't taken up.
2. Efficient office building: It shows the best efficiency standards available at the market today.

The “efficient office building” differs from the “standard office building” in the following points:

- Very high insulation standard of the building cover
- Very low electricity consumption of the equipment and lighting
- No active cooling, humidification and dissecation
- Heat and humidity recovery and an earth tube exchanger.

The energy consumption of the variants are calculated by dynamic building simulations with the program “TAS”. For the simulations the weather data of the test reference year No. 6 (Frankfurt am Main) are used as climate condition.

	Gas	electricity (mix)
Primary energy factor kWh_{Prim}/kWh_{End}	1,07	2,97

Table 1: Primary energy factors by [Gemis 3.01]

For the energetic assessment of the building both, fuel and electricity consumption, must be taken into account. This can be done by calculating the primary energy consumption. Therefore the gas and electricity consumption is multiplied with primary energy factors (Table 1). These factors were calculated by using the program Gemis (3.01).

The primary energy index is calculated by dividing the primary energy consumption by the gross base of the building. The energy index of a building consists of various single positions. To reflect the consumption structure, the single positions are divided according to the recommendations of the Swiss engineer and architects organization SIA 380/4.

PRIMARY ENERGY SAVING

For the two variants the annual primary energy requirement is calculated by using dynamic thermal simulations. The whole primary energy value of the building as well as the division on the different positions is shown in Figure 2.

By the increase of the energetic efficiency the primary energy requirement of the examined example building can be lowered from 235 kWh/(m² a) to 67 kWh/(m² a). This corresponds to a reduction of about 70 %. In the following it is briefly outlined how the savings are reached. The text concentrates on the important positions. A detailed description is found in [Knissel 1999].

<u>Heating</u>

The primary energy consumption for heating of the efficient office building is only 18 kWh/(m² a). Such a low value is reached by

- Insulation thickness between 30 cm to 40 cm
- Triple thermal protection glazing together with high-insulated window frames
- a ventilation plant with efficient heat recovery and an earth tube heat exchanger.

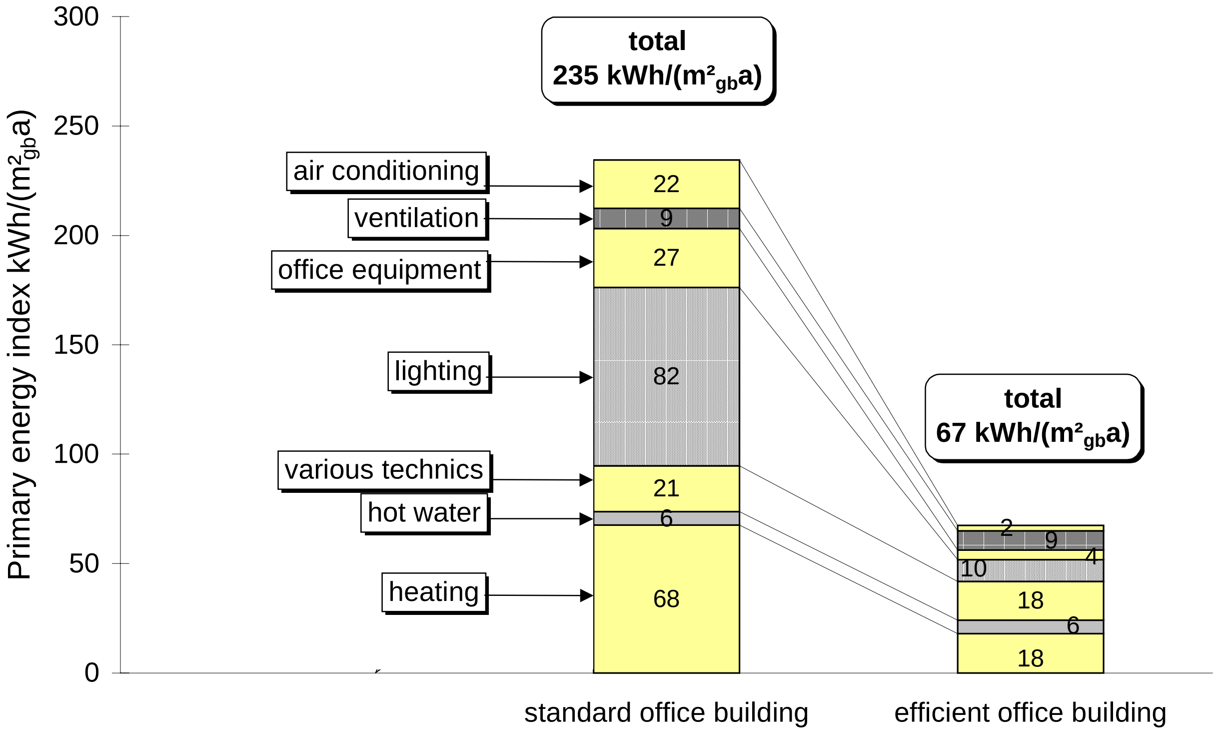

Figure 2: Primary energy index for the “standard” and the “efficient office building”

The positions “hot water”, “various technics” and “ventilation” are not discussed

<u>Lighting</u>
About 50 % of the total primary energy savings appear at position “lighting”. This is realised by

- high-efficient fluorescent lamps
- A lighting control, which switched off when exceeding the norm lighting intensity.
- dividing the room in zones with different lighting intensity [Hofmann 1998]. A base illumination of 220 Lux is reached by the ceiling-lamps. At the workspace 500 Lux are gained by a desk lamp.

<u>Office equipment</u>
By the use of the efficient equipment the primary energy consumption can be lowered from 27 kWh/(m^2_{gb} a) to 4 kWh/(m^2_{gb} a). In the “efficient office building” the following equipment is used:

- Notebooks as computer
- Photocopier, printer and fax with an electricity consumption of 75 % of the GED limiting values of 1998. [GED 1998]. Explanation: The community energy label Germany "GED" marks out a list of office products every year, which fulfil certain efficiency standards.

<u>Air conditioning system</u>
A primary energy consumption of 23 kWh/(m^2_{gb} a) is required in the “standard office building” for humidification and dissecation as well as for the active cooling. In the “efficient office building” these functions can be renounced since the space comfort stays in the desired

area itself. Also there is no air-conditioning system the primary energy index isn't zero since the consumption for night ventilation and free cooling is credited under this position.

The discussion points out, that no technical problems exist realising high “efficient office buildings”. All the energy-saving measures are available at the market today.
Another important question is to look at the additional costs for this high efficiency and the economy.

ECONOMIC ASSESSMENT

To assess the economy of the “efficient office building”, all payments which arise within a period of 30 years are looked at: the additional investment costs, the replacing investment after expiring the respective life time and the annual saving of energy and maintenance costs. The signs of the payments are defined as follows:

- savings: positive value,
- additional costs: negative value.

The value added tax isn't included in the payments. The assumed additional costs and savings are shown in Table 2.

Table 2: Additional costs and savings for the energy efficient office building

Additional costs and savings			Annual savings	
	€	life time		€/a
Insulation	-385.000	30	Electricity costs	26.000
Lighting	55.000	15	Gas costs	5.000
Office equipment	-160.000	5	Maintenance costs	8.000
HVAC* system	269.000	15		
Sum	**-221.000**		**Sum**	**39.000**

* Heating, Ventilation and Air Conditioning

From the discounted single payments the capital value of the investment is calculated. If the capital value is positive, the investment is profitable, if it’s negative the investment is unprofitable. The boundary conditions of the economy calculation can be taken from Table 3.

Table 3: Boundary conditions of the economic assessment

Time period	30 years
Price of electricity	0,13 €/kWh
Gas price	0,022 €/kWh
Maintenance costs	2,5 % p.a. of the investment costs
Rate of inflation	2 % p.a.
Increase of energy price	2 % p.a. (nominal)
Increase of the maintenance costs	2 % p.a. (nominal)
interest rate	6 % p.a. (nominal)

Figure 3 shows the results of the economical assessment. It points out the payments calculated under these conditions for a time period of 30 years as well as the capital value of the total investment. An owner–occupied building is looked into. The owner-occupier must pay the investment costs, however the energy and maintenance cost savings also are of benefit to him. So all payments can be added to calculate the capital value.

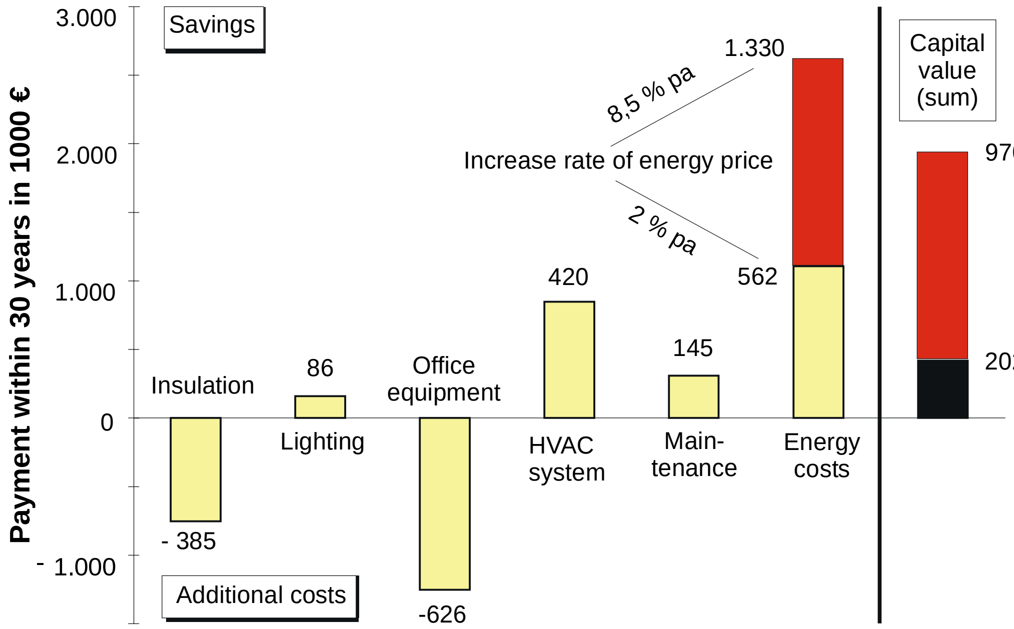

Figure 3: Additional costs and savings within 30 years for the "efficient office building"

Over the time period of 30 years the expenditures of an owner-occupier decrease. Thus it is economical for him to realise the "efficient office building" At a low energy price increase of 2 % p.a. the savings amount to 210.000 €. If the price of energy rises strongly around 8.5 % p.a., savings of 1.000.000 € show up. If the building is rented out, the same increase or decrease expenditure exists. They must however be settled by different parties or be of benefit to them.

The economical assessment points out that it is the right choice to build the office building in an high efficient standard, not only from ecological but also from economic points of view.

CONCLUSION.

Transforming these results to other projects you must consider that the primary energy savings and the capital value depend on the actual boundary conditions. Because of this the energy savings and economy must be determined individually. Nevertheless it gets clear that a high efficient standard has positive effects. It reduces the primary energy consumption and can lead to savings for the investors. The additional costs for the insulation and the efficient office equipment can be compensated by the low energy and maintenance costs and the decreasing investment costs for the lighting and the HVAC system. Because of this the high efficient option "efficient office building" should be checked for every new building.

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