Building performance evaluation – assessing the project sustainability through coherence analysis of sustainability indicators

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Abstract

With the recent increased requirements on the minimisation of national CO_2-emissions by the European Commission, private as well as public investors have started showing increased interest in alternative concepts of heating, cooling and ventilation of office and administration buildings.
The main objective of this paper is to explore how the energy-efficient buildings can be profitable for investors; who are primarily interested in sustainable rents or further sale (building as portfolio-asset), when the return of investment period of energy efficient buildings is sometimes longer than 30 years due to the costly innovative constructions and technologies.
The paper presents the case study of two recently built energy efficient office-buildings. The buildings will be evaluated applying the performance evaluation method that is assessing project sustainability through a holistic approach; evaluating economic (costs, yield), ecologic (resources consumption, emissions) and socio-cultural (architectural and urban significance, handling of green- and public spaces) issues.

Keywords

Sustainable building, indicators, low energy house, passive house, energy efficiency

1. Introduction – Thesis

Austrian construction market is internationally leading in the research and practice of low energy and passive house technology in the realm of construction of single- and multi-family homes and residential buildings. The joint project of IG Passivhaus Austria, together with the Federal Ministry for Transport, Innovation and Technology programme "House of the Future", set up a detailed database on representative cross-section of all passive houses in Austria. Up to July of 2006, the database covers around 2000 residential units: 67 multi-family and row houses and 334 single-family and semi-detached houses are documented and evaluated. However, the number of the office, commercial and public buildings is strikingly lower, with only 43 objects. (IG Passivhaus).

The reason for large number of passive single- and multy-family dwellings lies partially in the government housing subsidy programmes. However, the side effects of the encouragement of extensive building activity of passive single family houses are: the sprawl-development, increased consumption of building land and land for new infrastructure (roads), which again, through increased personal traffic, leads to increase of CO_2 emissions. When seen within this context, the passive single- and multy-family houses do not correspond to the image of sustainable building.

Currently, the European largest passive housing development - Eurogate, is under construction in Vienna's third district. The 20 ha area should be developed till 2016 offering 1700 apartments. The total investment of 103 million € will be subsidised through government housing subsidy of City of Vienna with app. € 36 million and additional passive-house subsidy of €3,8 mill. - in total 40% of investment will be covered by government housing subsidies (Oekonews, 2007).

The new requirements of the European Commission foresee the minimisation of CO_2 emissions by 20% and increase in the renewable energies ratio by 20% up to 2020 – Austrian percentage of current 24% ration of water-, wind-, solar- and biomass energy should be risen to 35% (Presse, 2008).

As a consequence of the new in-creased requirements, on the one hand, and of matured and tested energy efficient building research and practice of the small scale projects, on the other, private and public investors of office and commercial developments have started showing interest in alternative concepts of heating, cooling and ventilation of the buildings. The first office and administration buildings in low energy/passive-house technology have appeared; however, most of them have been built for clients own use.

The question rises if such buildings can be lucrative for investors who are interested in sustainable rents or resale (building as portfolio-asset) where return of investment period is sometimes longer that 30 yrs. through extremely costly façade (double façade) or HVAC (heating, ventilation, air-conditioning) technology. Moreover, the building with optimal energy-performance does not necessarily have to be optimal in terms of life cycle- cost or emissions.

2. Examples – Case Study

Two case studies demonstrate current issues in energy efficient building when implemented in the investor oriented realm of office and administration buildings.

2.1. ENERGYbase

In summer of 2008, Austrian most innovative passive-house office building will be finished. The investor Viennese Economy Funding Fond (WWFF) together with POS-architecture team is developing a competence centre for enterprises and research institutes in the realm of renewable energies. The mix-use concept is based on (WWF, 2007):

- ground floor containing a polytechnic school for renewable energy
- four upper floors in total of 7.500 m² RA situating flexible office-spaces, which rentable area varies from 250m² up to 1400m²
- underground garage with 63 parking spaces, plus free-bike post for 40 bicycles.

The building is constructed as mixed construction of:

- primary structure: reinforced concrete frame construction and concrete slabs
- secondary structure: interior prefabricated wooden wall elements, plasterboard interior walls
- tertiary structure - facade: prefabricated wooden wall elements as north facade, convoluted glass façade in the south

The energy concept is based on the activation of concrete core by the means of the heath pump (underground-water temperature is used for heating and cooling). Additionally, the south façade is composed of 400m² photovoltaik elements and 300m² solar collectors; that additionally provide for cooling and heating energy as well as to own electricity production (Kittel, 2007). The ventilation system includes 500 plants in "green-buffer-zones" that provide sufficient humidity in the winter months (WWF, 2007).

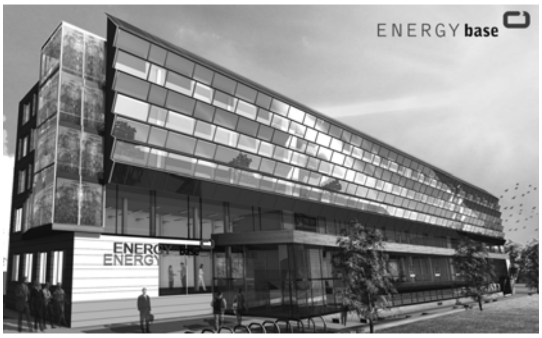

Figure 1: ENERGYbase (Kittel, 2007)

Use – Areas (Kochwalter, 2007):		
GFA (gross floor area)	11.400	m²
GV (gross volume)	42.750	m³
RA (rental area)over ground	7.500	m²
- polytechnic	1.300	m²
- laboratories	1.000	m²
- offices	5.200	m²
Economy – Costs (Kittel, 2007):		
Total investment	14,5 Mill.	€
Construction cost	12,8 Mill.	€
Cost/GFA	1124	€/m²
Governmental subsidiaries/Funding	2 Mill.	€
Approximated additional expenses for innovative technologies for energy efficiency	2 Mill.	€
LCC (life cycle cost) for heating, cooling and lightning	18.000	€/a
Ecology – Consumption/Emissions:		
Heating energy consumption	12	kWh/m²a
Electricity for heating (earth pump) - per m² GFA	3,03	kWh/m²a
Electricity consumption for cooling and ventilation – per m² GFA	8,51	kWh/m²a
Electricity consumption for lightning - per m² GFA	7,9	kWh/m²a
CO_2 emission saving compared to standard building	180	Tons/a
Electricity out of own production	25%	
Energy out of renewable resources	100%	

Table 1: Basic data ENERGYBase

2.2. Haus der Forschung

In 2006 the "HdF": House of Research - a new headquarter of Austrian research funding agency was built by the planning team of Mascha Seethaler with Neumann+Partner architects. The planning objective was to achieve the highest possible energy efficiency and comfort at the working place. The building was build without governmental subsidiaries as standard market-conform lease-object.

"HdF" is built in low energy house standard. The heating and cooling of the building follows through concrete core activation - the concrete structure is used as accumulation mass; which again results with comfortable interior climate due to the mild cooling and low air exchange rates. The primary energy index of 96 kWh/m²a is 20% better than passive-house standard (Mascha, 2008).

Figure 2: „HdF", (Mascha 2007)

Use – Areas:		
GFA	10.000	m²
GV	31.000	m³
RA	7.500	m²
Working places	350	Persons
Economy – Costs:		
Total investment	13,5 Mill.	€
Construction cost	11,2 Mill.	€
Cost/GFA	1120	€/m²
Governmental subsidiaries/Funding	0	€
Ecology – Consumption/Emissions:		
Heating energy consumption – per m² GFA	30	kWh/m²a
Electricity consumption for cooling and ventilation – per m² RA	12	kWh/m²a
Electricity consumption for lightning – per m² RA	8	kWh/m²a
CO_2 emissions	23	kg/m²a

Table 2: Basic data "HdF" (Mascha, 2007)

3. The evaluation strategy

The building performace evaluation of the two case-study buildings in terms of sustainability will be carried out applying the **dynamoB^{sd}** evaluation strategy (Kovacic, 2007). The strategy is based upon two basic tools:

- **flow-concept** (Kohler, 1999): building representation through superposition of different flows taking place throughout its life cycle: resources - materials and energy, capital - investments, reinvestments and profits, and information
- **parametric model**: a system of sustainability indicators (BMBW, 2001), reflecting the "prism of sustainability" and describing performance of:
    - *ecology*: construction demand, land consumption, soil pollution, CO_2 emissions, energy consumption, substitution of fossil energy sources through regenerative energy sources, innovative technologies in energy efficiency

- *economy*: construction costs, investments, yields, LCC (heating and cooling, ventilation, lightning, maintenance, inspection and service), flexibility
- *socio-cultural aspects*: relationship to the landscape, barrier free building, creation of liveable urban identity, accessibility of workplace residence quality for all ages, consideration of balanced income structure regarding working places, integration foreign co-citizens.

The ambivalent nature of building as composition of tangible and intangible aspects brings problems for development of an evaluation strategy. The tangible data are building's quantitative characteristics: ecological (consumption of resources and energy, emissions) and economic data (investments, initial and life cycle cost). The intangible data is expressed through qualitative characteristics such as formal, cultural and functional aspects.

Both tangibles and intangibles will be evaluated upon the same indicator–scheme; by the means of scale-rating (1-5), resulting with a final absolute value of sustainability performance potential.

3.1. Evaluation of the building performance of the two case study buildings in terms of sustainability

The evaluation by applying the **dynamoB^{sd}** evaluation strategy resulted with following results:

Potential:	*ENERGYbase*	*HdF*
Economy	3,20	3,33
Ecology	4,51	4,01
Socio-cultural	3,93	4,59
Total	**3,88**	**3,98**

The overall performance of both buildings can be rated as GOOD. It can be concluded that economic performance, however, is the weakest; rating only average.

4. Conclusion

The main objective of the evaluation of investor-oriented office-buildings was the eligibility of the additional expenses for ecologic issues (innovative energy-efficiency technology, environmentally friendly materials) in respect to economic sustainability (return of investment, profits).
The evaluation process encountered several major problems:

- The question of how the additional construction-costs can be rationalized through leases and yields can hardly be evaluated at this point in time, since the real-estate owners/managers are declining to publish actual the data on yields and leases.
- The same principle applies to the LCC for cleaning, inspection and maintenance – the real data has sill not been collected, since the buildings are not in operation for long enough; the approximated data by the facility managers is not accessible.
- When comparing the performance of the expected operational costs and energy consumption for heating, cooling, ventilation and lightning, as well as

the CO_2 emissions of the two case study buildings, the problem of data-standardization emerges. The values are not obtained upon the same calculation base – in one case the consumption is calculated per m² of GFA, in the other m² of RA (even for the same building); further on the consumption data is not separated for aspects of heating, cooling, ventilation and lightning; but bound together (e.g. cooling and ventilation) – therefore the building performances can hardly be comparable

The evaluation demonstrated that the buildings' construction costs are significantly higher than at standard office-buildings - the additional expenses have to be covered by governmental subsidiaries, which is a difficult issue when dealing with investor-oriented real estates. The buildings are also not as flexible in the operation and floor organization as the standard core-and-shell real estates (delay in tempering due to the concrete core activation, floor-plan inflexibility due to the illumination by predominantly natural lightning, for energy saving reasons etc.) and therefore harder to sell on the market for standard tenant. Such buildings can be interesting for a specific market-segment, such as companies dealing with energy efficiency, governmental agencies, spin-offs with governmental subsidiaries etc.
Generally, it can be concluded that for a significant evaluation on cost-effectives of energy-efficient office-buildings and their success on the free market (ability to lease) a few years of operational experience are still needed, in order to obtain representative data.

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