Introducing (energy) design processes into Austria's largest public real estate company

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Abstract

Bundesimmobiliengesellschaft m.b.H. (BIG) is one of Austria's largest public real estate companies. BIG holding owns roughly 2,800 public buildings (schools, universities, administration buildings). Given the high amount of real estate assets a considerable number of major renovation projects need to be implemented each year. Refurbishment projects with an energy performance going beyond the building code requirements, however, are difficult to accomplish due to conventional planning processes and strict investment budgets.

Given the fact that EPBD requires public building owners to take a front-runner position in energy efficient refurbishment of building stock BIG has started the BIGMODERN initiative, which aims at introducing integrated (energy) design processes in daily practice in order to achieve high levels of energy performance and sustainability in building refurbishment. BIGMODERN consists of the following core elements:

1. Establishment of two large demonstration projects as basis for developing and training major elements of integrated (energy) design "on the job";
2. Transferring the experiences gathered from the demonstration projects to key actors in the organization;
3. Introducing a standard of energy monitoring for quality assurance during building operation (target-performance comparison).

The BIGMODERN programme started in the 2009. In the meantime the construction process of the first demonstration project has been completed, whereas the second demonstration project is in the phase of detailed design. In addition, also the transfer process to key actors in planning processes is already well advanced. The paper gives a comprehensive insight into the results achieved and the lessons learned so far. Furthermore, the paper shows that a successful integrated design process must go beyond energy performance including also life-cycle cost assessment and sustainability certification issues in a well-structured way covering the whole design process.

Introduction

The Bundesimmobiliengesellschaft (BIG) is a service provider for the Republic of Austria, its subordinated departments and its outsourced companies. BIG's core business is the management and administration of real property from new construction to deconstruction. Since 2000 about 2,800 properties that were acquired by the Republic of Austria are owned by BIG (cf. Figure 1). Approx. 1,200 of these properties were built in the period between the 1950s and the 1980s.

BIG is the landlord and owner of the properties and rents out its buildings to the users, i.e. ministries, universities, public companies etc. Generally speaking major refurbishments of buildings of BIG are commissioned by the tenants, mainly as a result of changing user requirements. The standard process of major renovation projects conducted by BIG is presented in Figure 2: First of all, the budget for construction is approved by the Finance Ministry and distributed to the federal ministries. Within these ministries, the projects and the requirements are evaluated in cooperation with the users of the buildings. Hav-

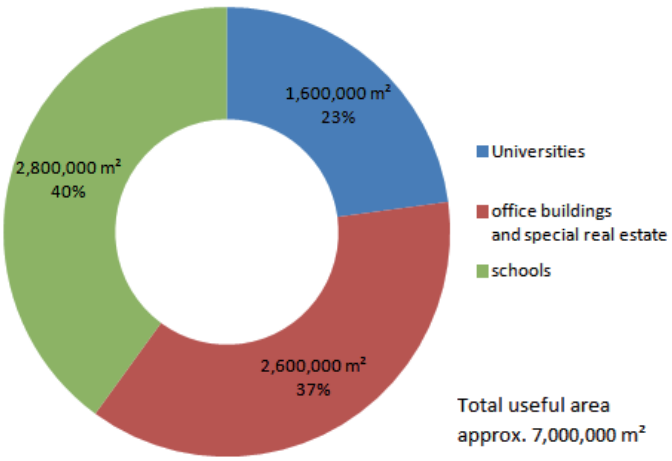

Figure 1. Overall useful area of BIG-buildings, sorted by use (source: BIG).

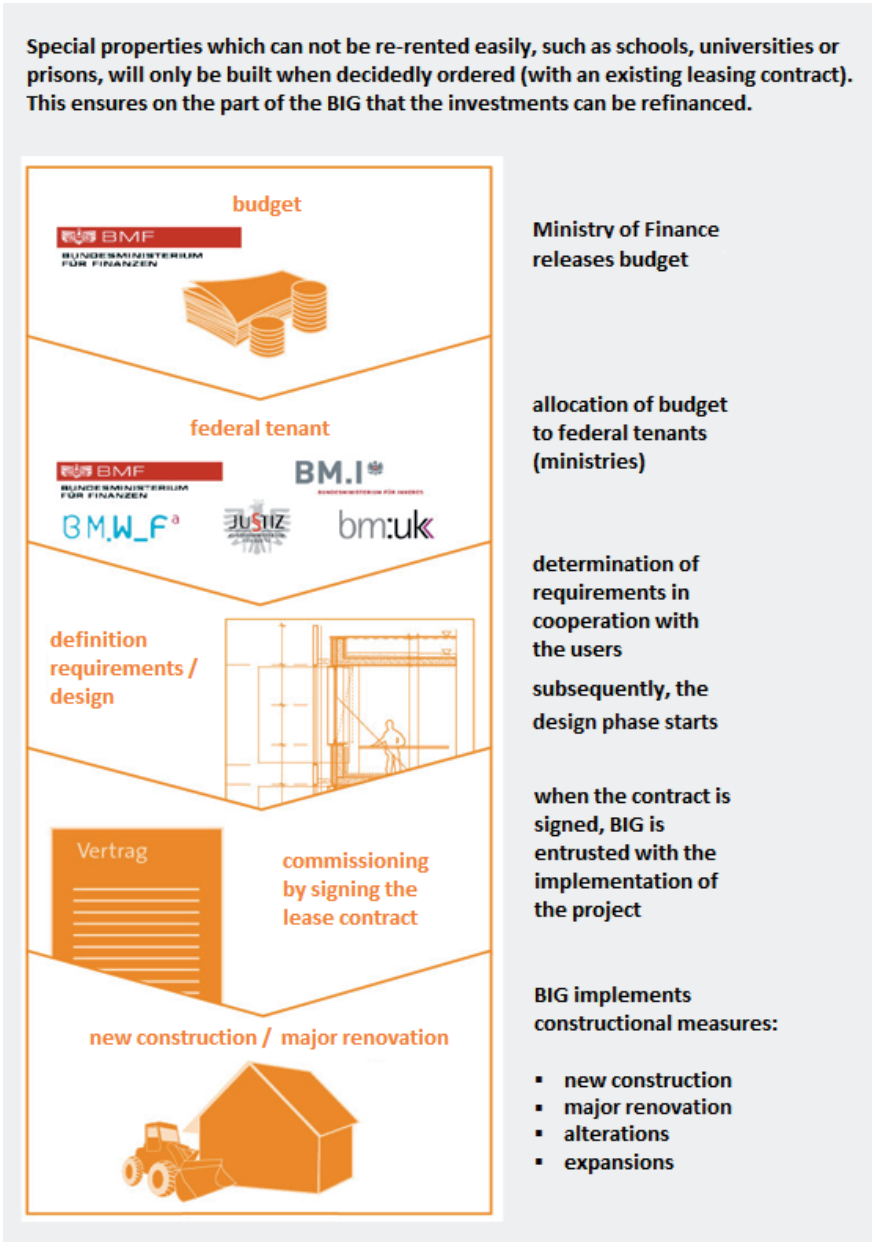

Figure 2. Standard procedure as applied by BIG for major refurbishments (source: BIG).

ing selected the projects, the design phase starts. Only after the lease contract is signed at the end of concept design phase, BIG is entrusted with the implementation of the project.

The framework conditions BIG has to comply with aggravate complete refurbishment efforts. On the one hand, BIG has to fulfil the public mandate to implement a sustainable, highly energy-efficient refurbishment, but on the other hand BIG also has to take economic aspects into account. Not least, the recast Energy Performance of Buildings Directive (EPBD, Directive 2010/31/EU) and the Energy Service Directive (2006/32/EC) emphasize the role model function of the public sector. Yet, BIG only has quite limited resources at its disposal for each of its reconstruction projects which are not allowed to be exceeded. Any additional costs for investments that reduce energy demand in operation would have to be borne by the tenants. The tenants, however – most often ministries, universities, etc. – are also struggling with limited budget resources, as means for investments in buildings are seldom envisaged in the budget. This entails that BIG gets caught in the classic investor-user dilemma for building refurbishment, which usually leads to conventional and not sustainable or innovative remediation.

Objectives and Approach of the programme BIGMODERN

While BIG has already implemented several energy-efficient and climate-friendly flagship projects as far as new buildings are concerned (e.g. Haus der Forschung in Vienna, passive house Jungstraße in Vienna), functional refurbishments and major renovations are still carried out according to the state of the art in a conventional way and are just adjusted to the local regulations and building codes.

In view of the public mandate with regard to fulfilment of energy efficiency and sustainability criteria in construction and given the high proportion of modernization projects in the total investments portfolio of BIG, consistent steps from conventional towards innovative solutions are demanded increasingly, especially in the field of major renovation.

In practice, a number of barriers arise which aggravate the implementation beyond individual cases:

- Usually, the tenants of BIG-buildings are government departments and universities, which are calling for comfort and functionality. In order to achieve high standards both for user comfort as well as with regard to sustainability and energy efficiency in renovation, the application of new technologies is necessary. Since these technologies have not yet been tested in many projects, the situation involves considerable risks both for the client and for the designers. Therefore BIG often eschews innovative solutions and relies on proven, but not very innovative measures;
- Sustainable and energy efficient refurbishments require new design processes, in which all involved designer work together more closely in order to improve adjustment and optimization processes between the designs of individual building systems (integrated design);
- In the sector of building management, investment decisions regarding modernizations are still largely based on production costs. However, in order to be able to implement innovative, climate-friendly and sustainable modernizations, the operating costs throughout the life cycle have to be taken into account to a greater extent in addition to the construction costs for providing an appropriate basis for investment decisions. As far as this point is concerned, on the one hand BIG is caught in a classic investor-user dilemma, because it does not directly profit from the benefits during the operation period. On the other hand, life-cycle cost based information is difficult to gain in the early design phases where the most important decisions on the further direction of design are taken.

To overcome these barriers, the flagship project BIGMODERN has been launched in 2009 as part of the Austrian building research programme "Haus der Zukunft". The core element of the flagship project is the implementation of two demonstration projects. Both projects are modernization projects of federal buildings of the construction period between the 1950s and the 1980s. For both buildings the architectural competition had already been completed and even at this stage emphasis was placed on energy efficiency. Within the scope of accompanying research, decisions necessary for the implementation of these demonstration projects are supported scientifically by several sub-projects.

The following aspects are provided in detail:

- Implementation of a life-cycle cost analysis (LCCA) accompanying the design phase in order to filter out those variants, which are optimal in cost over the whole life cycle and not just in initial investment.
- Moderation of an integrated design process to make all relevant designer of the individual building systems work together for the sake of achieving optimal combination of solutions for the building as a whole and not just for separated building systems.
- Feasibility studies for the use of innovative technologies which are required as energy-efficient and sustainable solutions in building refurbishment. Thus the risk perceived by designers and clients when applying innovative technologies is reduced;
- In addition, a monitoring system to evaluate the results of the demonstration projects is established and serves also as the basis for the subsequent dissemination of project results. In the evaluation and documentation part, knowledge and experience gained from design and implementing the demonstration projects is evaluated collectively.

With the elements as described above the programme BIGMODERN implements a learning-by-doing approach. The programme thus aims at developing standard design processes that are better prepared to reconcile the public mandate of energy-efficient and sustainable construction with the limitations of public budgets. As part of this standard design process specifications of standard requirements for sustainable and energy efficient modernization are to be developed. In addition, a concept is developed, how to include both energy efficiency and sustainability criteria as well as the impact of operating cost reduction into the contractual relationships between BIG and the respective user departments as well as the planners and

builders. In this concept the life cycle cost perspective serves as indispensable basis for investment decisions. The standard guidelines and principles developed during the programme BIGMODERN will subsequently apply for all modernization projects of BIG in existing buildings of the construction period between the 1950s and the 1980s.

The process of integrated planning

In the following chapters focus on the process of integrated design which represents a decisive corner-stone in the programme BIGMODERN. The integrated design has been tested in two demonstration projects and is aimed to become a standard for future design processes in BIG mainly with respect to refurbishment projects.

OVERVIEW

The integrated design process has been an issue in the construction industry for several decades but in construction practice most design processes are still run in a rather conventional way – perhaps including a few selected elements of integrated design processes but not reflecting the rationale of this approach as a whole.

A key motivation for integrated design is the increase in requirements for buildings that need to be taken into account already during the planning phase. Many aspects of the building are concerned by energy issues. In addition to the key components such as façade and building services, the effects on the user, on the indoor environment or on the energy balance of the materials used are energy-related aspects during construction.

The goal of integrated design is to find an optimum solution for the numerous single targets of the project. This shall be achieved at a lower cost than by achieving the single targets independently one after the other.

Therefore integrated design can be applied in the new construction as well as in major renovation of buildings. By looking at the different aspects of such an undertaking holistically, different goals can be set into relation and synergies can be utilized (Hofer et al., 2006).

The integrated planning process starts even before the first plan of the building exists (Figure 3). In the initiation phase target criteria are defined which on the one hand are derived from the strategic goals and requirements of the client and which on the other hand reflect a comprehensive set sustainability criteria including energy efficiency. However, they can also be prioritized upon certain issues and topics.

The criteria are part of the tender for the planner (e.g. architectural competition). Hence, orientation can be given for the first draft, as to how the building is to be designed. During the concept phase of the design process and starting from a first draft concept (e.g. the output of an architectural competition), initial testing and optimization steps are performed. Here the plan is tested to see whether the sustainability criteria are met.

At the same time, and with contributions from all members of the integrated design team, the building is optimized as best as possible. In the specific case of the BIGMODERN programme, the focus has been set on energy optimization and its impact on life cycle costs. This applies to both the concept phase and to the (detailed) design phase. In the concept phase the focus lies on systemic decisions and in design phase component solutions are to be optimized. The approach for the (detailed) design was to integrate the already existing solutions and ideas in the tender in such a way, as not to ”lose” issues and requirements that have already been defined beforehand.

The following chapters describe the most important elements of integrated design as applied in the BIGMODERN programme in more detail.

DEFINITION OF TARGET CRITERIA DURING THE INITIATION PHASE

At the beginning of the design process, i.e. during the initiation phase, in it is necessary to determine the target criteria the building has to achieve. At this early stage of the design process, when there is actually still no plan on the table, the client usually has only a rather vague and general idea of his objectives. Therefore, it is essential to translate the client's vaguely stated wishes and goals (strategic goals) into clear and measurable requirements (Von Both 2004, Hofer 2007).These requirements form the basis of the entire design process and can be used in the design competition or the design bid (see Figure 4).

The EU Buildings Directive and the Energy Service Directive urge public building to serve as a showcase action with respect to energy efficiency. Therefore BIG has set a strategic goal to continue implementing more renovations with high energy

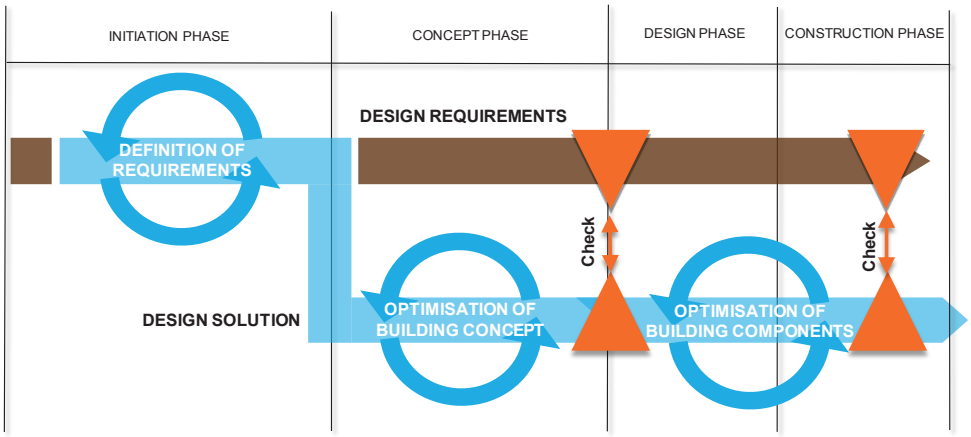

Figure 3. Design phase and activities (Source: M.O.O.CON GmbH, Hofer G. 2011).

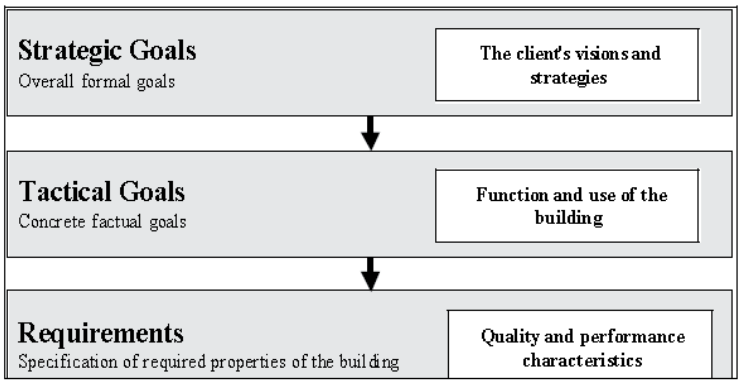

Figure 4. Process of defining requirements (Source: Von Both 2004).

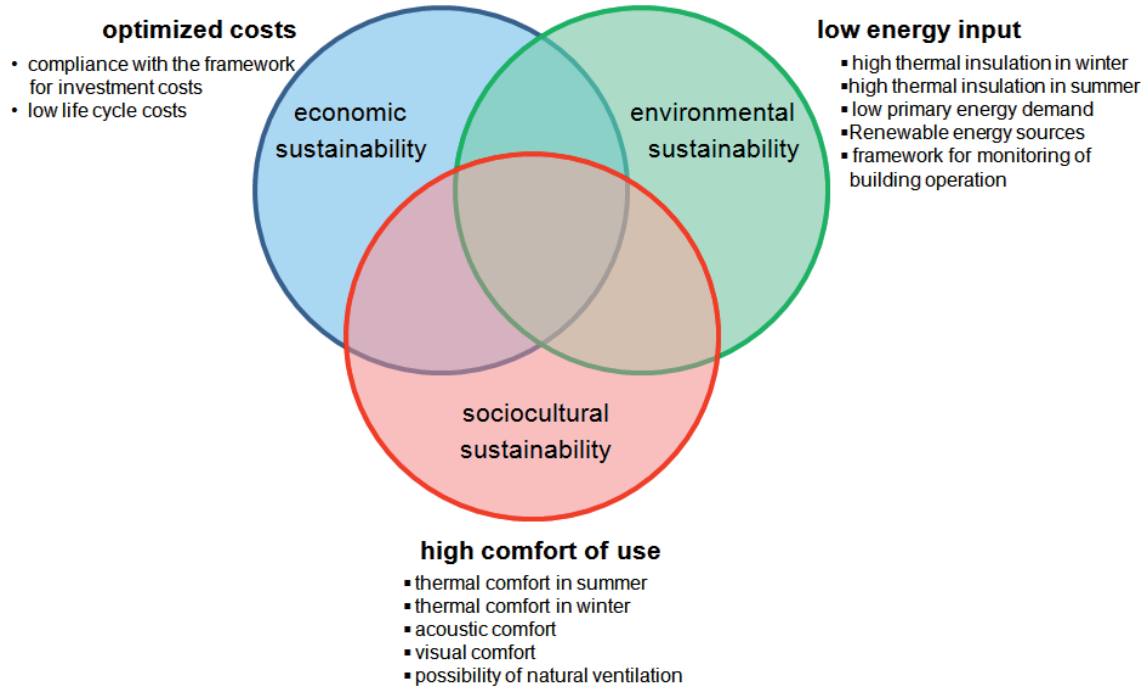

Figure 5. Tactical goals.

performance and thus assume the role model position. Hence, the BIGMODERN programme puts the focus of the target criteria on aspects of reducing energy demand and on the use of renewable energy systems. At the same time it is essential to look at the building as a whole system instead of solely limiting to energy efficiency issues. For instance, a low energy use must not lead to the reduction of user comfort. Therefore, in addition to the existing energy efficiency targets, further environmental, economic and socio-cultural criteria for refurbishment have been defined.

Since there were no sets of criteria for the renovation of service buildings at the beginning of the project, suitable criteria and requirement levels have been developed on the basis of existing national and international lists of criteria, such as the Austrian sustainability rating systems "Total Quality Building" (TQB) and klima:aktiv, as well as the international system "German Sustainable Building Council" (DGNB) or "BRE Environmental Assessment Method" (BREEAM) for renovation.

In order not to lose the focus on the energy issue, there was no elaborate sustainability certificate used as an orientation for the design process. Hence, energy criteria and further criteria which include the wider energy issues were taken into account.

This also includes the cost of the project in terms of life cycle costs. Thus a core goal is to demonstrate that projects with lower energy consumption and greater user comfort have little or no impact on the life-cycle costs.

Figure 5 translates the usual "three pillars of sustainability" – economic, environmental and sociocultural sustainability – in potential concrete goals related to building refurbishment and shows the interdependence of different sustainability goals. Figure 5 thus demonstrates that it is necessary to define a coherent set of target criteria already before the actual planning starts in order to be able to evaluate the proposed design variant in a well-structured way.

Based on the goals as they were defined for the BIGMODERN programme, the following set of criteria, which includes

criteria, level of requirements and verification methods has been created. It was designed to provide guidance for the general planner throughout the entire design phase:

Economic viability and technical quality of the object

- economic viability
  - calculations of profitability
  - integrated design and variant analysis
  - principles for building operation, maintenance and repair
- technical quality of the object
  - air tightness of the building
  - thermal bridges of the building

Energy demand and supply

- energy demand
  - net heating demand
  - net cooling demand
  - primary energy demand
- energy efficiency with regard to electricity use
  - energy efficient lighting
  - solar power system

Health and comfort

- thermal comfort
  - ensuring thermal comfort in winter
  - ensuring thermal comfort in summer
- room air quality
  - ventilation (comfort ventilation with heat recovery, natural ventilation – overnight ventilation)
- soundproofing/room acoustics
  - room acoustics in relevant sections of the building
- illumination, lighting, sun protection and anti-glare shields
  - quality of the artificial lighting
  - supply of daylight/daylight factor/line of sight outwardly
  - sun protection and anti-glare shields

SUPERVISION OF THE DESIGN DURING THE CONCEPT PHASE AND DETAILED DESIGN

After fixing the sustainability criteria which served as guidance for the whole planning process the BIGMODERN project team accompanied the client and the general planner through the entire design process. The background of this approach is to identify potential barriers and risks in the implementation of innovative and energy-efficient solutions as quickly as possible and to enable improvements by using suitable information and applying necessary calculations.

On the one hand, the design phase for the demonstration projects within the scope of BIGMODERN was designed to check the abidance of the sustainability criteria with a focus on energy criteria within the design. At the same time, on the other hand, the aim was to optimize the present plan concerning the (draft) concept as well as the design. Herein the BIGMODERN project team undertook the task of reviewing the compliance of the sustainability criteria. In case of non-compliance with criteria, the client and the general contractor were informed, in order to enable the initiation of a revision of the project.

If additional information or calculations for the realization of innovative solutions were required, these were carried out by the BIGMODERN team, so as to avoid any prolongation of the design process. The optimization of the design was carried out with assistance of the integrated design team. Herein all key stakeholders in the planning of the building were involved: the owner of the building, the general contractor, the tenants and members of the operational management.

Topic related workshops were used for the optimization of the planning process. Additional information from the thermal building simulation and life-cycle costs determined by the design contributed to these workshops. Hence proposals for energy performance optimization could be presented, and additionally economic effects could be proven. The result of this was that essential information for discussion as well as for decision-making was available.

The best possible solution was selected and then carried out in collaboration with the client. Further on the general contractor was supported in the integration of the high-quality design in the tender for the construction project by defining appropriate requirements for the components.

Ultimately the BIGMODERN team revised the tender in the means of quality assurance for the purpose of maintaining all the requirements that were agreed upon.

Flashlight on Energy optimization

As described above the aim of supervising the design is the joint optimization of the present building and energy concept by investigations of variants.

These investigations of variants are based on the integral design workshop. Within the scope of this workshop, suggestions for improvement are proposed and discussed freely. Thereby, inputs can be submitted by all stakeholders.

In addition to the participants mentioned above, experience from the BIGMODERN project shows that an expert in thermal building simulation should attend the meetings in order to check the possibility of simulating the variants immediately. The defined variants are evaluated using dynamic building simulation. This means that the effects of the variants will be regarded with respect to the energy balance of the building as well as related to the convenience of use. Concerning the ease of use, basically the interior temperatures in summer and in winter are calculated. In addition, the impacts on the supply of daylight and artificial light respectively are determined.

Flashlight on integrating life cycle cost assessment into the design process

The life cycle cost analysis during the design phase is of paramount importance. Using this method can contribute to bridge the main barriers which impede the implementation of innova-

tive measures. Even though there are arguments claiming that innovative measures are too expensive and not economically anyway, these arguments can be refuted easily.

For instance, by applying design accompanying life cycle cost assessment at a demonstration building, it could be proven that additional measures to conserve energy and to increase user comfort (ventilation in the administrative area, cooling of the courtrooms) causes no extra costs over a time horizon of 30 years. Thus, it was also shown that the measures to improve the sustainability of buildings are economical.

Achievements of integrated design: Showcase of BIGMODERN demonstration projects

Within the scope of the BIGMODERN-project, two demonstration projects have been realized, namely the office building in Bruck/Mur (including a district court) and the construction engineer faculty building of Innsbruck University. The refurbishment is already completed as far as the office building in Bruck/Mur is concerned. Regarding Innsbruck University, the invitation to tender for this construction project is currently carried through. Therefore in the following, the results of the administration building in Bruck/Mur are presented.

INNOVATIVE MEASURES

The integrated planning process resulted in several important key measures, which contributed decisively to the fulfilment of defined target criteria as described above. The main innovative measures were as follows:

- Façade: Prefabricated metal cladding panels with solar "honeycombs" for passive solar exploitation were attached to the existing façade
- Windows: The window elements are flush-mount integrated within the façade. The vent windows are opaque and – speaking of windows – have an excellent overall heat transfer coefficient of 0.30 W/m²K. Each room contains at least one openable wing, the rest of the window elements is tightly vitrified. A special three-pane insulating glass is used, which has an integrated daylight-directing sunscreen. The control of the blinds is radiation-dependent.
- Lighting: The offices are illuminated by presence and daylight dependent controlled floor lamps. The hallway area is lighted by a dimmable linear lighting system (presence control).
- Ventilation: In the wing of the district court, floor by floor ventilation systems are installed with highly efficient heat recovery systems. The ventilation of the courtrooms is done separately, utilizing a CO_2-sensor. The fresh air is provided as needed via the automatic flow controller and the speed-controlled ventilation device.
- Heating: in the course of the refurbishment, the existing gas heating is converted to biomass district heating.
- Cooling: A bivalent chiller with a deep drilling system is integrated into the ventilation system (see description of ventilation system). In summer, the cooling water from the deep drill is used to precondition the fresh air (free cooling), in winter, the air is pre-heated by the heat pump (in addition to high-efficiency heat recovery).
- Energy monitoring: The control and regulation functions for all major technical building service elements are operated by a central building automation system and are directly used also for energy monitoring purposes. This allows ensuring a constant supervision of energy flows in the building and monitoring of all relevant plant components such as ventilation systems, heating and cooling groups.

RESULTS OF THE ENERGY PARAMETERS

By carrying out the renovation of the administration building Bruck/Mur, a substantial contribution to the reduction of both energy input and CO_2 emissions is made. The heating demand of the building was reduced from 153 kWh/m²a to 24 kWh/m²a, which accounts for a reduction of 85 %.

Due to the consequent reduction of net energy demand and the renewal of building services, also primary energy demand could be reduced significantly. In order to increase the user comfort and to reduce heat loss, a ventilation system with heat recovery was installed in the building wing where the district court is placed. The ventilation system is also used for cooling purposes in the court rooms, in which before renovation no cooling was available which led to high user dissatisfaction. Hence, although after renovation there is additional energy consumption for ventilation and cooling, the primary energy demand could be reduced by about 60 %[1].

Due to the reduction of the energy demand and the conversion of the heating system to a biomass district heating system, CO_2 emissions were reduced by about 75 %.

The demo project in Bruck proved that a significant improvement in energy efficiency can be achieved at LCC levels that are comparable to those of conventional renovation. The approach of integrated design proved as important tool to reconcile high energy efficiency standards and cost-effectiveness over the life-cycle.

Conclusions

The BIGMODERN programme which aims at introducing integrated (energy) design processes in daily practice in order to achieve high levels of energy performance and sustainability in building refurbishment comes up with several conclusion of general relevance. The experience from implementing demonstration projects as core elements of the BIGMODERN programm shows that refurbishment projects with challenging energy efficiency and sustainability targets on the one hand and limited budgets on the other hand require the application of an integrated design approach. Energy-efficient optimization of a building will only work in an optimal way if there is an interdisciplinary team of technical planners working together. Hence, a good overall approach to the system building can be found. The dynamic building simulation is the appropriate tool to detect weak points of design variants on the table and to consider suggestions for improvement. Basically, the results of the building simulation serve as essential input for the integrated design process.

1. The relevant conversion factors for primary energy are fixed by relevant Austrian standards as follows: Electricity: 2.62; Gas: 1.17; District heating (CHP): 0.92.

This also applies to the calculation of life-cycle costs. After all, only measures, which are both innovative and energy-saving as well as economically viable over the life cycle can be implemented in a broader scale. Innovative measures often create an advantage in ease of use. These benefits often cannot be displayed monetarily, but they have to be communicated to both the client and the users in order to provide comprehensive information on the effects before making decisions. A comparison of life cycle costs of a standard refurbishment with a modernization which achieves high energy efficiency and sustainability standards is of great importance as it can serve as a basis for decision making. Moreover it is important that the life cycle costs are calculated accompanying all design phases, beginning with the early design phases, so that the results can still have an impact on design. Both the building owner and the tenant should be informed about the construction costs and the future operating costs already at the very beginning of the project, when the building is defined. However, they have to be informed at the latest when the (draft) concept design is on hand, i.e. when the design of the first plans is accomplished. Once the design has arrived in the phase of detailed design, the calculation of life-cycle costs can only influence design to a minor extent.

Only if the tenants understand, that higher investment costs as a result of higher quality standards and lower operating costs are economically reasonable, energy efficient solutions can be put into practice. The impacts on user comfort have to be pointed out within the scope of design. Furthermore, the budgetary constraints of the tenants have to be taken into account.

Within the scope of the demonstration projects, energy monitoring systems for the detailed assessment of energy consumption and the type of use have been installed in the demonstration buildings. Thereby, the results of design shall be validated by real operational data. Thus, weak spots in the adjustment of the building services systems can be recognized and remedied. This data is also used for the constant energy monitoring of the building.

Based on this experience, the results of the design and the energy monitoring, refurbishment standards for other buildings can be derived. Hence, BIG will be capable of reinforcing the realization of its goal to implement future renovations with high energy efficiency and sustainability standards.

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