Sustainable buildings in Austria – performance indicators and implications on the construction industry

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Abstract

Energy consumption in the building sector accounts for more than one-third of energy consumption in Austria. Heating energy consumption has been decreasing due to defined heating energy indicators required by subsidy schemes, and since 2009 also by the revised building codes, as required by the EPBD. However, electricity consumption has been rising due to increasing cooling needs, in non-residential buildings as well as in residential buildings. Therefore, emphasis is not only necessary to reduce heating energy use, but also on encouraging sustainable methods of ensuring summer comfort, for example through facilitating integrated design. This brings architects and energy engineers together in the early planning stage to limit overheating in summer by architectural design, passive measures, and solar cooling. To promote this development, the Austrian klima:aktiv building standard has been developed. The standard sets requirements to be met for heating and cooling needs, user comfort, ecological construction materials, and material use. Buildings meeting all the requirements are awarded the klima:aktiv label, and in addition they meet the basic requirements to achieve the even more ambitious building certificate according to TQB (the Austrian national sustainable building certification scheme). The combined step-wise model was chosen to lower the barriers for companies to become familiar with environmentally conscious construction. This contribution provides an overview of the Austrian building sector and the policy instruments applied to decrease energy consumption for heating and cooling. It points out the implications on the construction sector by describing case study buildings with excellent environmental performance.

Keywords: green building assessment, sustainable building, climate change.

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1 Introduction

Residential buildings represent the majority of the Austrian building stock: according to statistical analysis carried out by Statistics Austria, in 2001 there were 2.05 million buildings and approximately 3.86 million dwellings. Three quarters of all Austrian buildings are single family households and detached houses, and 14% are non-residential buildings. Concerning the number of flats, the distribution is more or less equal between single family houses and detached houses, and apartment buildings. 21% of residential buildings were constructed before 1919, and 47% were constructed in the period between 1945 and 1981 [1–3]. The latter portion is most important in terms of constructed buildings as well as in terms of energy consumption and thus also energy saving potential. In these buildings, annual energy use for space heating exceeds 200 kWh/m^2 in single-family houses and 145 kWh/m^2 in apartment buildings (see Figure 1).

Figure 1: Heating energy use in residential buildings by construction period [3].

While energy use for space heating and energy use for domestic hot water is predominant in residential buildings, energy consumption patterns are more diverse in non-residential buildings, depending on the purpose of the building: hospitals, shops, offices, schools, etc., and there is little statistical information. However, it is evident, that electricity consumption is increasing dramatically, mainly due to cooling needs. Studies (reclip:more project) carried out to analyse the impact of climate change on Austrian regions show that the number of days with temperatures above 30°C will increase fourfold in the East of Austria [4]. As a consequence, electricity consumption is likely to skyrocket if no precautionary measures are taken.

In order to reduce heating and cooling energy consumption in the building sector, and to optimise buildings as a whole in terms of sustainability, a package of policy instruments has been applied in Austria.

These consist of measures to further develop the regulatory framework, while there are also subsidy schemes, voluntary schemes, awareness raising programmes, and research activities. This bundle of activities has caused a shift in building quality towards a building performance close to what can be called truly “sustainable”, in terms of economic, environmental, and social aspects.

2 Subsidy schemes as drivers for sustainable buildings

The social housing subsidy scheme has been a driver for sustainable buildings in the residential sector. In Austria, the social housing scheme has a long tradition. Criteria are set up in way so that the majority of Austrians is eligible to apply. For many years, the social housing scheme has been extended towards including energy efficiency criteria, addressing renewable energy systems, and subsequently also to criteria targeting ecological materials. The social housing subsidy scheme provides additional money upon condition that energy and other ecological criteria are met. There are 9 provinces in Austria, and subsidy schemes as well as building codes are the responsibility of the provinces, thus resulting in 9 subsidy schemes and 9 building codes. Although this might seem not very efficient, there is a positive aspect in the competition among the provinces, resulting in a constant improvement and increasingly ambitious criteria and targets (see Figure 1 and Table 1). A treaty between all provinces and the federal government ensures that, among others, minimum requirements in terms of energy are met: heating energy use (useful energy for space heating; losses for transforming the energy in the heating system are not included; energy use for domestic hot water is not included, either) must not exceed the figures listed in Table 1. Limits are given considering the compactness of the buildings, described by the surface to volume ratio (A/V-ratio).

In this document, limits are also given for the new build construction of public non-residential buildings and for refurbishments of residential and public non-residential buildings [5]. They are more ambitious than the limits prescribed by the mandatory building code.

Table 1: Limits of heating energy use in the art. 15a agreement [5].

	Heating energy use in kWh/(m².a) for residential buildings, new build construction	
Minimum requirements	A/V-ratio ≥ 0,8	A/V-ratio ≤ 0,2
Until end of 2009	65	35
From 1.1.2010	45	25
From 1.1.2012	36	20

Regarding the social subsidy scheme, more ambitious targets are rewarded with more money. Funded measures include insulation of the building envelope, upgrade of windows, solar-thermal systems, biomass heating systems, heat pumps, district heating (traditional and based on renewable energy sources), controlled ventilation with heat recovery, and ecological materials. In addition, the municipalities are free to offer grants at the level of the community, for instance for better insulation or solar energy use. User behaviour strongly influences the actual energy consumption and is therefore also addressed by defined instruments such as energy advice programmes. For the non-residential sector, there is the environmental subsidy programme "Umweltförderung im Inland" provided at the federal level with corresponding programmes at the level of the Austrian provinces. This scheme addresses the building sector in terms of energy efficiency measures and installation of renewable energy systems [6].

3 Green building assessment

3.1 The Austrian green building assessment scheme TQB

In 1997, Austria joined the Green Building Challenge, an international platform for the development of green assessment schemes for buildings (successor organisation IISBE - International Initiative for a Sustainable Built Environment). At that time, the BRE Environmental Assessment Method (BREEAM, developed in UK) was in place and experiences delivered valuable input for establishing an international platform for green building assessment. In Austria, green building assessment schemes also offered an opportunity to address residential buildings outside the social subsidy scheme, and - even more importantly - to address the non-residential sector. There was the expectation that requirements regarding energy, materials, water, land, indoor air quality, emissions, and many others, would substantially facilitate the transition towards a sustainable building sector. However, it soon became evident that data generation, collection, and examination had to be adjusted to the Austrian planning and construction practice, in order to avoid high transaction costs. In Austria, small and medium-sized companies are predominant, and it was the objective to provide a tool for widespread application. Therefore, the Austrian TQB (Total Quality Building) assessment scheme was developed (at that time called "TQ – Total Quality assessment scheme", which was changed after a major revision of the system in 2009) and put into operation in 2003 following a testing phase [7]. A survey conducted among developers clearly pointed out that performance criteria limited to energy efficiency measures, renewable energy technologies, and ecological materials would lack acceptance. However, developers were willing to apply a comprehensive building assessment scheme which includes aspects such as noise protection, indoor air quality, flexibility, and others besides environment-related criteria. Furthermore, the assessment scheme should be useful as a quality control tool as well as a marketing instrument. Therefore, the TQB assessment scheme was composed of a comprehensive set of criteria to be applied at the very beginning of a project and to adjust design targets according to the criteria to achieve a good assessment result. In order for buildings to pass the TQB assessment, checks are made twice, first at the end of the planning stage and then after completion of construction. The objective is to ensure that the building was constructed in compliance with the design which will be especially important if the building is designed in an integrated way. In this case, architectural aspects and energy technology aspects are intertwined and small changes during construction to reduce costs will result in substantial problems concerning comfort and energy performance during building operation. After the planning phase, drawings and calculations are checked, and after completion the compliance with the design is examined, and measurements are carried out.

Figure 2 shows the concept of the Austrian building assessment scheme.

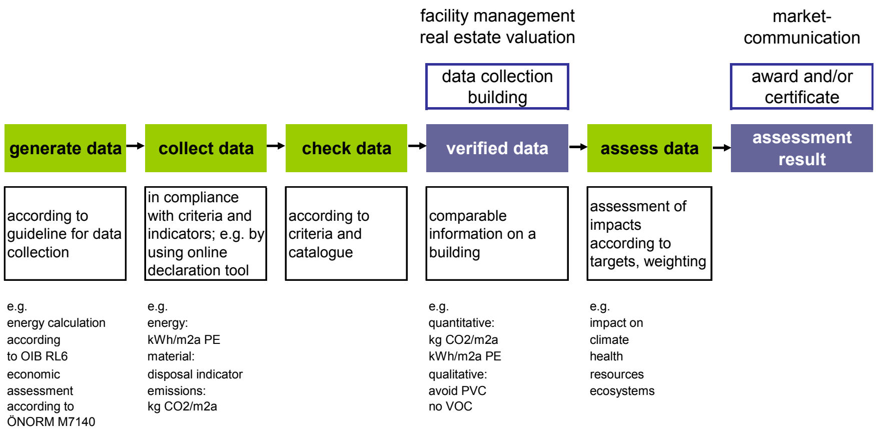

Figure 2: The concept of the Austrian TQB green building assessment scheme.

3.2 Climate protection and klima:aktiv building standard

In 2004, the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management launched the climate protection programme “klima:aktiv”, aiming at a substantial reduction of CO_2-emissions and a substantial increase in energy efficiency [8]. The programme addresses the relevant sectors, including construction, industry, households, and transport by funding comprehensive activities such as the production of information material, consulting services, network development, and the elaboration of quality control procedures. One sub-programme addresses the building sector by offering a building standard for residential and non-residential buildings, for new build constructions as well as for refurbishments. This standard consists of selected criteria of the TQB standard with a focus on outdoor and indoor environment, to communicate individual benefits along with the reduction of CO_2-emissions. Good indoor living quality through avoiding overheating in summer, ensuring thermal comfort in winter, fresh air, and avoiding indoor pollution raises demand for klima:aktiv buildings, at the same time resulting in more CO_2-savings.

The criteria system comprises the following categories:

- A Design and Construction
- B Energy and Supply
- C Materials and Structure
- D Comfort and Indoor Air Quality

All categories consist of several sub-criteria. Categories A, B, C, and D are the same for residential buildings, non-residential buildings, new build constructions, and refurbishments, but sub-criteria and allocation of points are different, taking into account differing options and priorities.

Table 2: Overview of klima:aktiv criteria for non-residential buildings [8].

New build construction	Refurbishment
A Design and construction	
Avoidance of individual motor car traffic	
Simplified calculation of life cycle cost	
Product management to avoid harmful substances in construction materials	
Minimization of thermal bridges in the design stage	
Energy efficient and natural ventilation	---
---	Inspection to detect harmful substances
---	Examination of compression opportunities
Construction of airtight building envelope	
Installation of monitoring devices for control of energy consumption during operation	
B Energy and supply	
Heating energy use (space heating)	
Cooling energy use	
Daylighting	---
Primary energy use	
Renewable energy use	
---	Energy efficient ventilation system
C Materials and structure	
Avoidance of substances harmful for the climate	
Avoidance of PVC	
---	Ecological optimisation of materials
OI3 indicator of thermal envelope	---
Disposal indicator for the building	---
Use of certified building products	---
D Comfort and indoor air quality	
Comfort in summer (avoidance of overheating)	
Controlled ventilation with heat recovery and optimisation regarding quality of air, sound protection	As per new build construction or optimised outdoor air ventilation (sound protection)
Actual air quality in compliance with guidelines for indoor air quality	

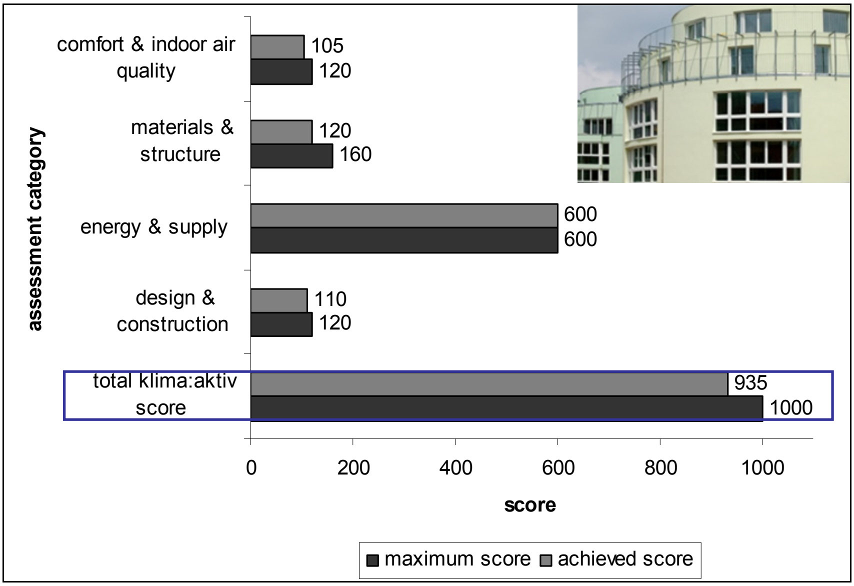

Figure 3: klima:aktiv residential building: part of documentation of passive house Dreherstraße 66, Vienna (5 storeys, 27 flats) on the database [9].

Compliance with klima:aktiv criteria is demonstrated by uploading the requested documents for a specific building to the klima:aktiv database. After having passed a plausibility check, the building owner receives the klima:aktiv award, and the description of the building is activated on the database. The description is accessible for the public and provides detailed information on the energy concept of the building, on materials used, on companies involved in the design, and more. It also displays how many points the building achieves compared with the maximum available score (example residential building, new build construction, see Figure 3).

The publication of this information and relevant data such as lectures, folders, and newsletters contribute to creating awareness to the advantage of eco-buildings.

In 2004, an awareness raising campaign on energy efficient buildings started on the European level. The GreenBuilding programme is funded by Intelligent Energy Europe and addresses specifically energy efficiency in the non-residential sector, aiming at achieving substantial reductions in energy consumption. Building owners who fulfil the requirements are awarded the GreenBuilding partner status [10]. In Austria, the GreenBuilding project has been carried out in close connection with the klima:aktiv programme. Often, carrying out energy efficiency measures to achieve the status of a GreenBuilding partner is just the first step towards broad improvements. Since 2009 the klima:aktiv building standard for non-residential buildings has been in place, offering the opportunity for GreenBuilding partners to receive the klima:aktiv award for high quality also beyond the energy sphere. The Austrian GreenBuilding project and the klima:aktiv programme are both managed by the Austrian Energy Agency.

3.3 Example: business centre: Niederoesterreich

The GreenBuilding partner status and the klima:aktiv label were awarded in November 2009. The building complex houses those institutions of the province of Lower Austria which offer information and services for entrepreneurs. There are 4 buildings which represent the four quarters of Lower Austria, also demonstrated by using different materials for the façades. Façades are highly insulated, windows meet passive house standards, and the buildings are equipped with a highly energy efficient controlled ventilation system. Primary energy consumption is low due to free cooling, and energy is provided by a heat pump, while using thermal-active building components for heating and cooling.

The indoor air quality is excellent due to the management of chemicals during procurement and construction. A process defined by the klima:aktiv building standard ensured that products containing volatile organic compounds (VOCs) were completely avoided. Energy monitoring secures energy savings during operation, and data are displayed on a screen in the lobby to raise awareness to employees and visitors [11].

Figure 4: Business centre Niederoesterreich (© Kammeter).

3.4 Step-wise system: energy certificate - klima:aktiv - TQB

Since the full implementation of the EU Directive 2002/91/EC (EPBD) in 2009, a step-wise system has been in place. The combined model was chosen to lower barriers for companies to become familiar with environmentally conscious design and construction. It was the objective to make use of the dynamism stemming from the EPBD, and to facilitate market penetration of eco-buildings by linking the voluntary, environment-related klima:aktiv building standard with the mandatory energy certificate [12, 13]. Therefore, the klima:aktiv category "B Energy and Supply" fully corresponds with the energy certificate. On the way towards a sustainable building, the first step is a good energy performance documented by the energy certificate. If the developer or building owner seeks good performance beyond the energy sphere, the klima:aktiv criteria "A Design and Construction", "C Materials and Structure", and "D Comfort and Indoor Air Quality" can be fulfilled, and after a plausibility check the klima:aktiv label will be awarded. If the building owner or developer is ready to document that the building achieves high quality also in terms of noise protection, flexibility, and other criteria, then there exists the option to build upon the klima:aktiv data and to extend the data collection in order to receive the TQB certificate. As a condition, the building must pass a detailed check of data.

klima:aktiv was developed based on a study commissioned by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, and TQB was developed based on studies commissioned by the same ministry, the Austrian Federal Ministry for Transport, Innovation and Technology, and the Austrian Federal Ministry of Economy, Family and Youth.

Since 2009, the ÖGNB - Austrian Council for Sustainable Construction has been running both building assessment schemes [14].

4 The role of research and demonstration

The Austrian research programme "Building of Tomorrow" is an integrated research programme which funds research projects, prototype development, and demonstration projects. Since 1999, numerous projects have been funded, among others the development of the TQB building assessment scheme.

Sustainability requirements resulted in development of new products and technologies, such as [15]:

- Thermal flat collectors to be used as 'facade collectors', which can be installed without any back ventilation onto facades. The new component represents a high architectural quality and style element for facades, and can be recycled after the lifetime has ended.
- Photovoltaic modules for building integration. PV-modules provide energy and at the same time take over additional functions such as building covering or shading. They can be manufactured on demand in various sizes, and due to their "break-through security" the modules are applicable for facades as well as overhead glazings.
- Single-stage adsorption chiller working with water as cooling agent and silica gel as adsorbent agent for a low range of performance (2 to 50 kW refrigerating capacity), and based on energy supply with hot water, provided by solar panels or district heating.
- Product development for the inside thermal insulation for houses designated as having special historic status, with restrictions concerning the insulation of outer walls.

Demonstration buildings were constructed using new concepts, products and technologies developed in the research programme. Demo-projects are easy to be found with the "Buildings of Tomorrow" roadmap, which is available on the programme website [16].

4.1 Demonstration building office building: Tattendorf

The objective was to encourage (1) the sustainable production of energy, (2) the use of sustainable energy efficient technologies, and (3) the use of sustainable building materials. The clay-wood-straw passive house construction is based on prefabricating large sized modular parts. The demonstration project generated valuable findings on construction details concerning the degree of prefabrication and cost reduction for future production.

The outer surface of the building consists of biofibre-clay and a section of the facade was built as a translucent thermal insulation based on reed by way of trial. The building is characterised by a very comfortable indoor climate, having avoided the creation of substantial sources (for example glue) of synthetic VOCs.

The integrated design team used simulation methods to optimise the building as a whole. After completion, the building was equipped with sensors to measure energy performance and comfort during building operation.

Evaluation results pointed out clearly that comfort targets as well as energy performance targets were fully achieved.

Figure 5: Office building Tattendorf, construction of south facade [17].

5 Conclusions

Energy efficiency is improving fast due to the mandatory requirements set by the building codes which have been revised in the course of the EPBD implementation. Awareness raising programmes such as the EU-funded GreenBuilding project have contributed to lowering the barriers for owners and developers to become familiar with energy efficiency aspects. Voluntary comprehensive building assessment schemes such as the Austrian klima:aktiv building standard address quality aspects beyond the energy sphere and contribute to constantly improving building quality not only in terms of energy efficiency but also regarding renewable energy use, indoor air quality, and other quality criteria. In Austria, the combination of mandatory and voluntary instruments, research funding and subsidies has resulted in energy savings and improved building quality. However, constant improvement never ends, because the best available standard is defined in relation to what is technically feasible and economically reasonable. Therefore targets and indicators of sustainable building assessment schemes are changing with the progress they cause, and vice versa. Thus, the next major revision of building assessment schemes is pending, also in the light of the EPBD Recast [18]. Among others, the term "nearly zero energy buildings" still poses a challenge for method development regarding the balance of energy flows in a building. However, work can build upon ongoing research activities, such as Task 40 "Towards Net Zero Energy Solar Buildings" carried out in the Solar Heating and Cooling programme of the International Energy Agency [19]. Requirements of the EPBD Recast will also activate further development of comprehensive building assessment schemes and facilitate the transition towards a sustainable building sector.

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