Nachhaltigkeit Massiv - Scientific fundamentals for the further development of solid building

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Abstract

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The Austrian Association for Building Materials and Ceramic Industries has decided to reposition the products and services of its affiliates in the context of sustainable construction and energy efficiency on a scientific foundation. For this the research initiative "Nachhaltigkeit massiv" ('Solid Sustainability') was started. The aim is to create a base for the further technological development of the products and services of the companies in building materials and ceramic industry and of the overall construction industry respectively. One essential instrument is the further development of the sustainability assessment tool Total Quality Building (TQB) in a comprehensive sustainable way i.e. considering the ecological as well as the economic and social dimension.

Comprehensive assessment over the entire life cycle

The comprehensive assessment of the entire life cycle is the challenge of the standardization committee CEN TC 350 [1]. As a result of our research initiative "Nachhaltigkeit massiv" (Sustainability in the field of solid building construction) it turned out that it is as extremely ambitious to evaluate buildings based on the life cycle idea.

Total Quality Building TQB is an instrument developed in Austria and based upon the results of the global Green Building Challenge [2]. The rating system in "Total Quality Building works with specific targets for each assessment criterion. For each criterion, a goal is defined, which sets the desired quality. The stated objectives are planning objectives to be achieved. These objectives were developed for Austrian conditions. The criteria are in nine groups: ressources, burden on humans and the environment, comfort, lifespan, security, quality of planning, construction quality, infrastructure and costs. TQB was discussed and improved now together with representatives of the building industry within the project "Nachhaltigkeit Massiv" and linked together with the building standards of the Austrian climate protection initiative, klima:aktiv [3]. Aim of the project is to position TQB as the Austrian way for sustainable building assessment and to further develop it to improve its usability and dissemination in the building sector.

By this, „Nachhaltigkeit massiv" [4] demonstrates on the one hand new methodical approaches for unanswered questions, such as how to include the life time of construction parts or how to comprise the ecological stresses of the transports from the factory gate to the construction site. On the other hand it becomes apparent that implementation of all these indicators in existing building evaluation

[1] http://www.cen.eu/cen/Sectors/TechnicalCommitteesWorkshops/CENTechnicalCommittees/Pages/default.aspx?param=481830&title=CEN/TC%20350
[2] www.greenbuilding.ca
[3] www.klimaaktivhaus.at
[4] www.nachhaltigkeit-massiv.at

systems is only insufficiently possible. Both the data basis as well as the question, which indicators should be selected and how the indicators should be weighted, show shortcomings.

For the building and construction industry it is of greatest importance to further develop existing building evaluation systems towards a simple instrument for the measurement and communication of the ecological, economic and social sustainability of buildings. It should also be mentioned, that what thereby is meant by sustainability, can differ highly. Investors, as well as funding agencies need information instruments that facilitate simple “ratings”. In contrast to this, scientists long for transparency, which means data should not be aggregated. If aggregations are made, they have to be done in an effect-oriented way and on a natural scientific basis.

An essential basis for each evaluation system representing the „Integrated Performance of Buildings“ is the all-embracing life cycle analysis on product level. Need for action does not only exist due to their requirement in the framework of building evaluation systems, but also due to the expected (economic) impacts of the use of resources on a global level as well as due to the directive of construction products. Manufacturers, who have the required information, are hence also able to recognize existing potential for the optimisation of their products and production processes.

The generation of additional data, however, is only then effective if the derived information thereof is interpreted correctly and if the products and construction methods can be improved by this information.

The life span of components as a parameter for life cycle cost forecast

The life span of buildings, components and materials influences the environmental quality of buildings to a large extent. It is therefore an important aspect in both the ecological and the economic life cycle analysis of buildings. Matching the service life of construction products and components on the estimated useful life of the building can save resources and reduce life cycle costs.

If planners should take into consideration these aspects they need reliable data. Existing information about expected service life span is mostly based on experience from experts. In many cases the definition of what is really meant by an expected service life is not clear enough. A review of the published literature about expected life time of construction products and components makes it obvious that there is uncertainty regarding expected service life [5]. For those reasons it is not foreseen to take into account renewing of components in the simplified environmental balance method which is used until now in the criteria system for subsidies in Austria, the OI3 index. So the environmental impacts that occur when components such as façades, windows or roof covering must be renewed after expiry of its life are not included. But it makes a difference whether e.g. a façade must be renewed after some years or not.

Therefore within the research initiative a general model was developed, demonstrating how more precise data about expected service life could be generated. This aging model makes a difference between particular installation conditions and makes use of the ISO 15686-factor class approach. [1]

In ISO 15686-2, Buildings and Construction - design lifetime, the following definition can be found:
service life - SL: defined as the lifetime of that period in which a building component or building product meets the defined requirements

[5] BTE 2008: Agethen et al: „Lebensdauer von Bauteilen, Zeitwerte“., 2008
GFÖB 2004: Rudolphi et al: “Projektteil Lebensdauer und Instandhaltungszyklen”. 2004
IFB 2004: Arlt und Pfeiffer: „Lebensdauer der Baustoffe und Bauteile zur Harmonisierung der wirtschaftlichen Nutzungsdauer im Wohnungsbau“. 2004
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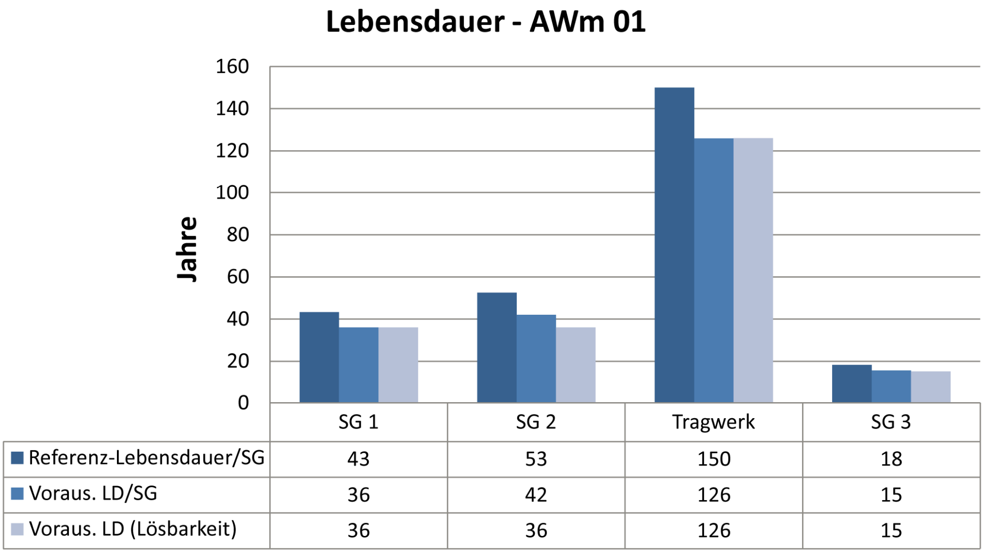
SIA 0123 2008: www.bauteilkatalog.ch
SV Stmrk+Ktn 2006: Ahlgrimm-Siess et al: „Nutzungsdauerkatalog baulicher Anlagen und Anlagenteile“. 2006
WertR 2006: „Wertermittlungsrichtlinien 2006 – Technische Lebensdauer von baulichen Anlagen und Bauteilen“

reference service life - RSL: Reference service life is that life, which can be expected under a given reference installation condition, also serves as a baseline for the lifetime prediction using the factor method
estimated service life - ESL: The method using the factor to calculated life
design life - DL: planned life of the works

The general aging model can be explained by the example of a reinforced concrete outer wall with a thermal insulation system.

Schicht-gruppe (SG)	Bezeichnung	Referenz-Lebensdauer/SG	Faktorwert/SG	Voraus. LD/SG	Lösbarkeit	Voraus. LD
1	Silikatputz	43	0,83	36	SG 1 - SG 2 lösbar/nicht lösbar	36
1	Putzgrund (Silikat)	43	0,83	36		36
1	Glasfaserarmierung	43	0,83	36		36
1	Klebespachtel	43	0,83	36		36
2	Dübel kompl. 38cm	53	0,80	42	SG 2 - TW lösbar	36
2	Polystyrol expandiert (EPS) -F-Fassadendämmplatte 27 cm	53	0,80	42		36
2	Klebespachtel	53	0,80	42		36
Tragwerk	Normalbeton	150	0,84	126	Tragwerk	126
Tragwerk	Armierungsstahl	150	0,84	126		126
3	Gipsspachtelung	18	0,84	15	SG 3 - TW lösbar	15



Picture 1: The pictures show the reference lifetimes (Referenz-Lebensdauer) and the estimated service life (Voraus. LD) of layer groups (Schichtgruppe, SG), based on the example of a reinforced concrete outer wall with a thermal insulation system. Taking into account if layers can be seperated or not (Lösbarkeit) gives the final result of the estimated service life (Voraus. LD) of the construction as it will perform in practice.

The aging model shows how realistic assumptions for life-cycle assessment can be determined as part of building rating systems. For the broad application reference lifetimes (Referenz-Lebensdauer) would be needed for all used products for a defined installation condition. The determination of the factor value (Faktorwert) per layer group can be done by a descriptive assessment according to the factor method of ISO 15686.

Building component	**reference service life**
Concrete screed	60
Adhesive bridge	50
Lime plasters outside	70
Resin	50
Vertical perforated brick	100
Mudbrick	100
Aerated Concrete	100
Vapour barrier PE	50

Table 1: Examples for reference service life, results from the review: the average maximum value [2]

The benefits of durable building products could be highlighted by the inclusion of a calculated life span (estimated service life) in the building's rating. If that is the case, measures should be taken that the estimated service life can be reached. Hence, quality management would be a prerequisite to achieve the reference lifetime. An unanswered question until now is which institution should manage the necessary databases.

Cost forecast for the life cycle

In the development of buildings the investment costs in many cases are the key decision criterion. By this, it is not sure, that construction methods are chosen that cause minimum cost in the whole life cycle. Until now methods for a life cycle cost forecast are not used frequently, because they seem to be too complicated or due to other reasons.

Within the research initiative Nachhaltigkeit Massiv a method was developed which should be as simple as possible. It should be possible to compare variations in the design of the buildings, and the outer shell of the building and thus the life-cycle costs of a building optimized for a given use.

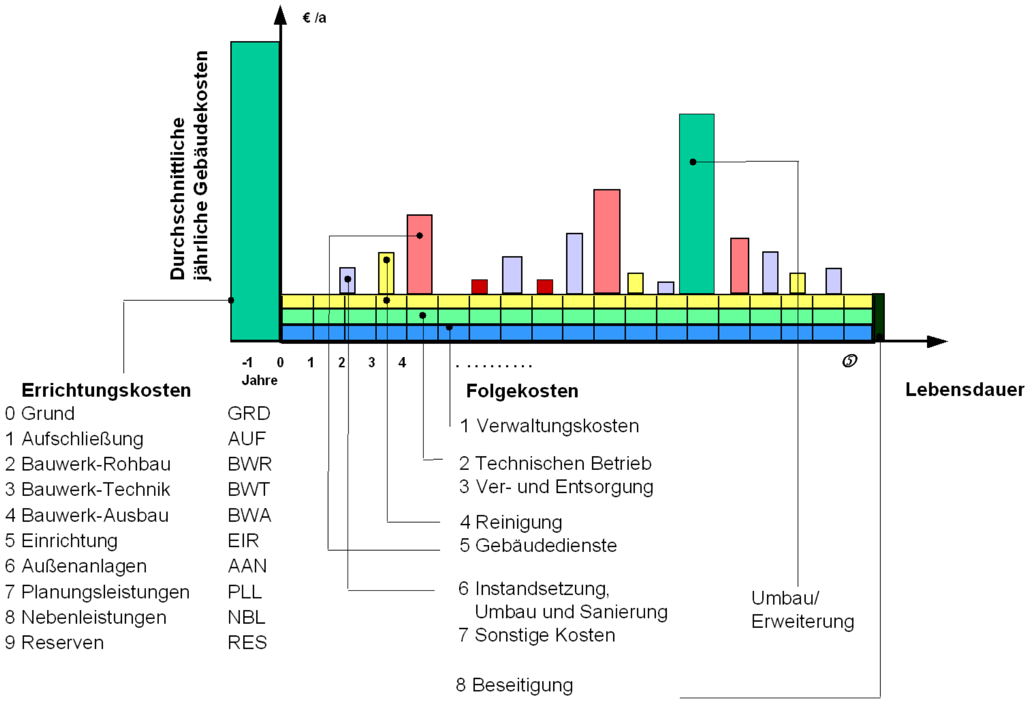


Figure 2: The elements of the life-cycle cost forecast [3]

Average annual building costs (Durchschnittliche jährliche Gebäudekosten)

Building costs (Errichtungskosten)

Costs for operation, maintenance and other costs (Folgekosten)

Life span (Lebensdauer)

A practicable tool for calculating the lifecycle costs of real estate for use in the project development was developed. The model is based on existing standards and methods of calculation:

· Model of a life-cycle cost forecast by 12 major groups and 54 (or 39 "true") costs groups
· Detailed analisys of the annual and long term costs
· Input parameters: geometry data from the draft plan
· prices for technical building equipment and running costs from energy pass calculation
· Cleaning costs will be calculated from the available data

The model was validated for an existing three-story office building in steel construction with 5,500 m² of gross floor area. The results were compared with a not realised variant, the same building with a massive outer wall (façade) and the results compared. The Life-cycle assessment turns out the version with the massive façade by 9.6% cheaper.

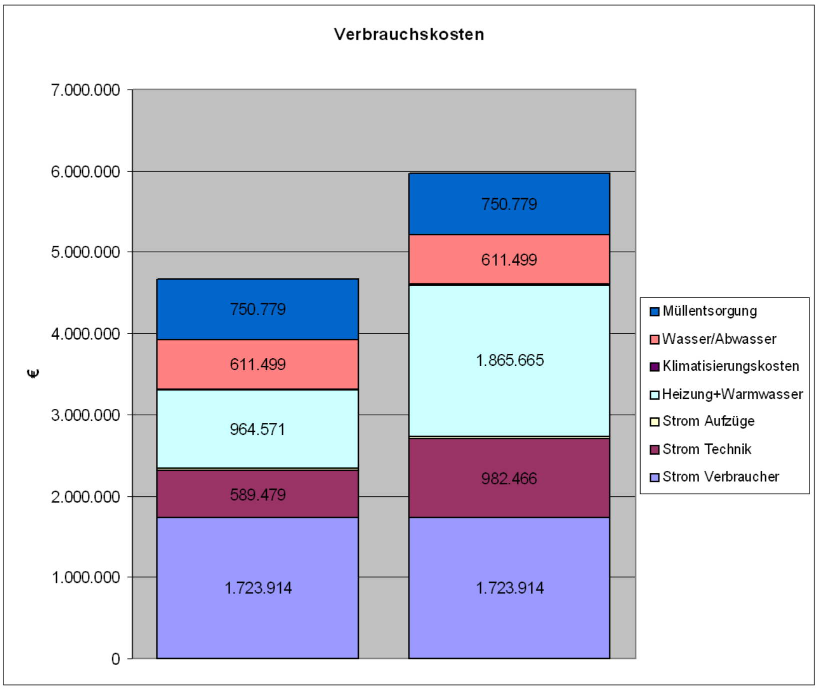


Figure 3: Consumption costs: the result shows that the massive variant could bring a considerable reduction of heating and cooling costs (-49.8%) and a reduction of building-related cost of electricity is (-36.4%) compared to the realised version in steel construction. [3]

Consumption costs (Verbrauchskosten)
Waste disposal (Müllentsorgung)
Water / Wastewater (Wasser/Abwasser)
Air conditioning (Klimatisierung)
Heating and hot water (Heizung+Warmwasser)
Power lifts (Strom Aufzüge)
Current Technology (Strom Technik)
Electricity consumers (Strom Verbraucher)

The life cycle cost model can only provide general statements about the building (due to the chosen cost structure), component or building services optimisation is not possible so far.

The heating costs are projected only from the input heat requirement, meaning all the shortcomings of this calculation such as variation of temperatures and consumer behaviour are carried. Hereby it should be mentioned that in office buildings in many cases it is no more the heating that causes the highest energy costs, but in more and more cases cooling is even more expensive. This is why in this research initiative the reduction of overheating in summer was topic of another project [5], some results are presented below.

The life cycle cost model is elaborated also as an Excel file and can be used in the construction industry as well as by planners and in the consultancy sector.

New method for real estate assessment

If the benefits of sustainable buildings should be a decision criterion on the market, the qualities of sustainability have to be included not only in high level building assessments but also in the real estate assessment as it is used everyday all over the country. The benefits therefore must be quantified and monetized.

The project "Technical and environmental and human ecological indices as evaluation parameters for the market value of buildings" has developed a procedure, which can complete the central instrument of this research initiative, the TQB, for existing residential buildings: a criteria and indicator set for a rapid assessment of the environmental, social and economic qualities. The checklists have been compiled in such a way that the bulk of the required data can be taken from the plan documents and the Energy pass or can be covered in the course of committing. The checklists are available.

The procedure shall enable a monetary valuation of sustainability criteria in future. The hedonic pricing method is used to estimate economic values for ecosystem or environmental services that directly affect market prices. It is most commonly applied to variations in housing prices that reflect the value of local environmental attributes. This requires, however, a broad data base with demand and transaction prices, which is in preparation by now, therefore to determine prices for the various properties. Finally, the final price of the property will be the sum. Contradictions between the value that the customer is giving and the value that is foreseen in relation to the objectives of sustainability can certainly occur. A software implementation of the procedure is in preparation. Software implementation will later make use of spatial information systems to collect site characteristics. It can be assumed that with the development of this method the real estate business can be influenced to give more emphasis on the assessment of sustainability. [4]

New methods to handle overheating in summer

Thermal comfort in buildings in summer is part of the criteria in TQB as well as in other building assessments. This is of special interest, because climate change scenarios show a high probability that the summerly outdoor air temperatures in Austria will be further increasing. The rising sales numbers for small air conditioning systems are an essential factor for the consumption of electricity in the future. Hence, it is getting more important to avoid summerly overheating, especially in office buildings with large glazed facades.

Therefore an adequate verification procedure is required that also indicates correctly the differences of various construction methods. The current verification procedure for the avoidance of summerly overheating of rooms (ÖNORM B 8110-3) shows losses of air infiltration heat, internal and solar gains and the storage capacity of the building in a very simple way. Recent buildings can very easily fulfill this verification, but what in reality leads to high temperatures in the summerly heat waves. The currently most common verification according to ÖNORM B 8110-3 usually ends with the statement that summer suitability is given respectively is only given on condition of a shadow measure. A differentiate statement on the quality of the summer suitability is not being offered.

The comparison of temperature responses of the room in heat periods according to various construction methods is showing considerable differences in the operating room temperature (Figure 2).

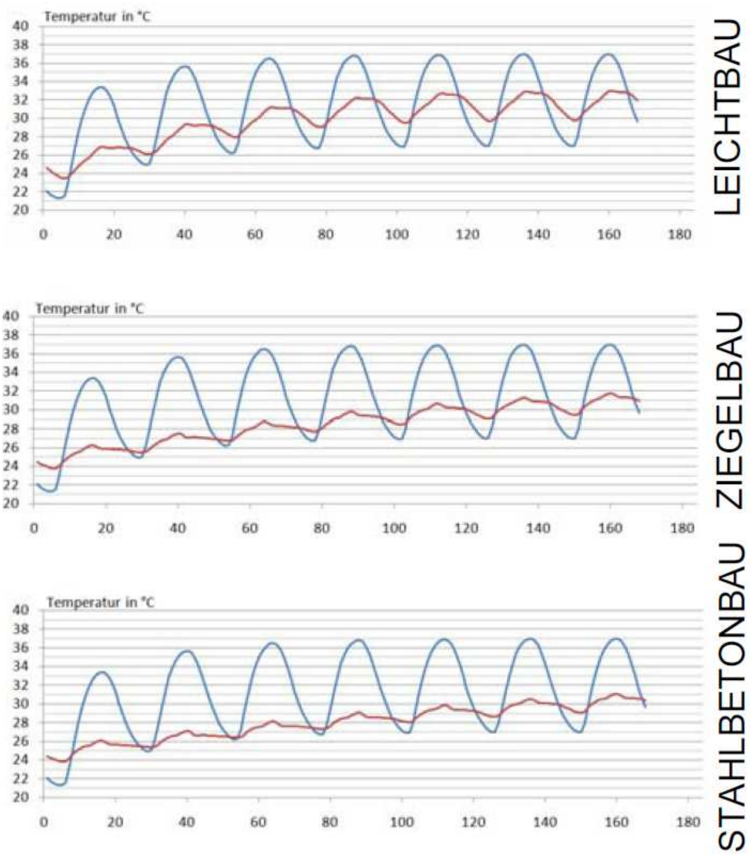


Figure 2: Comparison of responses of the room according to various construction methods (light, brick, steel, concrete) as a function of internal loads (residential or office building); with the windows closed. Blue line: temperature outside. Red line: Operating room temperature. Result produced with developed simulation tool. [5]

Reinforced concrete building (Stahlbetonbau)
Brick building (Ziegelbau)
Lightweight building (Leichtbau)

In the framework of the European standardisation a simulation of the room behaviour as a procedure for the verification of summerly room temperatures is defined (ISO 13791:2004). Thus, a revision of the ÖNORM B 8110-3 is foreseen. A proposal for the point evaluation was developed for the TQB criteria catalogue. This point evaluation differentiates as an innovation three comfort classes.
For the certification of sustainability of buildings in the field of thermal behavior in summer this shown calculation algorithm demonstrates a very good possibility, to indicate and to take in the evaluation both, minimum requirements as well as increased securities towards summerly overheating. [5]

Lessons learned

Recommendations for the construction industry are a crucial output of the research initiative. These recommendations were developed in discussion with representatives of the industry associations. The research initiative is to be seen as a starting point for an ongoing process. [6]

The building assessment Total Quality Building TQB turned out as an instrument that can be used as guideline for the improvement of building systems for the building industry and for planners. It was useful to discuss the development of the TQB together with the building industry. Generally spoken, by this Austria`s building industry has changed its attitude a little bit: Sustainability is more regarded as a challenge now. Solid building can put out it's advantages for sustainable building over the whole life cycle. Aim is not only to sell tons of material, as much as possible, but also to provide innovative solutions. It will be essential to cooperate with planners and developers more and better especially to improve the systems! Some of the results of this research initiative might be a contribution.

Further information about the project, the project management, project reports and project summary can be found on: www.nachhaltig-massiv.at

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All reports can be ordered from www.nachhaltig-massiv.at

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