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Expanding Boundaries:
Systems Thinking for the Built Environment

MANAGEMENT OF USER AND STAKEHOLDER INTERESTS IN MULTI CRITERIA ASSESSMENTS

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Abstract

Individual user and stakeholder interests in the context of project requirements and goals often lead to trade-offs; especially during the early design stage of a building. Investors for example strive to achieve a maximum sustainability assessment score on the one hand and optimized initial costs on the other. Users often prefer good indoor environment conditions and low operating costs. A systematic approach is called for in order to achieve both, a high level of stakeholder satisfaction on the one hand and a high performance in the context of sustainability assessment on the other.

We applied a new approach linking building assessment and network analysis based on the Austrian building assessment system (ÖGNI/DGNB) and using a reference project of a public office building in Austria. Giving full consideration to the individual user and stakeholder goals, the determination of sustainability performance is carried out by a scenario analysis taking into account criteria interdependency.

Depending on the investigated scenarios for improvement representing stakeholder influence, the results indicate an optimization potential of ÖGNI/DGNB target achievement between 1.3% and 5.2%.

Systemic influence caused by different optimization strategies on single assessment criteria is an important aspect for the sustainability improvement of buildings. Arising as a result of system trade-offs, inappropriate optimization scenarios – induced by users and stakeholder goals – improve the instantaneously assessed criterion but simultaneously these can lower overall building sustainability. A balanced improvement of all assessment areas is thus indispensable to ensure a high assessment level already in early planning stages and furthermore to achieve stakeholder satisfaction.

Keywords:

Systemic Approach; Sustainability Assessment; LCC; LCA; multi criteria design optimization

1 INTRODUCTION

During the past few decades various building assessment systems (e.g. LEED (Leadership in energy and environmental design), BREEAM (BRE Environmental Assessment Method) or DGNB (German Sustainable Building Council)) have been established for the assessment of buildings' sustainability. National assessment systems - for example in Austria - are DGNB/ÖGNI (Austrian Green Building Council), ÖGNB/TQ-B (Austrian Sustainable Building Council) and klima:aktiv (building and refurbishment assessment system). The quality of a building is described by individual assessment criteria in these systems. These criteria are dedicated to different sustainability targets and often related to specific audience groups (depending on the assessment system). In most of the assessment systems the included assessment criteria address more or less similar topics, however the criteria assessment method as well as the weighting algorithms behind the systems are quite different [7]. In the context of the CEN/TC 350 assessment concept, sustainability assessment systems [4] should cover a broad range of environmental, social and economic aspects as well as functional and technical performance.

A comparison of current assessment systems showed the advantages of DGNB/ÖGNI system in context with the main goals of this study. This assessment concept is in line with the most recent concept of CEN/TC 350 and is even more a performance based approach [14], [15], [21]. This performance-based approach is the foundation for highlighting the quantitative and systemic consequences of stakeholder decisions during the planning process. In other words, achieving a high quality building is closely and strongly related to a balanced improvement of building sustainability taking into account all categories of sustainability assessment.

The current lack in suitable methods for the estimation of change in building sustainability due to stakeholder decisions is often associated with relatively high efforts in early planning phases [14]. Current optimization strategies are thus often based on singular issues disregarding effects of possible criteria interdependencies. [1], [9], [13], [18]. The improvement of building sustainability could not be fully exhausted; in the worst-case scenario building sustainability decreases.

A systemic approach is a requirement in order to ensure implementation of stakeholder decisions next to high sustainability performance of a building. Based on a systemic approach the behaviour of ÖGNI assessment and final energy demand due to variation of several design measures is presented in [14]. In this article the results achieved by stakeholder analyses (represented by scenario analyses of investigated measures in [14]) are presented.

2 METHODS

Systemic thinking (i.e. systems engineering, building cybernetic, etc.) is gaining ever more attention – not least in the construction sector - as a result of the increasing complexity caused by multi criteria assessments in the sustainability improvement process of buildings, [6], [12], [20], [22]. Several systemic approaches to identify correlations of sustainability-criteria have been developed and described [2,6,16,17]. Current works covering important aspects in context with systemic building improvement are described in [1], [2], [10], [11], [23].

The studies on multi optimization approaches described show that most of the current methods in hand are only partly suitable for application to holistic building improvement using building assessment systems. They do not permit an optimization approach covering both estimation of optimization scenario influence on overall building sustainability and (varying) stakeholder objectives by highlighting their system interdependencies.

A new systemic approach to improve the sustainability performance of office buildings in the early design stage is presented in [14] and applied to show the systemic behaviour caused by varying stakeholder interests in context to sustainability assessment.

2.1 Systemic approach

The approach defines the quality of building as an open, dynamic system [19]. The term "dynamic" represents life cycle approach; the term "open" is associated with variable stakeholder objectives.

The applied methodological approach for systemic improvement of building performance includes 6 main steps. The identification of ÖGNI assessment criteria role is implemented using the sensitivity model of Vester [20] identifying the "key"-criteria and the different roles of the assessment criteria (step 1). During the planning process knowledge about the influence of single measures on the sustainability performance of building is of key interest. Appropriate construction measures for optimization must be carried out by a prior semi-quantitative assessment of building sustainability based on a reference building (step 2). One the quantitative (results from LCCA (Life Cycle Cost Assessment) and LCA (Life Cycle Assessment)) and qualitative optimization potential and the behaviour of sustainability criteria (from Vester-analysis) are known and established possible optimization measures can be defined (step 3). The identification of systemic influence of each measure is then identified by a subsequent project specific systemic evaluation due to network-analysis (step 4). Finally, after identification of the holistic influence single measures have on building sustainability assessment (step 5) the influence of stakeholder interests is investigated (step 6). The investigated single measures are thus combined to scenarios that fulfil stakeholder goals best possible. Due to understanding the systemic behaviour of single measures possible trade-offs can now be highlighted and considered during the further planning process.

2.2 Case Study

The methodological approach has been applied to a case study. The investigated building is part of a renovated building complex in the centre of Graz, owned and operated by the Styrian LandesimmobiliengesellschaftmbH. Tab. 1 provides an overview of the key building parameters (in acc. to [14]).

Parameter	Description
Size	Appr. 2.300 m^2 (gross floor area)
Floors	5+1 / reinforced concrete
Facade	Concrete, bricks, Thermal insulation composite system, double glazing-iso with aluminium frame
Energy certificate	B (39 kWh/m^2*a) n acc. To standard H5055
S/V-ratio	0,21 [m^{-1}]
HVAC	District heating / Convectors, manual ventilation, hot water supply (ground floor: central; upper floors: instantenious water heater), no cooling supply with exception of multi-functional room (multi split air conditioning)
Mean U-value	0,565 [W/m^2*K]

Tab. 1: Key parameter of case study.

The semi quantitative sustainability assessment is based on the building assessment system of ÖGNI (usage type – office and administrative buildings) [16]. Tab. 2 gives a short overview of the sustainability criteria and their weighting as a basis for further investigations.

LCA	Life Cycle Assessment	13,5%
C6	Risks to the local environment	3,4%
C8	Sustainable use of resources / wood	1,1%
C14	Drinking water demand and volume of waste water	2,3%
C15	Space demand	2,3%
LCCA	Building related life-cycle costs	13,5%
C17	Suitability for third-party use	9,0%
C18	Thermal comfort in the winter	1,6%
C19	Thermal comfort in the summer	2,4%
C20	Interior air hygiene	2,4%
C21	Acoustic comfort	0,8%
C22	Visual comfort	2,4%
C23	User control possibilities	1,6%
C24	Quality of outdoor spaces	0,8%
C25	Safety and risk of hazardous incidents	0,8%
C26	Handicapped accessibility	1,6%
C27	Space efficiency	0,8%
C28	Suitability for conversion	1,6%
C29	Public access	1,6%
C30	Bicycling convenience	0,8%
C31	Assurance of design and urban development quality in a competition	2,4%
C32	Percent for art	0,8%
C33	Fire prevention	4,5%
C34	Sound insulation	4,5%
C35	Quality of building envelope with regard to heat and humidity	4,5%
C40	Ease of cleaning and maintenance	4,5%
C42	Ease of dismantling and recycling	4,5%
C43	Quality of project preparation	1,3%
C44	Integral planning	1,3%
C45	Optimization and complexity of planning method	1,3%
C46	Evidence of sustainable aspects in call for and awarding of tenders	0,9%
C47	Creation of conditions for optimal use and management	0,9%
C48	Construction site / construction process	0,9%
C49	Quality of contractors / prequalification	0,9%
C50	Quality assurance for construction	1,3%
C51	Commissioning	1,3%

Tab. 2: Assessment criteria (in acc. to ÖGNI).

A preliminary assessment of the building showed a quantitative optimization potential for construction work areas “Façade” and “Technical Building Services”. Through system analysis criteria C35 and C10/11 (representing primary energy demand as a part of term “LCA” in Tab. 2) has been identified as “systemic suitable criteria” for further optimizations (in acc. to [20]). In a next step, appropriate optimization measures have been identified. In total 25 different variants were analysed and dedicated to the following optimization measures [14]:

- Thermal insulation - facade
- Thermal insulation - roof
- Windows
- Thermal insulation - ceiling above passage
- Lighting
- Ventilation
- Heat generation
- Heat supply
- Hot water
- Cooling
- Shading + glazing
- Power generation

Due to the active and critical system influence [20] of the chosen optimization criteria a project specific network analysis was carried out to identify the chain of causes and effects for the measures described.

2.3 Stakeholder Scenarios

Construction measures are combined to different optimization scenarios based on the primary optimization goal of individual stakeholders. Depending on the type of usage (i.e. for investment, for private use or for rent, etc.) and the associated optimization strategy, those indicators are defined that need to be optimized.

Tab. 3 gives a short overview of the investigated scenarios. Scenario 2 represents the reference case (as the case study is built) where no optimization indicator has been dedicated.

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Stakeholder scenario	Optimization goal	Performance indicator	Unit
S 1	Short-term return	Initial cost	EUR/m2
Case Study (S 2)	-	-	-
S 3	short- to medium-term reduction of operating cost	Heating demand	kWh/m2
S 4	short- to medium-term reduction of operating cost incl. Improved comfort	Heating demand	kWh/m2
S 5	long-term reduction of energy consumption	Final energy demand	kWh/m2
S 6	long-term reduction of environmental impact	LCA performance	%
S 7	long-term reduction of of economic impact	LCCA performance	%
S 8	Increase of social perfomamce next to reduction of economic impact	User benefit	%
S 9	Reduction of environmental and economic impact	LCA+LCCA performance	%
S 10	DGNB/ÖGNI performance	DGNB/ÖGNI assessment	%

Tab. 3: Stakeholder scenarios.

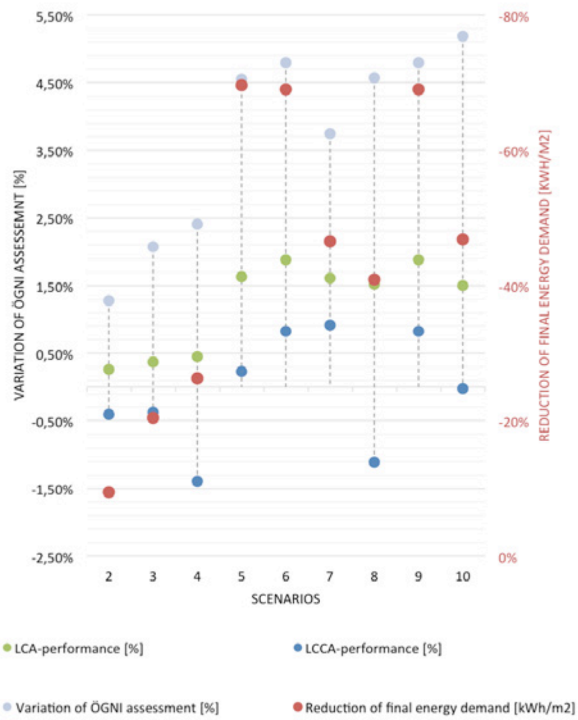

Fig. 1: Influence of stakeholder scenarios on building performance.

3 RESULTS

The evaluation of the optimization potential of each scenario is compared to a reference scenario (=scenario 1) which represents minimum requirements in the context to legal energy efficiency standard (see OIB-Richtlinie 6 [17]; HWB* (Heating demand) and KB* (Cooling demand)). Also with regard to technical building services, the reference scenario is characterized by the fulfilment of minimum requirements and is therefore designed as "initial cost optimum building".

Fig. 1 shows the variation of the ÖGNI assessment in the categories LCCA, LCA and ÖGNI overall assessment. In the context of European H2020-targets [8] the results are additionally compared to a possible reduction of final energy demand and related to reference scenario 1 .

In dependence on the optimization strategy, the results show a relative reduction potential of final energy demand from 9.5% to 69.6%. An improvement of 2.2% to 16.2% compared to the reference scenario is possible in the assessment category "LCA" [3], [5]. ÖGNI assessment (representing the term "variation of ÖGNI-assessment" in Fig. 1) can be increased between 0.3% and 1.9 %. By contrast LCCA [12, 13] indicates trade-offs (variation from -11.5% to 7.5%). The ÖGNI assessment varies from 1.4% to 0.9% in total.

By considering systemic effects of all criteria based on the investigated strategies and compared to the reference case, the ÖGNI assessment can be improved from 1.3% to 5.2%.

4 DISCUSSION

Depending on the primary goals of building performance optimization and in order to manage stakeholder trade-offs in the specific decision making process the results in Fig. 1 are discussed in exemplary form in scenarios 5 and 6 both of which represent public interests. With regard to the European directive 2010/31/EU [8] on the energy performance of buildings scenario 5 represents energy policy objectives (i.e. covering the reduction of final energy demand). By contrast scenario 6 represents environmental policy targets (reduction of global warming, reduction of primary energy demand, etc.) The results show that reduction of final energy demand is in line with improvement of LCCA

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performance of the building even in scenario 6. This is due to the implicit consideration of final energy assessment in LCA and the importance of energy impact in the use phase of the building. In this case scenario 6 is recommended for further investigations due to negligible difference between the final energy reduction and the improvement strategies that have been considered. Furthermore, scenario 6 results in a lower initial investment together with a significant reduction of LCC to reach the described optimization targets. The overall assessment almost equals the results for the balanced improvement (see scenario 10). A consideration of the other strategy results shows that any potential improvements from focusing on the parameters “initial cost”, “heating demand” and “customer benefit” are less suitable for implementation in the context of the given stakeholder goals.

The results show, however, that a balanced improvement for highest sustainability performance must not necessarily go hand-in-hand with achievement of the highest energy reduction or the highest reduction of environmental impact. Those decisions with the scenario potential for implementation in practice will at least be based on the willingness of the stakeholders to find a consensus within often complex and specific project conditions.

The advantage of the methodological approach presented is the supporting and managing of multi criteria decisions by providing the systemic and holistic impact of different optimization strategies.

5 CONCLUSION

Systemic influence caused by different optimization strategies on single assessment criteria is an important aspect for the sustainability improvement of buildings. Building assessment combined with a systemic approach is an appropriate method for improving building sustainability. Inappropriate optimization scenarios resulting from system trade-offs – induced by stakeholder goals – improve the immediately assessed criterion but simultaneously can lower overall building sustainability. A balanced improvement of all assessment areas is thus indispensable for ensuring a high assessment level already in early planning stages and also for achieving user and stakeholder satisfaction.

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