SPATIAL QUALITY INDICATORS FOR ENERGY RENOVATION OF RESIDENTIAL BUILDINGS

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Summary

This paper consists of the conclusion of the first part of the on-going PhD research: the crossing between spatial quality definition on building scale, energy renovation measures and building performance assessments. The current paper presents the results of a *search for* and an *evaluation of* available indicators that best represent perceived spatial quality, with particular weight on energy renovation. The results of the analysis of the available spatial quality indicators show a significant potential for improvement of the indicator's basic scientific characteristics (validity, specificity, sensitivity and reliability) in assessing spatial quality. That is the indicators on spatial quality are entirely to be developed. Improved spatial quality gives decision-makers, politicians and building owners solid argumentation for increased investments in energy efficiency, making a highly visible contribution to the attractiveness and public image of a building block, as well as people's every-day life, well--being and health. This is, however, only possible if objective, measurable spatial quality indicators, assessment and design methods are available for decision-making. By stressing the architectural and user value of energy efficient renovation, this research thus aims to contribute to widespread implementation of energy efficiency goals in building performance assessments. This paper forms part of PhD research project *"Definition, Assessment and Implementation of Spatial Quality Parameters in Energy Renovation of Residential Buildings",* aiming to contribute to decision-support for the design of energy-efficient built environments with high spatial quality. The main aim of the PhD is to propose a clear definition of spatial quality to be considered in energy renovation; and to develop practical indicators to assess spatial quality parameters on building scale.

Keywords: spatial quality indicators, energy efficiency, building renovation, residential buildings, building performance assessments

1 Spatial Quality Definition

One of the goals of this paper is to present the definition of spatial quality parameters for energy renovation of residential buildings, and their in- and outdoor environments. The concept of spatial quality is usually handled on the macro scale of the city. But deeper study on both literatures on architecture and environmental aesthetics showed that there are spatial quality parameters, which clearly address the micro scale of the building. Rapoport (1969, 1994), Alexander (1977, 1979) and Gehl (2010, 2011) are the main authors considered for the study. The following parameters are the result of the literature study on the definition of spatial quality:

1. Views, isolation and contact (access to external views and visual privacy);
2. Internal and external spatial arrangements (daylight conditions);
3. Transition between public, semi-public, semi-private and private domains (availability of semi-public/semi-private spaces and private outdoor space);
4. Perceived density (high degree of enclosure and intricacy of spaces).

The next step is to relate these four perceptual parameters to physical measures for energy renovation of residential buildings, for buildings components as floors, walls, roofs, windows, double skins and mechanical services (see tab. 2). In order to start this work, first a review has been made of how the parameters are represented in three building performance assessments (see tab. 1 for the SBTool assessment).

2 Tools for building performance assessment

After defining the spatial quality parameters on building scale through literature study (column Literature Study on Spatial Quality Definition of table 2), the next step was to analyse the energy renovation measures for residential buildings (column Energy Efficient Measures for Sustainable Refurbishment of table 2). The goal was to identify the measures that directly affect the spatial quality parameters. Subsequently the availability was checked of assessment systems those consider and/or evaluate the impact of such measures on the spatial quality parameters (column Building Performance Assessments of table 2). Thus the result of the initial literature study on spatial quality guided the later selection of the building assessments indicators to be further considered in the research.

The table 2 partially presents the results of the first part of the research. The table shows an example of the sort of relations identified between literature on spatial quality, energy renovation measures and building performance assessments. The example shows the relation between the energy renovation measure of *reduction of aperture* on the building component *windows*, the spatial quality parameters of *views, contact and isolation*, and the indicators belonging to the building performance assessments SBTool (indicator F1.3/F3.7), BREEAM (indicator Hea 2.) and LEED (indicator IEQ Credit 2.4). These indicators are considered to fulfil the assessments on visual contact and consequently the level of privacy, field of vision, overview and light access (Rapoport 1969, Gehl 2010).

The study was made for all the building components of floors, walls, roofs, windows, double skins and mechanical services. The indicators of the SBTool assessment related to the parameters of spatial quality are partially described in table 1.

The first and main assessment tool analysed in this study is the SBTool Generic system (version of 2012), which is “a generic framework for building performance assessment that may be used by third parties to develop rating systems that are relevant for a variety of local conditions and building types” (Larsson 2012). The secord tool considered is the BREEAM for Major Refurbishment (2008), which consists of an assessment method for sustainable refurbishment projects (BREEAM website). The last tool analysed is the LEED (2009), which is an assessment program for “third-party verification of green buildings” (LEED website) (see tab. 1)

3 Conclusions

The available spatial quality indicators belonging to the three building performance assessments SBTool 2012, BREEAM 2008, and LEED 2009 analysed in this study do not

offer an effective assessment of the spatial quality parameters considered (see section 1). However there is clearly a considerable potential for improvement of the indicator's basic scientific characteristic of validity, specificity, sensitivity and reliability in the existing indicators in order to assess spatial quality. The danger of underdeveloped indicators is that spatial quality will essentially depend on the judgment and awareness of the architect and stakeholders involved in the renovation of the building. This may lead to fragmented measures that do not recognise the relevance of spatial quality neither promote its inclusion in building renovation. This inclusion is, however, only possible if objective, measurable spatial quality indicators, assessment and design methods are available for inclusion in decision-making tools for energy efficiency renovation.

The deficiencies of the available indicators on spatial quality were identified in this first part of the PhD research. In the second part the goal is to develop and propose spatial quality indicators to be included in the building performance assessment SBTool. The third part of the PhD research will consist of the evaluation of the indicators proposed in the second part. The goal is to clearly integrate spatial quality assessment in the energy renovation. Methods that can be used to assess the spatial quality parameters will be analysed, and their potential will be explored for further use in the development of indicators.

Tab. 1 *Relation between spatial quality parameters and the building assessment SBTool (2012).*

Building performance assessments	**(Perceived) Parameters – Building/Building Block Scales (micro scale)**		
	Views Isolation/Contact	**Internal/External Spatial Arrangements**	**Transition Public/ Private Domains**
SBTool (2012) Indicative: Indoor Environmental Quality	SBTool F1.3 Visual privacy in principal areas of dwelling units. Indicator: The percentage of dwelling units with exterior views. SBTool F3.7 Access to views. Indicator: Visual quality	SBTool F1.2 Access to direct sunlight from living areas of dwelling units Indicator: The percentage of dwelling units whose principal daytime living areas have direct sunlight for at least 2 hours per day	SBTool F1.4 Access to private open space from dwelling units Indicator: Minimum area and dimensions, in m

4 Future application in case studies: FP7 project ZenN Nearly Zero Energy Neighbourhoods (2013–2016)

This research is connected to ZenN project "Nearly Zero Energy Neighbourhoods" funded by the European 7th Framework Programme. The ZenN project aims to promote energy efficiency renovation both at district and building level and to replicate this experience around Europe. ZenN will support demonstration cases in Norway, Sweden, France and Spain. The PhD research is planned to link to Work Package 4 "Non-Technical Drivers", which concerns to main non-technical issues related to architectural and cultural values, social and financial barriers. In addition the WP4 promotes the engagement of users to ensure the success of strategies for energy efficiency, and the optimization of synergies between energy efficient strategies considering the quality of the urban environment. The PhD research will concentrate mainly on ZenN cases in the Nordic context, i.e., Oslo and Malmö, with a possible transferability to other European cases.

Tab. 2 *This table express the crossing between Efficiency Measures for Sustainable Refurbishment, Literature Study and Building Performance Assessments. Example of Building Component: Windows, and Spatial Quality Parameter: Views Isolation/Contact.*

Spatial Quality - Literature Study - Energy Renovation - Building Performance Assessments			
		Spatial Quality Parameter: Views, Isolation/ Contact	
Energy Efficient Measures for Sustainable Refurbishment		**Literature Study on Spatial Quality Definition**	**Building Performance Assessments: SBTool (2012)/ BREEAM (2008)/ LEED (2009)**
Windows	**Reduction of aperture area** (reduction of heat loss and unwanted solar gain, provision of more wall space for furnishings and equipment)	**Reduction or increase of aperture area, or changing the distribution of glazing by making new apertures are related to** *psychological effects of unwanted sensory interaction with other people, equivalent to loss of privacy (privacy levels)* ***(Rapoport, A.)*** *Field of vision, overview and light/ hindered line of vision/ visual contact on street level/ protection of the private domain (privacy levels)* ***(Gehl, J.)***	***SBTool F1.3*** ***SBTool F3.7*** ***BREEAM Hea 2.*** ***LEED IEQ Credit 2.4***
	Increase of aperture/glazed area to improve daylight conditions as a last option		
	Changing the distribution of glazing by making new apertures to improve daylight distribution		
	Implementation of shading to reduce the quantity of radiation and to redistribute daylight	**Implementation of shading related to** *psychological effects of unwanted sensory interaction with other people, equivalent to loss of privacy (privacy levels)* ***(Rapoport, A.)*** *Field of vision, overview and light/ hindered line of vision/ visual contact on street level/ protection of the private domain (privacy levels)* ***(Gehl, J.)***	***SBTool F1.3*** ***SBTool F3.7*** ***BREEAM Hea 2.*** ***LEED IEQ Credit 2.4***
	Implementation of external shading which can be fixed, adjustable or retractable		
	Implementation of internal shading		
	Implementation of interpane shading		
	Implementation of integrated shading (address daylight distribution function as well as selective shading)		

References

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[6] Use of the following web-sites: iiSBE web-site: *www.iisbe.org*, BREEAM web-site: *www.breeam.org* and LEED web-site: *new.usgbc.org/leed*.