Architectural Strategies for Long-Term Obedience to Increasing Building-Constructive Energy Performance Requirements

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Summary

Two findings in the building industry are considered: the ever increasing statutory energy performance requirements and the urge for 'future-proofing' buildings, both as part of the sustainability quest. It is argued that contemporary renovated and new buildings do not anticipate future building-constructive statutory energy performances. These buildings mean a dragging legacy for sustainability-related and more specific energy-related matters.

The paper advocates that a building-constructive 'futures-thinking' in view of the energy performance is needed. To facilitate, an explicit low-complexity framework of architectural strategies enabling building envelopes long-term obedience to increasing energy performance requirements is provided. Three strategies constitutes the framework: outperforming current statutory requirements; building with adaptive ability; and a mixed mode, partly outperforming and partly adaptive. For each architectural strategy, a tentative anatomy of design decisions and design amenities is introduced, leading to a knowledge map. Based on first reflections, hot spots for future research and development are identified.

Developed tentative framework is promising for: first, researchers to identify and position future research; and second, architecture students, early-career and unexperienced practicing architects to guide design decisions in view of aimed design amenities. As long as outstanding energy performances are not obliged, provided, verified and supplemented framework means an interesting and designated transitional.

Keywords: framework, architectural strategies, future-proofing, building-construction, energy performance requirements

1. Introduction

Futures thinking in architecture is on the agenda of the building sector for many decades. The awareness of changing needs and requirements in view of efficiency and effectiveness regarding practical functionalities and building performances, and ultimately financial investments, underlines the need for 'future-proofing' built works of architecture. Looking at the Brundtland Commission's definition of a sustainable development [1], it is clear that futures thinking is inextricably linked with sustainability: '"sustainable development seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future". The urged relation with the sustainability quest has been leading to an increased attention for futures thinking in architecture both in research and in practice.
While discussing 'future-proofing' within the sustainability quest in architectural projects, design

teams, but also state-of-the-art literature, hold a rather narrow approach. Univocally, reference is made to the ability of the project to adapt to changing needs in view of: first, physical-spatial aspects (e.g. extendibility, partionability, reconfigurability); and second, building-technical aspects (e.g. electricity/water/gas supply, heating, ventilation, cooling). Both aspects are predominantly related to user-bound and/or function-bound demands following often stated definitions on adaptable building like e.g.: *"providing the resident with forms and means that facilitate a fit between their space needs and the constraints of their homes either before or after occupancy"* [2]; and *"the capacity to adjust the spatial plan to variable social needs"* [3].

Climate change policies imply significant reductions of energy use in buildings. In respond to the Energy Performance of Buildings Directive (EPBD) 2010/31/EU [4], EU –member states / regions prescribe tighter energy performance standards year by year. Especially for major renovations, the increase of statutory requirements will be significant in the coming years as current standards lack tightness in comparison with those for new buildings. For instance for residential buildings in Flanders (Belgium), currently the energy performance of major renovations need to be at least E90 while for new buildings the minimum is E50 [5]. By 2050, the Flemish government wants major renovations to have an energy performance of E60 [6].
Futures thinking regarding the energy performance of the building envelope, the long-term up-to-datedness with these ever increasing statutory requirements of the building-constructive performance (e.g. insulation and airtightness), is not commonly addressed. As a result, standard-obeying artefacts are created only fit for one specific user/function. Only a small share of contemporary buildings hold an energy related future-proof design that enables meeting evolving technical requirements, maintaining market value, gratifying comfort demands, minimizing energy use and associated costs, and meeting social expectations and environmental regulations. Observed energy performances, of both major renovations and new buildings, do not anticipate unknown but certain future evolutions. This may create significant energy and sustainability challenges already within the first cycle of the building's lifespan. These architectural projects are a dragging legacy as fully future-proof buildings, referring to physical-spatial, building-technical and thus also building-constructive aspects, as part of sustainable building, are not achieved.

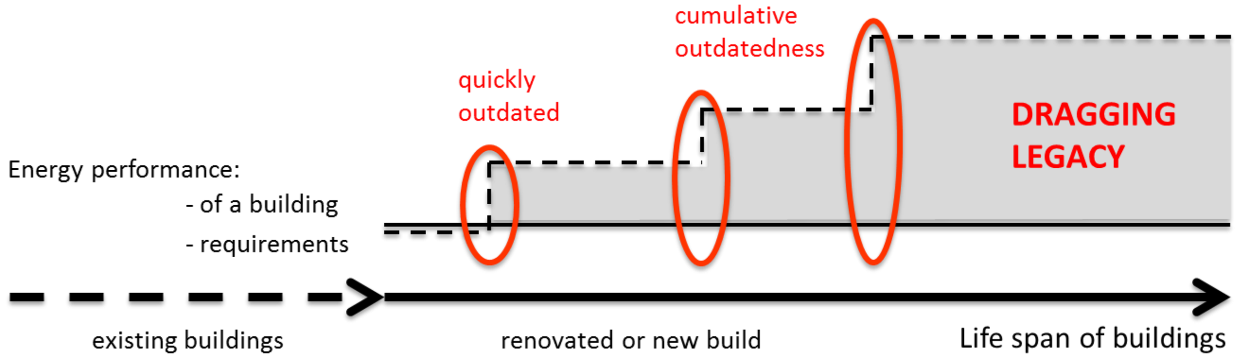

Figure 1: Illustrated problem statement, indicating the evolution of increasing statutory energy performance requirements and the dragging legacy of quickly outdated current statutory obeying buildings.

To counter this legacy this paper expands on the aspect and scope of building-constructive 'futures-thinking' in view of the energy performance. It responds to the urge addressed by Georgiadou, Hacking and Guthrie [7] that the building sector is in need of design strategies that will anticipate and proactively manage future trends and drivers affecting the energy performance of buildings; thus, representing a shift from the current prevailing 'build-it- now and fix-it-later' philosophy.

The paper introduces an explicit, low-complexity framework of architectural strategies enabling and facilitating building envelopes long-term obedience to increasing energy performance requirements. It provides an appropriate terminology and fixes a breadth-first substantiated interpretation. Supplementary, the framework introduces a tentative anatomy of each architectural strategy so researchers can identify and position future research and development, and architecture students, early-career and unexperienced practicing architects can use the framework as a knowledge map to guide design decisions from the early design stages. Following Janssens [8], the framework in this regard can be seen as a generative design support tool with a guiding nature: it supports the generation of design solutions, preceding to any kind of design, in whole or in part, in general or in detail; it guides by including shortcuts for decision-making through a lattice-like network of elements.

After this introductory section, the paper consists of three core sections and a concluding section. The second section addresses the framework of architectural strategies for long-term obedience. Section three presents the anatomical knowledge map developed. In section four, an agenda-setting outlook is suggested for possible research, development and implementation, based on a first reflection on the framework and the anatomical knowledge map.
During the oral presentation, all aspects of the paper will be discussed and illustrated in depth.

This paper must be seen as a concept paper. It is based primarily on reflection and must be verified (scientific backing). Within the scope and purpose of this paper, displayed framework and knowledge map is illustrative and thus seek by no means to be exhaustive.

2. Architectural strategies for long-term obedience

Opposed to current statutory obeying building, three architectural strategies can be determined for long-term obedience to increasing building-constructive energy performance requirements:
1. outperforming current statutory requirements; 2. building with adaptive ability; and 3. mixed mode, partly outperforming and partly adaptive. (see figure 2)

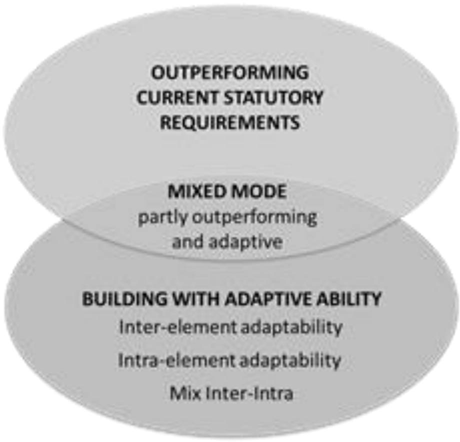

Figure 2: Architectural strategies for long-term obedience to increasing building-constructive energy performance requirements.

2.1 Outperforming current statutory requirements

Applying proper investment theory, Verbruggen [9], Verbruggen, Al Marchohi and Janssens [10], Janssens, Verbruggen and Al Marchohi [11], Al Marchohi, Janssens and Verbruggen [12] and Janssens and Verbruggen [13] show that installing the outstanding energy performance endowment is the financially sound option at first construction. It goes back to the philosophy of 'choose or lose' described by Verbruggen [9]. In contemporary building, this is currently the prevailing view to future proof the energy performance of a building. Despite this incentive, outstanding energy performance concepts are not widely adopted by the housing market. This situation is mainly strengthened because of two reasons: 1. current standards lack tightness, and 2. the lack of financial capacity of builders to buy the best solutions. A third factor may be the low degree of innovation of the building sector.

2.2 Building with adaptive ability

Next to the decision ‘choose or lose’ [9], many authors, e.g. Georgiadou et al. [7], Georgiadou and Hacking [14], Verbruggen et al. [10], Janssens et al. [11], Janssens and Verbruggen [13], either implicitly or explicitly urge for new design strategies which can ‘future proof’ the energy performance of buildings. Verbruggen et al. [10] states that irrevocable energy performance related building investments should be deferred by the ‘wait and learn’ principle: keeping open the possibility to decide later. Building on the theoretical approach of time-sequential decision-analysis by Verbruggen et al. [10], several publications (Verbruggen [9], Janssens et al. [11], and Janssens and Verbruggen [13]) promote the provision of more flexibility for irrevocable attributes and measures which facilitates later transformations to higher energy performances. This flexibility enables to postpone a certain investment, which responds to the uncertainty of some scenarios. The flexibility of postponing certain decisions necessitates the use of options. An option represents a possibility, but no obligation, to take a particular decision in the future. Options derive their value of future developments and their outcomes. Options are in other words ‘contingent decisions’. Flexibility options, described by Janssens and Verbruggen [15] can thus be defined as: “*building measures which facilitate transformations in the future, whenever certain relevant developments occur”*. Irrevocable decision-making is deferred because required upgrading is possible even during the first life cycle of a building and/or independent of normal renovation cycles of individual buildings components. This concept closely resembles with research and scientific literature on ‘life-cycle options’ by Ellingham and Fawcett [16] and Fawcett, Hughes, Krieg, Albrecht and Vennström [17].

Based on Janssens, Bosserez and Verbeeck [18], this flexibility can be inter-element, intra-element, and a mix inter-intra. The first, inter-element flexibility, refers to the replaceability of building elements. In view of the energy performance of the building as a whole, elements (walls, floors, roofs) serving several performances (thermal/acoustic insulation, water/wind/vapour tightness, finishing, etc.), can be demounted and replaced by better performing elements. The second, intra-element flexibility, means that the element itself can be adapted. Here, certain layers / materials of the element can be supplemented, adjusted and/or replaced, so the adaptability is on micro level. The third flexibility combines the inter- and the intra-element flexibility. This way, building elements can be upgraded (intra-element adaptability) and can also be used in other buildings when demounted from the initial building (inter-element adaptability).

2.3 Mixed mode: partly outperforming and adaptive

Dealing with the fact that urban contexts, architectural preferences, and building-constructive methods are diverse, a mixed mode between outperforming and adaptive might be preferable. Here, more long-lasting, rather rigid building elements, and/or elements which are difficult/not suited (practically, financially, …) for inter- and/or intra flexibility, outperform statutory requirements (outstanding performances), while other building elements can be designed with the ability to adapt.

3. Anatomical knowledge map for design support

In the literature, sustainable building and associated aspects (e.g. the design process, the built environment) are often referred to as ‘complicated’, ‘complex’, ‘messy’, ‘wicked’. Almost all design situations offer potentially infinite and limitless sources. These sources contain inter alia an exhaustive number of solutions. Exploring these solutions is not possible. Stolterman [19] states: “*Facing such ‘infinite’ information sources might lead a designer (even an experienced one) to experience an overwhelming design complexity. An inexperienced designer might suffer from*

‘design paralysis’ when confronted with such endless opportunities”. Stolterman characterizes these design situations as ‘underdetermined’ problems, referring to the ‘messy’ situation of Schön’s words [20] and a ‘wicked problem’ as defined by Rittel and Webber [21].
The issue of ‘design paralysis’ is caused by an infinite and limitless number of solutions. Central in this issue surrounding sustainable building is a situation of insufficient knowledge. This ‘epistemic uncertainty’ is “*the subjective feeling of uncertainty caused by a situation in which a designer has insufficient knowledge, or cannot easily retrieve appropriate knowledge from memory*” [22].

Epistemic uncertainty in design is detrimental for the efficiency and effectiveness of the design process and the design outcome. However, this epistemic uncertainty is likely to be tackled by a good design support. This section provides a tentative anatomical knowledge map for design support when designing for long-term obedience to increasing building-constructive energy performance requirements. It relates design decisions (variables) to design outcomes (amenities) through the identified architectural strategies.

3.1 Design decisions: variables

Built works of architecture manifest themselves as a combination, a synergy, of design decisions. Related to the building envelope, decisions predominantly related to the material selection, the constructive design, and aimed architectural aesthetics have a big impact. These three variables define the amenities of the building envelope.

Within these variables, following choices (related to the sustainability quest, non-exhaustive) can/must be considered:

- Material selection:
  - Renewable: infinite resources, natural, recycled, no/limited environmental impact
  - Non-renewable: finite resources, synthetic, environmental impact

- Constructive design:
  - Rigid: fixed, long lasting as a whole
  - Lenient: changeable, demountable

- Architectural aesthetics:
  - Fixed: to be maintained over the buildings’ life span
  - Loose: changeable over the buildings’ life span

3.2 Design outcomes: amenities

Outcomes of design decisions result in design outcomes, in amenities of the building, of the building envelope. Amenities are vast and can be categorized in different ways. Within the scope of this paper, a limited number of relevant amenities regarding certain aspects is included:

- Paradigm for ecological / social / economical responsible architecture:
  - Durability: product to last, robust, having a long lifespan
  - Sustainability: development to last, availability, not compromising the environment and other products or services, here/now and later/elsewhere

- Continued usage of the building:
  - Affected: significant impact of needed (renovation) works, strongly influencing normal usage
  - Non-affected: low/no impact of needed (renovation) works, no influence on normal usage

3.3 Anatomical knowledge map

The anatomical knowledge map 'maps' variables and amenities by/on the identified architectural strategies for long-term obedience to increasing building-constructive energy performance requirements. This way it supports decision making regarding these architectural strategies in early design stages, which is especially relevant for architecture students and early-career and unexperienced practicing architects.

The knowledge map enables a versatile consultation. It can be used from different starting points:

- The variables of design decisions: to what design outcomes do they lead within a certain architectural strategy
- The architectural strategies: what are needed design decisions and design outcomes of choosing a certain architectural strategy
- The amenities of design outcomes: which design decisions needs to be taken into account in view of a certain architectural strategy

Figure 3 provides an illustrative knowledge map. Identified relationships between variables, strategies and amenities are tentative and non-exhaustive. The presentation discusses the map in depth.

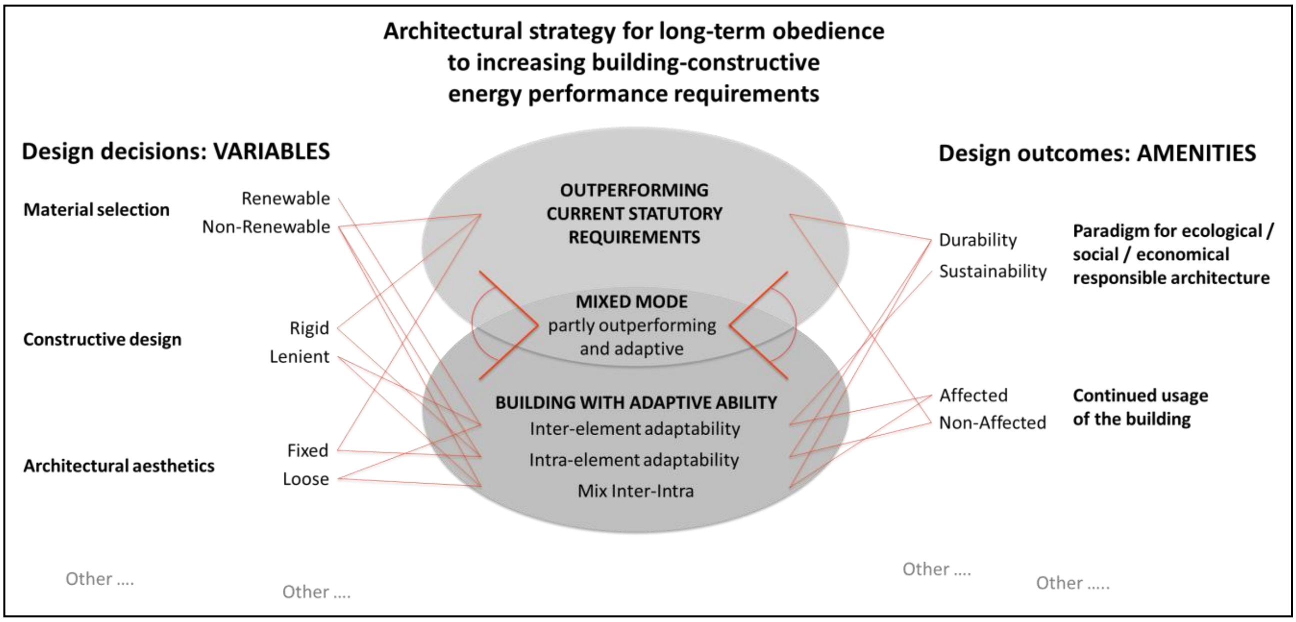

Figure 3: Tentative knowledge map showing the anatomy of the architectural strategies, design decisions (variables) and design outcomes (amenities), for long-term obedience to increasing building-constructive energy performance requirements.

4. An agenda-setting outlook

First reflections on presented/discussed architectural strategies and anatomical knowledge map, resulted in a non-exhaustive set of topics/issues and explorative innovative ideas which can set the agenda for further research, design and development. During the oral presentation, presented topics/issues will be discussed and illustrated.

4.1 Durability of outperforming constructions

As the anatomical knowledge map indicates, outperforming current statutory requirements are suitable when aiming for durable constructions. In this regard it is important that all building materials have the same durability. This attention point is especially relevant for locked-in materials such as foils and insulation. As the effectiveness of a construction as a whole is the result of many parts, weak parts must be avoided. Existing configurations of building-constructive concepts and constructive junctions need to be analysed and if needed adjusted.

4.2 Facilitating Inter-element adaptability

Inter-element adaptability is a powerful strategy: in specific, for enabling meeting ever increasing statutory energy performance requirements; and in general, for sustainability. The benefits for the latter are based on the high degree of flexibility in view of function-bound and user-bound demands. In order to facilitate/promote the implementation, building-constructive concepts, and especially constructive junctions, need to be fine-tuned and/or redesigned. This is relevant within and between specific building-constructive concepts (wood frame, steel frame, massive wood, masonry, concrete, etc.), and between changeable (temporary infill) and permanent building elements (e.g. loadbearing structure). Important aspects to take into account are e.g. demountability and degree of genericity.

4.3 Development of Intra-element adaptability

The principle of flexibility options, operationalizing intra-element adaptability, is a promising innovation in the building sector. In order to incentivize the implementation and formulate practical recommendations for the building industry and policy makers, an exploration and validation of the principle for different building-constructive concepts (heavy-weight, light-weight, hybrid), building typologies (single family houses, dense housing projects, offices), on- and offsite building methods, etc. is needed. Supplementary, the applicability within the inter-element adaptability must be studied. Theoretical insights and practical design/build experiments must identify possible solutions, the application range, opportunities and threats.

4.4 Mixed mode: attuning outperforming and adaptive building elements

Combining the architectural strategies, outperforming and adaptive, in building envelopes result in situations where different building-constructive concepts meet, each with its own constructive configuration, aimed life span, etc. These meeting points are challenging due to building-constructive requirements (e.g. avoiding cold bridges, ensuring wind/water/vapour tightness) influencing performances on building physics (e.g. transmission losses, condensation).
Building-constructive concepts addressing different architectural strategies for long-term obedience to increasing energy performance requirements need to be attuned, specifically at the meeting points, the constructive junctions.

5. Conclusion

This paper advocates and addresses the need for ‘futures-thinking’ regarding the long-term obedience of buildings to increasing building-constructive energy performance requirements. As long as this kind of ‘future-proofing’ is not treated equally as physical-spatial and building-technical aspects, built works of architecture will remain dragging legacies for the future, for a sustainable development.

Three architectural strategies for long-term building-constructive obedience are identified: 1. outperforming current statutory requirements; 2. building with adaptive ability; and 3. mixed mode, partly outperforming and partly adaptive. Supplementary, the paper presents a tentative anatomical knowledge map which can be used by: first, researchers to identify and position future research; and second, architecture students, early-career and unexperienced practicing architects to guide design decisions in view of design amenities.

Based on the provided agenda-setting outlook, it is clear that further research is needed in order to incentivize the building industry and policy makers to respectively implement the architectural strategies and to upload building codes with statutory requirements regarding long-term obedience of buildings to increasing building-constructive energy performance requirements. Despite the wide range of possible future research, it is clear that the design and development of building-constructive details of constructive junctions are key, for both renovation projects and new projects.

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