

Re-design for change: A 4 dimensional renovation approach towards a dynamic and sustainable building stock

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In the present-day context, a large amount of the current residential buildings are well-known for their excessive energy consumption and outdated user comfort. Many housing projects were built on large scale before the 1970s, in a time where fossil fuels were still cheap and abundant and global warming was unheard of. Today, we live in an era in which we have to face up new environmental challenges and in which sustainable buildings have become a necessity. Since the number of new buildings annually constructed barely corresponds to 1,5% of the building stock, it would take from 50 to 100 years to replace all existing buildings entirely with new, more sustainable ones. Hence, refurbishment of our existing building stock is the key.

Typical refurbishment approaches upgrade existing buildings according to specific problems of today: the operational energy consumption is currently pushed down to near-zero and passive levels, whilst comfort is updated to current standards by adding the best technical accommodation available today. These interventions use recently developed technologies of which the long-term side-effects on the user's health - for instance, due to ventilation issues - and the environment are not yet fully understood. But are these generally applied 'best solutions' necessarily the most convenient solutions for each building type? Will they not form problems in future refurbishments, since most of them are not reversible or easily altered?

In addition, future building upgrade, transformation and re-adaptation are unavoidable, due to demographic changes such as fluctuating size, composition and age structure of the average household, global warming and further development in the legal environmental framework. To anticipate these unpredictable changes there is clearly an urge to introduce dynamic concepts, moving away from the traditional perception of buildings and their static technical composition.

This PhD proposes an alternative approach to current refurbishment practice, based on a 4 Dimensional Design Strategy (4D) introduced and investigated at the ARCH department of the Vrije Universiteit Brussel (VUB). The concept of "Re-design for Change" is introduced, integrating the time factor as an initial design parameter to anticipate future building scenarios. This work offers a framework to guide architects towards comprehension, selection and development of dynamic building systems and materials. The "Re-design for Change" approach will enable the reduction of both future material and energy demand of buildings, as well as the building waste over the entire life cycle of buildings.

The research illustrates that re-design of buildings for change is a complex topic that is influenced by *design* factors (e.g. dry detailing, selection of reusable materials, pre-assembly of components), *evaluation* factors (environmental impact, financial cost) and *contextual* factors (legal framework of buildings, building physics, existing building characteristics). As an overview, several refurbishment solutions for existing building assemblies are evaluated on their potential for change, revealing their restrictions when it comes to dealing with change in a near future. An alternative design and materialisation of building assemblies is proposed, using dry detailing techniques, and introducing deconstruction and reuse potential, in compliance with the current legal framework. These solutions are composed using basic building elements, which are standardised, as in a Meccano system. This makes any future replacement or upgrade possible in a non-destructive way, without adding to the waste stream such as conventional building solutions.

The influence of a 4D approach is evaluated over the total life cycle of a building, using an integrated approach for both environmental and financial aspects. This is applied on a case study for refurbishment of social housing of the 70s in Brussels. This analysis reveals that "Re-design for Change" *can* be a crucial addition to energetic refurbishment of today.