The Innovative Prefabricated “Powerhouse”: Potentials for the Rehabilitation of Panel Buildings

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ABSTRACT
The existing housing stock holds an enormous potential for energy saving. The housing rehabilitation measures implemented so far exclusively have been aimed at reducing the energy input, i.e. at transforming the buildings from “energy gobblers” into “energy savers”. In these approaches, energy is still needed for water and room heating, depending on the respective rehabilitation standard (low-energy, three-litre or passive house). The aim of the presented research approach lies in the use of endogenous existing, now seemingly lost energies. Every building, and thus every residential structure, not only consumes but also generates energy. The energy generation potentials resulting from comprehensive rehabilitation should therefore be rendered visible and useable. The thesis advanced contends that comprehensive rehabilitation gives rise to new energy potentials in an urban, architectural, structural, social an energetic context, which could contribute towards a notable upgrading of prefabricated housing estates.

Key words: housing refurbishment, green building, sustainable housing, large housing estates

1. INTRODUCTION
The outward shape of many European cities changed dramatically in the second half of the 20th century. In urban expansion areas, large-scale housing developments with modern flats were erected. Industrialised and standardised housing production was to eliminate the housing shortage and improve both the quality of housing and the quality of life for the population at large, and the architectural and urbanistic concepts of interwar modernism were combined with the rapid evolution of industrial mass construction technologies to attain this goal. Prefabricated large-panel structures seemed a highly economical and efficient construction technique to make these technical and social visions reality.

The transdisciplinary INTERREG IIIA-funded research project "Architectural, Structural and Social Rehabilitation of Prefabricated Housing Estates in Vienna and Bratislava" continues the effort towards know-how transfer and scientific co-operation – concretely, between Austria and Slovakia with the assistance of experts from various European countries – and strives for its sustainable further development [6]. This project aimed at a comprehensive examination of the phenomenon of prefabricated housing estates in Vienna and Bratislava while taking account of structural and architectural, aesthetic and design-related, social and environmental aspects.

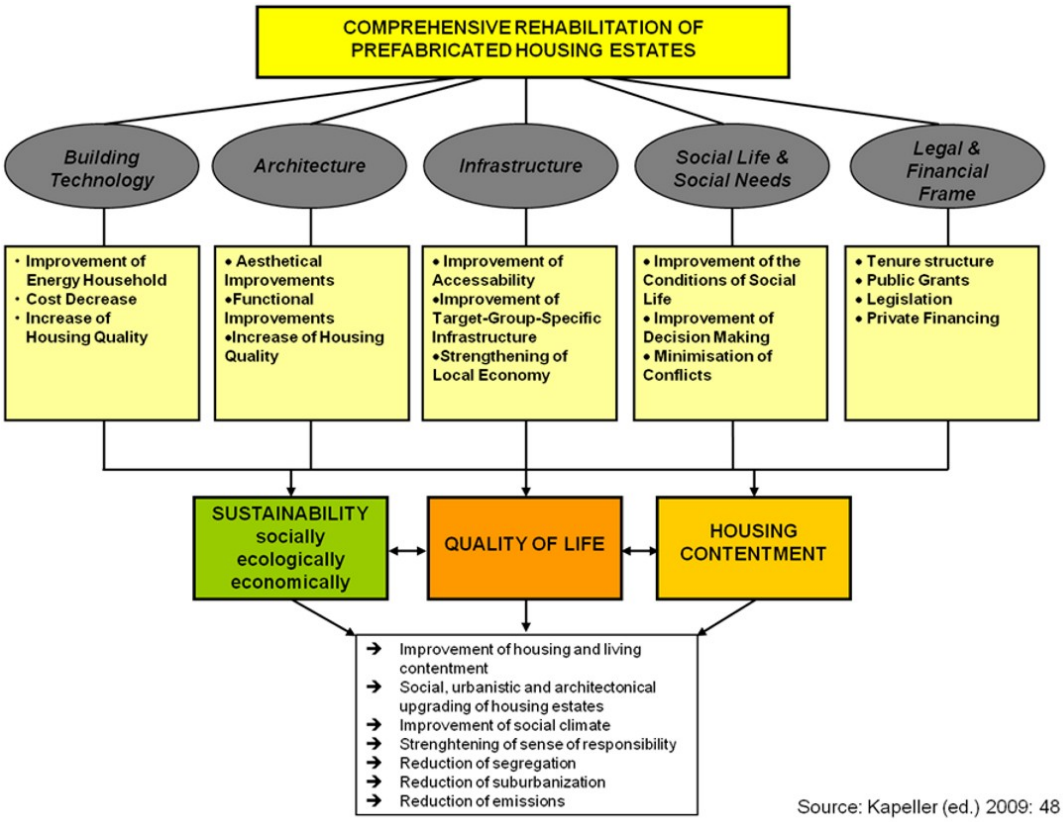

Fig. 1: Comprehensive concept for rehabilitation of prefabricated housing estates

Housing policy-related, economic and social frame conditions in Vienna and Bratislava as well as various financing concepts were likewise analysed [cf. 6,8]. Suggestions for the rehabilitation of prefabricated structures towards low energy consumption offer an excellent starting-point for continuing and intensifying the work undertaken so far [6,10].

2. NEW RESEARCH APPROACH TOWARDS PREFABRICATED POWERHOUSE AND OBJECTIVES

It is assumed that the housing rehabilitation measures implemented so far were exclusively aimed at reducing the energy input, i.e. at transforming the buildings from “energy gobblers” into “energy savers”. Despite this approach, which is certainly exemplary in view of the climate change, energy is still needed for water and room heating, depending on the respective rehabilitation standard (low-energy, three-litre or passive house). At the moment, room and water heating account for 35.1% of the entire energy consumption of Austria [2]. Approx. 60% of the energy consumption of residential buildings is due to these activities; thus more than one fifth of Austria’s energy consumption in general is caused by room and water heating in residential buildings. Similar consumption volumes apply to residential buildings in Germany or Switzerland. These figures emphasise the necessity of restructuring the existing housing stock and highlights an enormous potential for energy saving.

Fig. 2: High-rise buildings in Petržalka, Bratislava
Photo: Harald Kapeller 2003

The aim of this new research approach lies in the use of endogenous potentials – the use of the existing energies produced by humans, buildings and the environment giving rise to new energy potentials in an urban, architectural, structural and social context.

This contribution aims at tapping existing, seemingly lost potentials. Every building, and thus every residential structure, not only consumes but also generates energy.

The energy generation potentials resulting from comprehensive rehabilitation should therefore be rendered visible and useable. The thesis advanced contends that comprehensive rehabilitation gives rise to new energy potentials in an urban, architectural, structural and social context, which could contribute towards a notable upgrading of prefabricated housing estates. Modifying and rehabilitating built and spatial structures and open spaces allows for the optimum focusing and use of the existing energies produced by humans, buildings and the environment.

The key question is therefore:

- *What energy and development potentials in the current and future urban context are inherent in prefabricated housing estates?*

In order to visualise the potentials of the so-called PREFABRICATED POWERHOUSE (prefabricated housing estates produce more energy than they need), it is necessary to develop concepts with highly innovative potentials and viable visions, but also utopias whose implementation may seem unrealistic today.
For this reason, the crucial questions for research are:

- *How can existing energy potentials be activated?*
- *How can these energy potentials be tapped for use?*
- *How can largely independent energy supply be rendered possible?*
- *What adjustments and rehabilitation measures and what urban approaches and housing models can be recommended as a result of analysing the energy potentials of the PREFABRICATED POWERHOUSE with the objective of transforming prefabricated housing estates into contemporary, independent, socially and ecologically fair places of living?*

This calls for a re-evaluation or redefinition of existing structures (open spaces, buildings, flats) and interactions within the context **building – space – people – nature**. Creating a symbiosis between the inhabitants – the people inside and outside the building – and the building itself is essential for an even energy balance.

It is a key intention of this proposal to activate local, social, ecological and economic potentials. This endows residential buildings with new functions while at the same time adding new social value to the estates as a whole through the creation of contiguous spaces and the reinforced identification of the inhabitants with “THEIR” estate, which in its turn stimulates entirely novel forms of social interaction. Key aims include the improvement of the conditions of social coexistence, the strengthening of both the individual responsibility of private flat owners and personal life situations by exploring human energy potentials through the establishment of suitable communication structures and the boosting of the local economy. In addition to improving the quality of housing and life, both economic viability and affordability – i.e. social and economic aspects – must be likewise taken into account. In the following e*nergetic, urban, architectural, structural, social and open space potentials* are dealt with in greater detail.

2.1 Energetic potentials

Aiming at developing **energy-generating residential buildings**, the proposed rehabilitation concept goes beyond most of the existing energy-saving concepts (low-energy and passive houses). Widely accepted ideas (solar and wind energy) are expanded by adding novel energetic, social and architectural concepts. Buildings, their inhabitants and the environment must be **actively** involved into this concept (active house, active estate). The thematic areas listed below are dealt with experimentally:

1. Using the gravitational energy of descending persons, objects, materials, etc. inside and outside the building: of rainwater from the roof to the sewer or seepage into the earth, of waste, excrements, wastewater, water for domestic use, etc.

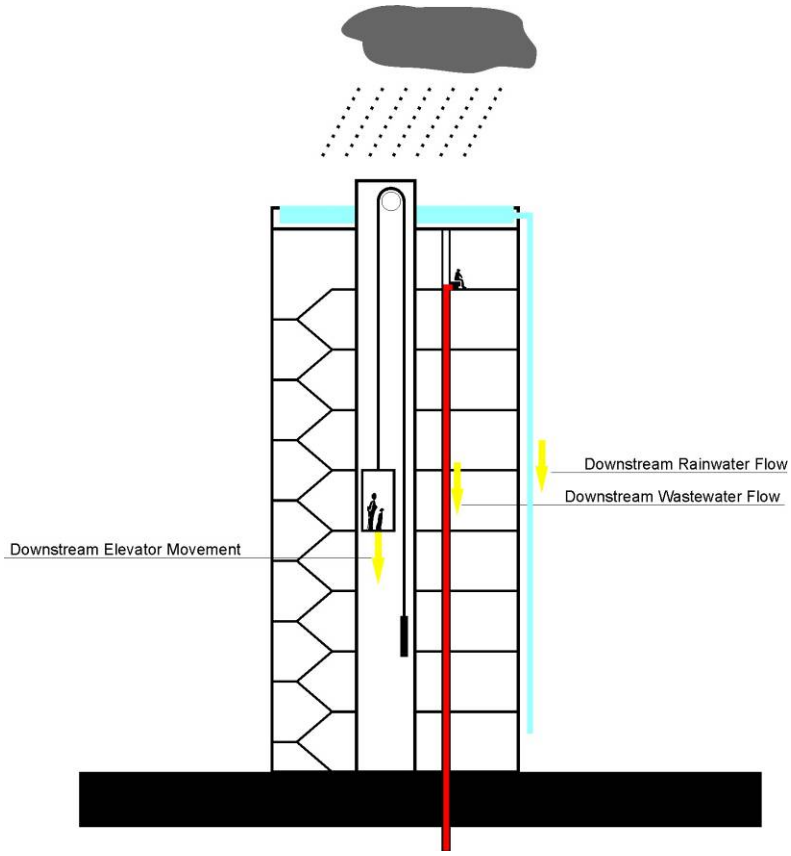

Fig. 3: Using the gravitational energy in buildings
Graphic: Johannes Huemer

2. Using the existing green and open spaces as biomass: often over 50% of the area covered by prefabricated housing estates are green spaces that in addition to their recreational effects offer further vast potentials, e.g. for biogas generation.

Using the biomass produced by the existing green spaces entails a substantial energy input that helps inhabitants to cut down on heating expenses.
3. Innovative approaches to using the waste or wastewater volumes generated.
4. Using flow energies (of ventilation, thermal lift): this could be attained by a special design of the shell and interior of buildings.
5. Using heat dissipation by evaporation to create natural climatic conditions by means of the targeted implanting of plants, shrubs, etc.

Fig. 4: “Per-Albin-Hansson-Estate East”: map of the estate and areas partition
Graphic: Johannes Huemer

2.2 Urban and architectural potentials

The findings relating to the urban, built and settlement structures, design, function and construction techniques of prefabricated buildings offer a key basis for identifying the urban and architectural potentials of the PREFABRICATED POWERHOUSE. Prefabricated structures harbour great development potentials that can be activated, transformed and put to new uses. It is therefore important to analyse and visualise the urban and architectural qualities of prefabricated housing estates. In this, it is vital to highlight the structural and architectural potentials of urbanism and housing

construction and their effects on prefabricated estates and vice versa and, ultimately, to reinforce the positive potentials.

In this context, **open space potentials** are amongst the most vital urbanism structures. In our era of tighter energy resources and dwindling living spaces in cities and developments, the fight for undeveloped plots inside prefabricated housing estates has become a veritable battle. The value of these open space potentials was already recognised by investors and developers and claimed for profitable investments such as shopping malls, business centres, etc. (cf. Bratislava, Prague). This is bound to lead to conflicts with local inhabitants. It is therefore necessary to initiate an objective analysis of the open space potential of prefabricated housing estates with a view to function and design. However, optimised open space management is only possible within the scope of an overall urbanism concept, i.e. only within the context of the city as a whole. This calls for an accurate evaluation of the functions of prefabricated housing estates within the urban tissue in order to derive a novel and innovative open space concept. The most important concern lies in a responsible and ethically correct use of the existing open space resources (unused built structures, open and green spaces) of prefabricated housing estates, a challenge that must also address questions of social and ecological sustainability. The potentials for architectural additions and further developments thus constitute an important contribution to the PREFABRICATED POWERHOUSE by furthering sustainability and urbanistic condensation and compacting.

2.3 Structural and material-related potentials

2.3.1 Product lifespan potentials

A question of crucial significance for the PREFABRICATED POWERHOUSE is addressed on the basis of an analysis of energetic, urban and architectural potentials. With just a few exceptions [3,12,13], the issue of the lifespan of prefabricated housing estates in general and prefabricated structures in particular has been mostly neglected. Decisions regarding the positive or negative qualities of prefabricated structures are often motivated by emotional or ideological conceits – arguments usually controlled by economic interests (of different lobbies advocating new construction or, conversely, rehabilitation). An objective and scientifically sound discussion and analysis of the lifespan of prefabricated structures is therefore urgently called for. At the European level, the qualitative differences between individual countries, individual estates and individual construction types are very likely substantial. However, the systematic production, construction and assembly techniques used for prefabricated structures make them ideally suited for methodical comparative evaluation and the development of a catalogue of criteria.

2.3.2 Demolition potentials and reuse of prefabricated concrete panels

Another key question exclusively concerns the potentials inherent in the demolition of buildings and the reuse of prefabricated concrete panels. If the lifespan of a prefabricated structure is assessed negatively and rentability is scant (vacancies), the resulting “demolition potentials”, too, must be dealt with. When talking about the demolition or retrenchment of prefabricated structures, it is essential to take account of the experience made in East Germany as a key contribution to the discussion [11,12]. While it is well known that demolished concrete panels are often recycled in East Germany (by destroying, separating and reusing the building materials), these work processes – e.g. the destruction and comminution of the concrete panels in complex plants to produce gravel – require enormous energy input.

It is therefore one of the objectives to develop concepts that ensure an efficient and environmentally friendly approach to the energy potentials derived from prefabricated structures. The thesis is: demolished prefabricated structures are energy destroyers; recycled prefabricated structures are energy generators in the sense of the PREFABRICATED POWERHOUSE. The potentials for reuse or continued use of the panels obtained by demolition need to be analysed. In this field of research, too, preparatory basic research has been done and can be made use of (5). The reuse of the demolished panels harbours enormous potentials, as it permits the construction of new buildings for a wide variety of uses. This prevents the consumption of energy for the production of building materials or structural components, which in its turn is directly reflected in the overall energy and CO_2 balances of the PREFABRICATED POWERHOUSE.

2.4 Human potential – New approaches towards participation and Emergence of new socio-economic structures

Human resources are decisive for the future of the PREFABRICATED POWERHOUSE. However, due to the complexity of this issue, the activation of these potentials in today’s prefabricated housing estates must go far beyond conventional participation processes. A vital objective of this proposal is clearly manifested in the search for new energies, actions, activities and interlinkages between human beings, energy and buildings. This strategic approach essentially comprises two steps – firstly, activation and, secondly, creation of new energy and action potentials. The analyses dealing with the PREFABRICATED POWERHOUSE will respond to the new demographic and socioeconomic requirements by drawing on the flexibility of prefabricated large-panel structures and existing spatial potentials. Functional and infrastructure modifications are necessary to avoid generational conflicts.

To give rise to new qualities and enhance the attractiveness of prefabricated housing estates, the human stakeholders – flat owners, tenants and housing co-operative members – directly concerned must be won over to support the rehabilitation measures. It is obvious that the human potential for rehabilitation measures has not

yet been sufficiently activated, above all in the CEE countries. Activating a sense of responsibility, not only for one's own flat, but also for the immediate housing environment and ultimately for the entire estate is a task that must be resolved through a participatory approach. The combination of democratic-participatory with (local-) economic and employment policy objectives to strengthen civil society is of eminent importance especially in those countries where social contrasts are on the rise as a result of the dynamic introduction of a neo-liberal market economy. Social exclusion and ghetto formation must be combated. For this reason, rehabilitation measures facilitating social renewal must be developed. Inter alia, these rehabilitation measures should contribute towards economic renewal, e.g. by creating new jobs. New jobs can be thus created as a result of both the construction of new office and commercial spaces and the demand for resident gardeners, machinery attendants, agricultural workers, utility engineers, supervisory staff, etc. within the estates. This would additionally reduce commuter traffic between flats and workplaces and thus contribute towards decreasing the CO_2 load.

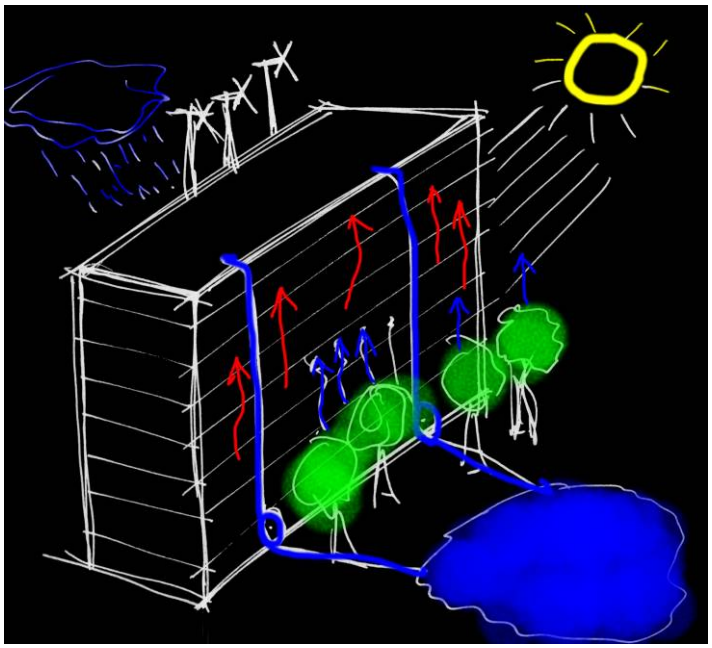

Fig. 5: Using existing climatic potentials
Graphic: Johannes Huemer

3. THE STUDY APPROACH / RESEARCH MODEL AND RESEARCH DESIGN

3.1 Research model

A theoretical basis for the activities is provided by the network and environment approach, which understands innovation. A theoretical basis for the activities is provided by the network and environment approach. Innovation networks are understood as a sequence of information links between developers, users and actors

within a knowledge network. Innovation networks therefore result from the creative combination of know-how accumulated through integration into knowledge networks and specific expert knowledge [4]. In addition, informal and formal knowledge and information networks play an important role in the innovation process [7].

The concept of **innovation potential for the rehabilitation of prefabricated large-panel structures** is developed to capture all interconnections inherent in the comprehensive rehabilitation process [7]. The innovation potentials of relevance for the rehabilitation of prefabricated large-panel structures are generated from a wide variety of task- and process-oriented phenomena which in part still need to be activated. To safeguard sustainability, these mostly very complex potentials must therefore be first identified, captured and analysed as a whole before being tapped individually. The quality, structure, intensity and interactions of these potentials are decisive for successful rehabilitation measures and **determine the shape of the PREFABRICATED POWERHOUSE**. Concretely, this includes e.g. energetic, urban, architectural, structural and static, social, geographic, climatic, etc. potentials.

3.2 Research design / Methodology

Methodologically, the development of an innovative system for the comprehensive renewal of prefabricated housing estates in keeping with social, economic and ecological standards derives from basic and applied research as well as from communication networks. The individual research phases aim at providing an analysis of innovative rehabilitation measures and verifying them on the basis of an experimental example, i.e. the rehabilitation of one concrete building complex. In due course, the concept is to be extended to all buildings of the same type. Fundamentally, the concept of industrial construction is to be evolved and specifically adapted to the rehabilitation and renewal of prefabricated housing estates, as this would effectively continue the original ideas behind the prefabricated construction technique (e.g. rationalisation through standardisation). The following research phases are to be implemented:

3.2.1 Data capturing / Development of a European database on prefabricated large-panel structures

Project-relevant data are to be compiled on the basis of the already extensive and comprehensive stock of data on European prefabricated housing estates and respective research outcomes. Urban, architectural, structural, energetic and demographic parameters as well as estate, building and flat data will be captured for the statistical coverage and characterisation of prefabricated structures.

3.2.2 Analysis of exploitable potentials

All data captured will then be subjected to a **potential analysis** that is to facilitate the evaluation of the information gathered and to highlight exploitable potentials inherent in a building. This research phase is carried out in close co-operation with institutions

in the energy sector. Thus the potential analysis provides a connecting link between basic and applied research. It is the objective of this phase to assess the usefulness of techniques already well known from other areas of application for their possible employment in housing (in the PREFABRICATED POWERHOUSE) and, in case of a positive assessment, to create the necessary technical preconditions. Simulations will have to be developed for this purpose to define optimum frame conditions.
By way of example, the section below presents three selected problem areas suited for potential analysis:

- The **analysis of energetic potentials e.g. comprises an evaluation of the available green spaces inside a housing estate.** The potential of these open spaces for biomass and biogas generation is examined. In the first phase, the estimated volume of e.g. biowaste produced by a prefabricated housing estate is extrapolated on the basis of statistical data. It is examined whether the volume of thus "produced" biowaste could be employed for biogas generation. The effects of such planting plans on the quality of the open spaces and/or inhabitants of the estate should be analysed as well.

- **The analysis of climatic influences** is to show in its turn whether and to what degree traditional forms of solar and/or wind energy generation (solar collectors, wind wheels) make sense or whether alternative options should be considered (double walls for heat retention, air collectors for the support of thermal lift forces on façades and/or inside buildings, etc.). These analyses will be above all based on the climatic and meteorological data captured.

- **Another subject-matter** for analysis is the question of whether rehabilitation concepts can be not just transferred to other prefabricated large-panel structures of the same type, but whether **prefabricated rehabilitation techniques, such as projecting prefabricated façade elements or prefabricated ventilation modules, can be used – with minimal modification – in all prefabricated large-panel structures of one basic type.**

3.2.3 Case study

Applied research – an experimental study of one concrete object – is to be employed in the final project phase. The theoretical approaches – interactive model of innovation processes, network and environment approach and innovation potentials for the rehabilitation of prefabricated large-panel structures – need to be verified in practice. The data analysis will lead to the selection of one specific type of prefabricated structure, i.e. the type presenting most characteristics of all prefabricated large-panel structures stored in the database, as this type quantitatively and qualitatively harbours the best application potentials. A key element of the analysis of the case study object lies in an in-depth potential analysis which on the one hand looks experimentally into the first-phase potentials and on the other hand

offers an intensified analysis of the energy potentials applicable to this specific case. This is to yield possibilities going beyond the practical techniques used so far. An example includes the possibility of tapping the gravitational energy of humans, objects and rainwater in housing construction. Finally, it should be clarified whether the findings obtained hold true and hence are applicable to the selected type of prefabricated large-panel structures, and which adaptations must be carried out for other types of prefabricated large-panel structures.

4. SUMMARY: INNOVATIVE ASPECT AND POTENTIALS OF SUCCESSFUL APPLICATION

Viewing prefabricated housing estates as “POWERHOUSES” of their own with all complex aspects, opens up totally new perspectives of housing refurbishment. This view shall also lead to innovative scientific results. It is one of the key objectives of the submitted project to examine in which way the results of the potential analysis can be integrated into concrete rehabilitation concepts as a basis for the development of prefabricated building units. This aims at utilizing the advantages of prefabrication (rationality, efficiency) for rehabilitation. Because of the enormous number of prefabricated units of the same type there are big potentials for application. Following this, the results of the conducted research should round off the already highly developed existing technologies of prefabrication (e.g. prefabricated timber frame construction). The synergies should result in rehabilitation technologies supposed to be “better, faster, less expensive and more ecologically sound” than the most of today’s common strategies.

Concerning the implications with other scientific fields, the presented proposal pursues a transdisciplinary approach – the cooperation between basic and applied research is a precondition for successful rehabilitation. The results should be useful for both further basic and applied research as well as other scientific fields, such as spatial, urban and landscape planning, architecture, housing research, sociology, construction, energy engineering.

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