Zurich, June 15-17 2016
Sustainable Built Environment (SBE) Regional Conference

Expanding Boundaries:
Systems Thinking for the Built Environment

SUSTAINABLE STEPWISE BUILDING RENOVATION

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Abstract
Based on current renovation activities in single-family and multi-family buildings in Switzerland, the relevance and the drivers of stepwise building renovation in Switzerland are shown. The obstacles to more comprehensive energy related renovation measures as well as to planning for a longer term of phased renovation measures are highlighted. The analyses of the drivers for and the shortcomings and advantages of phased building renovation are summarized in a SWOT analysis of stepwise building renovation. Based on the advantages of phased building renovation it was explored how stepwise building renovation can be carried out sustainably, meeting ambitious energy demand and greenhouse gas reduction targets in the longer term. Policy measures for making stepwise building renovation more sustainable and achieving existing energy and greenhouse gas related targets are identified.

Keywords:
Building Renovation, Sustainability, Green House Gas Emission Reduction, Energy Conservation, Subsidy Programs, Building Strategy

1 INTRODUCTION

The renovation of the building stock is a major field of action for sustainable development, energy and climate policy. While the European research community, promotors and policy makers in the field of building renovation (e.g. approach of the EPBD - Energy Performance of Buildings Directive) usually assume that building renovation towards nearly zero energy buildings is realized by rather comprehensive packages of energy related renovation measures, real life reveals that most renovation projects focus on urgent problems, having a limited scope. Hence, current building renovation projects often tend to be carried out stepwise, spread across a relatively long period of time. Too often they fall short of fully tapping the potential for reducing non-renewable energy demand and greenhouse gas (GHG) emissions which would be necessary to meet the targets set by the energy and climate policy.

For the Swiss Federal Office of Energy (SFOE) it was investigated how buildings are currently renovated, why stepwise renovation is in the majority of cases the renovation strategy of choice and whether current renovation in small steps will meet existing long term energy and GHG emission reduction targets [1]. Attempts were made to come up with recommendations on how to meet existing sustainability targets while renovating in steps.

2 METHODS

The research was based on a multidimensional approach: First the literature was analysed for an overview on observed renovation strategies, obstacles for and drivers of stepwise building renovation. Second 14 experts and practitioners in the field of building renovation (building professionals, architects, energy consultants, investors, representatives of associations, researchers) were interviewed with a focus on shortcomings and advantages of stepwise building renovation and how to assure this renovation type to be executed in a sustainable way. Third a web-survey among home owners was carried out. Fourth the effect of different renovation packages on costs, GHG emissions and non-renewable energy demand for two generic buildings was calculated. The assessment also addressed the effect of spreading the package over a longer period of

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DOI 10.3218/3774-6_60, ISBN 978-3-7281-3774-6, http://vdf.ch/expanding-boundaries.html

time. The findings and conclusions are presented in a SWOT matrix, a synthesis of the results and recommendations for policy measures.

3 TARGETS FOR BUILDING RENOVATION

Long term energy and CO_2 emission targets for the Swiss building sector are defined by the "SIA Energy Efficiency Pathway" [2] of the Swiss Society of Engineers and Architects (SIA). The targets are set for non-renewable primary energy use, GHG emissions and the limit value for heating requirements, as per SIA 380/1, of buildings. These targets correspond to the long term targets of the SFOE and the 2000-Watt-Society (see subsequent Table 1).

Besides the energy and GHG targets there are further objectives to be considered in building renovation:

- Densification (spatial planning)
- Maintenance of cheap housing (social policy)
- Minimize harassment of building users (social policy)
- Preserve historical buildings and the townscape

Residential buildings	Primary energy [MJ/a*m^2]		GHG emissions [kg CO_{2eq}/a*m^2]	
	New	Retrofit	New	Retrofit
Reference values				
Construction	110	60	8.5	5.0
Operation	200	250	2.5	5.0
Mobility	130	130	5.5	5.5
Target values (construction+ operation+mobility)	440		16.5	15.5

Table 1: Overall target values and reference values for primary energy use and GHG emissions for building construction, building operation and building related mobility needs according to the SIA Energy Efficiency Pathway [2].

4 BUILDING RENOVATION TODAY

We distinguish the following categories of building renewal:

- Restoration without energy efficiency improvements (only functional restoration for another renovation cycle)
- Energy related renovation (renewal striving also for energy efficiency improvements)
- Comprehensive refurbishment: Complete renewal, comprising also energy efficiency related improvements
- Partial renewal, limited to certain building elements, with or without energy efficiency related improvements

69% - 71% of Swiss residential buildings are renovated continuously or stepwise, 16% - 17% are only maintained and only 7% (single family buildings - SFB) to 12% (multifamily buildings - MFB) are comprehensively refurbished [3].

Period: 2001-2010	Restoration without energetic improvements		Energy related renovation	
	SFB [% /a]	MFB [% /a]	SFB [% /a]	MFB [% /a]
Windows	1.1	0.5	2.1	3.0
Façade	1.8	1.6	0.6	0.7
Pitched roof	0.4	0.5	1.2	1.5
Cellar ceiling	0.2	0.1	0.4	0.9

Table 2: Annual renovation activities per envelope element during the evaluation period from 2001-2010 for Swiss residential buildings built before 1990 (% of envelope area per year). SFB: Single family buildings; MFB: Multifamily buildings (source: [4]).

An earlier survey on the renovation behaviour for SFB [5] discloses that 82% of SFB renovations are carried out without previously elaborating a comprehensive long term concept or strategy. For MFB [6] a survey showed that in only 8% of the cases renovation measures are embedded in a long term planning scheme.

While in case of a building renewal 66% - 90% of the windows, pitched roofs and cellar ceilings are energetically improved, only 25% - 30% of the façades renewed are energetically improved. This will make it difficult to achieve current energy targets.

5 DRIVERS AND OBSTACLES

The review of the literature, available surveys regarding building renovation in Switzerland and the interviews with 14 experts and practitioners yield the subsequent main drivers of stepwise renovation and obstacles to sustainable phased building renovation.

5.1 Drivers of stepwise renovation

Particularly private non-professional building owners phase renovation measures for the following reasons:

- Ability to match financial resources and costs of chosen renovation measures. Very often it is presupposed that building renovation is financed with available liquidity to prevent borrowing [3, 7, 8, 9].
- Attempt to maintain affordable rents and current tenancies. Staggered rent increases

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can be beard better and tenancies are maintained more easily [7].

- Desire to take maximum advantage of tax deductions of expenses for building maintenance and energy related renovation measures [10].
- Risk aversion due to uncertainty as to the future marketability of the building, needs of the users, energy price developments, development of costs, reliability and durability of new technologies, etc. [11, 12].
- Circumvention of building regulations which require costly modifications on the existing building once it is necessary to apply for a building permit. More comprehensive renovation projects have to apply for a building permit. In this process it is usually checked if the building complies with all of the existing building regulations after having carried out the renovation, i.e. also with regulations which didn't exist at the time the building was erected (like new fire protection regulations, etc.) [7].
- Phased renovation allows for replacing only building elements which have reached the end of their service life (fewer sunk costs for too early replacement within a comprehensive renovation project) [7, 9].
- Chance to make use of more advanced technical solutions and to adapt to changed user needs in subsequent phases of building renovation.

5.2 Obstacles to sustainable phased building renovation

In principle, in the majority of the cases phased building renovation could be sustainable and meet existing and upcoming energy and GHG targets. But sustainable stepwise renovation is demanding and needs integral planning, comprising the different steps of the overall renovation process. The following main obstacles to sustainable phased building renovation were identified:

- As was previously shown, 80% - 90% of building renovations are not based on a medium to long term strategy for the building and are not integrally planned for all of the upcoming phases of the renovation process [3, 5, 6, 13].
- Usually there is no setting of final targets which are supposed to be achieved at the end of the renovation process taking place in several steps [6]. Therefore, the first steps risk to be too short sighted and not embedded in a long term strategy.
- Costs for developing a strategy and for initial integral planning are an important obstacle [7]. They hinder carrying out this essential preparatory work, resulting often in sub-optimal solutions or follow-up costs, if ambitious targets still are to be achieved.
- The incentives for architects and planners are not strong enough to make them promote actively initial strategy development and integral planning of several steps of building renovation. In general, they have the know-how and could be the promotors of these issues.

6 BEHAVIOUR OF BUILDING OWNERS

The decision making behaviour of residential building owners with respect to building renovation was investigated by a web-survey. 1'686 building owners from the subsequent data bases were contacted, about half of them from SFB and MFB respectively. 288 owners filled in the questionnaire from which 263 questionnaires were complete (16%), 147 from MFB and 116 from SFB:

- Database of "Baublatt Infodienst": 886 addresses of residential building owners in the cantons of Basel-Stadt, Bern, Schaffhausen and Thurgau, who have applied recently for a building renovation permit.
- Database of "Hausverein Zürich", which is an association of building owners who are committed to the principles of fairness and ecological awareness: 800 addresses of residential building owners in the canton of Zürich.

50% of responding owners phase their building renovation, pursuing one of the three following strategies: "investing a fixed sum per year", "investing according to immediate needs" or "now and then a smaller partial renovation".

Almost two thirds of the respondents have already some kind of an energy concept, a concept for building renewal or a building strategy and 18% have a building energy certificate (GEAK).

Long term planning happens more often in the case of more comprehensive renovation attempts.

About 50% of the façades which have been renewed have not been enhanced in energy efficiency. 27% of the respondents renewing the façade without increasing energy performance indicated, that energy related improvements haven't even been an issue in planning and commissioning the façade renewal. 30% of respondents renewing the façade without improving energy performance referred to lacking financial liquidity or insufficient profitability or problems to pass incurring additional costs on the renters as a reason to turn down façade insulation.

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33% of the buildings have an oil heating system and 34% a gas heating system. 30% of the buildings with fossil heating systems will have to replace their heating system during the next 10 years. Half of these systems shall be replaced by a fossil system again. Most mentioned alternative to fossil is a heat pump system.

7 PHASED RENOVATION SWOT-ANALYSIS

Phased building renovation is not necessarily unsustainable. Several aspects might even be more sustainable than far reaching comprehensive building renovation in one step: e.g. economic viability, social compatibility and sustainability, embodied energy use.

A risk of (unplanned) small steps of renovation measures is that they tend to be only repairing or replacing building elements without tapping the potential of improving ecological standards and upgrading building quality.

Strengths	**Weaknesses**
• Full life time of building elements is exploited (reduces costs and embodied energy use) • Adapting the scope of a renovation step to the available financial resources of the owner • Necessary rent increases can be staggered, no need to terminate existing tenancies • Renovation possible while building inhabited • No need to involve authorities and to comply with all existing building regulations if individual partial steps do not require approval or if the associated impact is low • Effect of tax deductions more pronounced if distributed across different periods	• Most owners renovating in steps do not consider to base the renovation steps on a long term concept, benefitting from synergies and avoiding adjustment costs • Smaller renovation projects requiring no planning permission may sometimes fail to comply with statutory minimum energy standards (can be difficult to verify) • Components with only minimal new insulation lead to excessive energy consumption over the years but will still be too new to warrant replacement for quite some time • Fewer opportunities to contribute to any improvement of the local district
Opportunities	**Threats**
• If the phasing of a renovation project is based on a long-term overall concept, the level of energy standards associated with an overall renovation programme can be achieved • Some aspects of phased renovation can be more sustainable than other strategies: Embodied energy use, social compatibility, preservation of good architecture, etc. • Lower-income households find it easier to fund projects which are carried out in steps	• Without any overall concept missing of synergies and optimizing potentials as regards costs, energy savings, comfort, etc. • Problems in terms of bringing things together (because of a failure to coordinate measures properly) lead to compromise solutions to energy and aesthetic issues and/or follow-up costs • Risk of problems with building physics (particularly mould) • Risk of patchwork buildings with poor architecture, not contributing to the image of the surrounding district.

Table 3 Matrix with the SWOT-analysis for stepwise building renovation.

The above Table 3 summarizes the main strengths, opportunities, weaknesses and threats of phased building renovation according to the findings of the project, combining the perspectives of policy makers and private home owners.

8 HOW TO ENSURE SUSTAINABLE PHASED RENOVATION – MEASURES

Subsequent measures can contribute to improve sustainability of phased building renovation and increase the chance that stepwise renovations achieve ambitious long term energy conservation and GHG emission reduction targets after having carried out the last renovation step.

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- Greater financial support for elaborating analyses and concepts for sustainable mid to long term building renovation. These concepts have to comprise several renovation phases and define the target which has to be achieved after the final renovation step. Building development strategies and renovation concepts for the longer term are considered to be a crucial prerequisite for far reaching and economic viable sustainable building renovation in phases.
- Amendment of subsidy programs for energy related building renovation: Subsidies for energy related renovation measures are only granted if subsidized measures are based on an overall renovation concept for the next 15 years (e.g. GEAK Plus with amendments), indicating future renovation steps within this period. This shall make sure that for the current measures carried out an overall concept for the longer term has been drafted.
- Continuous information campaign addressing building owners, architects, planners and craftsmen is recommended to raise awareness for the need and the benefits of comprehensive planning of building renovation for the longer term.
- Promotion and support of training and further education for renovation professionals, architects and planners with respect to consulting in building development strategies, energy related renovation strategies and energy certification. It should address phased building renovation processes and point out potential benefits and pitfalls.
- Simplified building approval procedures for energy related renovation measures to prevent complete approval procedures which might require costly and extensive measures to fulfil all of the requirements of present building regulation.
- The firms and craftsmen carrying out the work should be more in tune with initiatives involving public bodies and any objectives pursued through the energy and climate policy.
- Distinct efforts are required to increase façade insulation in case of building renovation, e.g. significant higher subsidies for façade insulation, clearly depending on the level of insulation.

9 CONCLUDING REMARKS

It is a matter of fact that a majority of building renovation projects is carried out in phases. Our analyses show that phased renovation risks falling short of existing targets for sustainable buildings for the longer term. However, it is shown that it is possible to achieve ambitious long term energy and GHG targets if phased renovation is planned from the beginning with the aim to meet demanding targets in the longer term and in a way that the particular renovation steps are designed and carried out mutually coordinated. If renewable energy sources are deployed and the elements of the building envelope except the façade have a very high energy performance, it is even possible to achieve ambitious nonrenewable primary energy and GHG emission targets without insulating the façade. Moreover, good planning from the beginning allows benefitting from particular advantages of stepwise renovation without compromising existing energy and GHG targets for the longer term. It is shown that for the time being it is indispensable to foster the sustainability of stepwise building renovation. Among the supporting measures presented, fostering initial strategy development and concept elaboration for a longer term, comprising all of the upcoming renovation steps at the beginning of the renovation process is crucial. If building renovation is subsidized it should be required that subsidies are only given if such concepts for the longer term, comprising several renovation phases are elaborated first.

10 ACKNOWLEDGMENTS

The research project "Nachhaltige Gebäudeerneuerung in Etappen" ("Sustainable Stepwise Building Renovation") was commissioned by the research program "Energy in Buildings" of the SFOE. It was supported and co-financed by the cantons Basel-Stadt, Thurgau, Schaffhausen and the city of Zürich. We would like to thank these institutions for making this research possible and for supporting the work.

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