# *LONG-TERM AND STEP-BY-STEP DEEP RENOVATION APPROACH: INCLUDING BUILDING OWNERS' ABILITY TO INVEST IN A RETROFFITING OPTIMISATION MODEL*

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## Overview

The recast of the Energy Performance of Buildings Directive (EPBD) 2018/844/EU introduced in Article 19a (European Parliament, 2018) the building renovation passports serving to improve building's energy efficiency, by providing a long-term and step-by-step deep renovation roadmap for a specific building.
In the literature, there is no consensus that deep renovation can also be achieved by a sequence of step-by-step renovation measures: e.g. in a study on renovation rates of energy performance activities in the residential building stock in the Netherlands (Filippidou et al., 2017) the results showed that, despite the realization of many building renovation activities, only small improvements on the energy efficiency of dwellings were observed. The authors pointed out the need of single stage packages for deep renovation measures, rather than single measures.
Another study (Risholt and Berker, 2013) on the success for energy efficient renovation of dwellings in Norway emphasizes the importance of private homeowners to have access to relevant and reliable advices, to make energy efficient choices in the process of renovation, as a role player in the process of increasing building renovation rates.

Preliminary results showed that optimisation models for deep renovation of existing building almost exclusively optimise single stage retrofitting. In fact, "deep renovation" is not necessarily restricted to single stage renovation, but can also be achieved by step-by-step renovation measures. Different from the single stage approach, in the step-by-step approach the retrofitting measures are not performed at the same time. Neverthless, studies have showed that in the real-life most renovation of single family house are performed step-by-step (EuroPHIT project, 2016). In this context, the main goal of the present paper is to compare both deep renovation approaches, single stage and step-by-step, by applying a net present value optimisation model.

## Methods

To carry out the analysis, a methodological approach of an optimisation model is outlined, and applied to several reference buildings (representative of the building vintage). The method optimisation modelling considers building owners' ability to invest for energy related expenditures (assuming owner-occupied buildings only). The main target is to maximize the net present value of (cumulated) income available for energy related expenditures minus energy related expenditures over a certain optimisation period. It is assumed, that the building owner allocates a regular part of her/his income and spends part of it for energy related expenses (investment costs for retrofitting measures, running energy and maintenance costs).
Over the time, the difference between, cumulated allocated assets and energy related expenditures, generates the energy related assets. Energy related expenditures are investment costs for retrofitting measures, energy and maintenance costs. The results from the optimasation indicate the optimised timing of retrofitting measures, and consequently, the new final and primary energy demand for space heating.
Then, by upscaling reference buildings for the German single family houses into building stock level, we analyse and discuss possible impacts of these step-by-step deep renovation approach on the building stock decarbonisation target until 2050.
Finally, the results from the step-by-step approach are be compared to single stage major renovation measures.

## Results

The first results show that the step-by-step sequence of deep renovation measures varies for each building vintage, based on the building typology database (EPISCOPE project, 2016). The reason for that is, that the timing of the each retrofitting step is defined according to the aging process distribution of building element's and equipment's material lifetime (Hansen, 2010)(Pfeiffer et al., 2010). The building typology database indicates that each building vintage is characterized by different construction systems.

This also implies that non-insulated building elements (external walls, roof and floor) have higher probabiblity to take longer time until the first renovation cycle is completed, than insulated ones (as insulation leads to shorter life span than almost all other materials) (Pfeiffer et al., 2010). Naturally, this also affects the energy needs savings for space heating.

When comparing both step-by-step and single staged approach, in terms of building's adaptation to the codes in force, the first approach enables faster adaptation to the building code, as the building elements can be improved at different time steps. On the other hand, in the second approach, the renovation time step is determined by the overall building's lifetime, which means that by the time of the renovation a building element might not have reached its end-of-life.

Overall, for the year 2050 the results show that the analysis of both thermal renovation concepts, step-by-step and single-stage present plausible. Further expected results aim at going deeper on singularities regarding the economic aspects of the step-by-step, especially focusing on building owners' ability to invest: income, budget restrictions for retrofitting and energy related expenditures. We consider that these are key issues to performe energy efficient retrofiiting in single family houses and therefore, achieving the residential building stock decarbonisation targets.

## Conclusions

We believe that the present study considers relevant aspects of real-life retrofitting, by analyzing the step-by-step retrofitting approach under the consideration of building owner's ability to pay. Therefore, these aspects should be considered, when designing policies and incentives to achieve building stock decarbonisation targets. Limitations of this study are related to assumptions mainly regarding reference buildings characeristics (building elements and components), building lifetime and economic aspects of building owner's ability to invest. To guarantee accuracy on the analyses, sensitivity analyses should include important parameters as income projection, energy price scenarios and related policies. Further plausibility analysis should include human behaviour aspects (i.e. rebound effect), building stock characterisation and constructed materials, market value of the building after retrofitting, ambitious of building energy codes in terms of energy efficiency, unpredicted incomes and assets (e.g. bonus or inheritance).

## References


EPISCOPE project, 2016, 2016. TABULA WebTool - National Building Typologies [WWW Document]. URL http://webtool.building-typology.eu/?c=ba#bm (accessed 1.24.19).

European Parliament, 2018. Directive (EU) 2018/ of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency 17.

EuroPHIT project, 2016. Step by step retrofits with passive house components.

Filippidou, F., Nieboer, N., Visscher, H., 2017. Are we moving fast enough? The energy renovation rate of the Dutch non-profit housing using the national energy labelling database. Energy Policy 109, 488–498. https://doi.org/10.1016/j.enpol.2017.07.025

Hansen, P., 2010. Entwicklung eines energetischen Sanierungsmodells für den europäischen Wohngebäudesektor unter dem Aspekt der Erstellung von Szenarien für Energie- und CO2-Einsparpotenziale bis 2030, Schriften des Forschungszentrums Jülich Reihe Energie & Umwelt. Forschungszentrum Jülich, Jülich.

Müller, A., 2015. Energy Demand Assessment for Space Conditioning and Domestic Hot Water: A Case Study for the Austrian Building Stock 285.

Pfeiffer, M., Bether, A., Fanslau-Görlitz, D., Zedler, J., 2010. Nutzungsdauertabellen für Wohngebäude - Lebensdauer von Bau- und Anlagenteilen.

Risholt, B., Berker, T., 2013. Success for energy efficient renovation of dwellings—Learning from private homeowners. Energy Policy 61, 1022–1030. https://doi.org/10.1016/j.enpol.2013.06.011