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Techno-economic potential of large-scale energy retrofit in the Swiss residential building stock

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Abstract

A statistical analysis of more than 6,000 energy performance certificates including retrofit options proposed by experts for different building elements is performed. This provides an overview of the most commonly suggested renovation measures and their estimated investment costs and U-Values. Based on an energy model of the Swiss residential building stock (SwissRes), the theoretical energy savings are estimated. Together with the estimated investment costs, the levelized costs of each renovation measure is then determined in order to identify the most cost-effective measures. It is shown that a large-scale energy retrofit of the residential building stock would result in theoretical energy savings of up to 84% regarding the current simulated energy demand. Yet, existing technical and social constraints would lower the expected energy savings significantly. None of the selected measures is cost-effective, but under a more optimistic scenario, the cost-effective share reaches up to 85% of the total potential energy savings.

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Keywords:
Building Energy, Retrofiting, Investment Costs, Levelized Costs

1. Introduction

The building sector represents about 37% of the Swiss final energy use [1]. A reduction of the space heating energy demand by up to 64% was therefore identified as a key element of the Swiss Energy Strategy 2050 [2]. However, the rate of renovations per year is still below 1% and therefore insufficient to reach the targets set by the Swiss Energy Strategy 2050. The aim of this paper is to analyse the techno-economic potential of commonly used renovation measures for energy savings in the Swiss residential building stock. For this, a statistical analysis of more than 6,000 energy performance certificates including expert-based renovation proposals for different building elements is performed. This provides an overview of the most commonly suggested renovation measures along with their average estimated investment costs and resulting U-Values for different groups of building elements. Based on an energy model of the Swiss residential building stock (SwissRes), the theoretical energy savings from a large scale

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Table 1. Selected renovation measures and derived median values of the CECB. (n = sample size, Ic = specific investment cost [CHF/m2], U = U-Value [W/m2K], L = lifetime [a])

Measure	Element	Element Type	Measure Type	n	Ic	U	L
Gr-Ex-Ex	Ground	Exterior	Exterior Insulation	1387	225	0.20	50
Ro-Ex-Ex	Roof	Exterior	Exterior Insulation	7942	325	0.18	40
Wa-Ex-Ex	Wall	Exterior	Exterior Insulation	31606	225	0.19	50
Gr-So-In	Ground	Soil	Interior insulation	1901	150	0.25	50
Wa-So-In	Wall	Soil	Interior insulation	1329	125	0.23	50
Gr-Un-In	Ground	Unheated	Interior insulation	9872	150	0.24	50
Ro-Un-In	Roof	Unheated	Interior insulation	3355	150	0.21	40
Wa-Un-In	Wall	Unheated	Interior insulation	7652	100	0.25	50
Wi-Ex-Ne	Window	Exterior	New built	52956	850	1.00	30

renovation programme are estimated [3]. Together with the estimated investment costs, the levelized cost of each renovation measure is then determined. In the final step, the results of the techno-economic analysis are summarized in the form of an Energy Efficiency Cost Curve (EECC), which shows the levelized cost of a measure together with its expected potential of reduction of energy consumption. While the archetype approach of the SwissRes model allows to calculate the cost supply curves for 48 archetype categories in the residential sector, this paper focuses on the differences between Multi-Family (MFH) and Single-Family Houses (SFH) in terms of techno-economic potential.

2. Methods

The input data for this techno-economic potential analysis is derived from a statistical analysis of building data provided by the Swiss Cantonal Energy performance Certificates for Buildings (CECB) [4]. These certificates are issued following an assessment of the energy performance of buildings either before or after retrofit and they are mandatory in some Cantons. The assessment is based on the judgment of certified experts. Beside the standard CECB, an advanced certificate (CECB Plus) can also be issued which includes a proposal for different retrofit strategies and their economic viability. In a previous study, the detailed building data of 12,000 standard certificates was classified according to different archetype categories[1] representative for the Swiss residential building stock [5]. This analysis allowed to develop a detailed bottom-up energy model that can simulate the annual space heating energy demand for the current stock as a whole, but and also by archetype and by building elements [3].

2.1. Common retrofit measures

As first step of this study, the most common retrofit measures suggested by CECB experts are determined using the CECB Plus certificates featuring 6,000 buildings. In general this database allows to differentiate between the building elements (i.e., wall, ground, roof and window) and their specification (i.e., facing against exterior, soil or unheated). Beside the element specification, the CECB furthermore differentiates between different types of renovation measures, such as interior or exterior insulation. For this study only the most common measure per element category in the CECB data is taken into account (see Table 1). For instance, in 67% of all cases the expert was proposing an exterior insulation for walls facing the exterior, which makes this the most frequently proposed measure in that category. This paper does not include a differentiation of investment costs, U-Values and lifetimes by archetype category. However, there are no statistically significant differences between MFH and SFH for these values. Moreover, a test of the Pearson Correlation between investment costs and the expected U-Value after renovation showed no significant results. Therefore, it was decided to take the median investment costs, U-Values and lifetimes for each measure as input data for the techno-economic analysis. In future research we will study the influence of additional parameters, such as the insulation material or construction period of the buildings, on the estimated investment costs.

[1] 48 archetypes are defined based on 8 construction periods, 2 building types and 3 spatial categories depending on the share of the core urban population in each Canton