Energy and Buildings 123 (2016) 41–49

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Socio-economic impact of renovation and energy retrofitting of the Gothenburg building stock

Mikael Mangold[a,*], Magnus Österbring[a], Holger Wallbaum[a], Liane Thuvander[b], Paula Femenias[b]

[a] *Chalmers University of Technology, Civil and Environmental Engineering, Sven Hultins gata 8, 412 96 Gothenburg, Sweden*
[b] *Chalmers University of Technology, Architecture, Sven Hultins gata 8, 412 96 Gothenburg, Sweden*

ARTICLE INFO

Article history:
Received 23 November 2015
Received in revised form 11 March 2016
Accepted 13 April 2016
Available online 16 April 2016

Keywords:
Measured energy usage
GIS
Building specific data
Average income
Tenure
Equity
Multi-family dwellings

ABSTRACT

The European building stock was renewed at a rapid pace during the period 1950–1975. In many European countries the building stock from this time needs to be renovated. There is an opportunity to introduce energy efficiency measures in the renovation process, but in this process social aspects should also be taken into account. The purpose of this article is to provide an estimate of the economic and societal challenge of renovating and energy retrofitting the aging building stock. Building specific data on energy usage and previous renovation investments made in the multi-family dwellings in Gothenburg (N = 5 098) is aligned with data on tenure type and average income. Based on conducted energy retrofitting projects, costs are estimated for renovating and energy retrofitting multi-family dwellings that will reach the service life of 50 years before 2026. It is found that the pace of renovation needs to increase and that there is risk of increasing societal inequity due to rent increases in renovated buildings.

1. Introduction

In many European countries the building stock increased at a rapid pace during the period 1950–1975 [1]. This aging building stock needs to be renovated, and there is a need to introduce energy efficiency measures in the renovation process [2–4]. The Directive 2002/91/EC *On the Energy Performance of Buildings* proposed the implementation of Energy Performance Certificates (EPC) for European buildings as a part of addressing energy retrofitting needs. This data has in some European countries been used by researchers to describe the energy usage demand and potential in building energy retrofitting [5–8].

The previous Swedish national target to decrease energy usage in the building stock by 50% by 2050 based on 1990 levels [9] would require extensive energy retrofitting [10]. In Gothenburg, Sweden, 42% of the multi-family dwellings were built during 1961–1975. This era is known as the Million Homes Program named after a large national initiative focused on building one million dwellings to cover an urgent housing need [11,12]. Buildings from the Millions Homes Program era will reach the 50 year service life in the next ten years, and a service life of 50 years is a commonly used as lifespan of buildings in Swedish building stock energy retrofitting studies [13,14]. The Buildings from the Millions Homes Program has been mentioned as a priority for renovation [15] and energy retrofitting [16].

Although the energy retrofitting of the existing building stock has been pointed out as one main area to achieve global, European and Swedish energy and climate goals, many studies have pointed out the economic challenges associated with these energy retrofitting activities [17–22]. First, the difficult economic framework conditions with low energy prices and high labor costs that restricts the (pure) market driven incentives for energy retrofitting results in a return on investment ratio that is often far beyond 10–15 years that e.g. multinational investors accept as the maximum time for return on invest. Second, the fact that (deep) energy retrofitting often results in socio-economic drawbacks, namely increased rents [17,23,24]. Recent concerns [25] for increased societal costs and decreased societal equity as a result of inhabitant relocation after renovation has spurred a debate about the inclusion of social sustainable development criteria in the required national renovation plan [26]. Quantitative studies that include equity perspectives are needed to make informed decisions in such renovation plan [27].

* Corresponding author.
E-mail addresses: Mikael.mangold@chalmers.se, mikael.mangold@gmail.com (M. Mangold), magost@chalmers.se (M. Österbring), holger.wallbaum@chalmers.se (H. Wallbaum), liane.thuvander@chalmers.se (L. Thuvander), paula.femenias@chalmers.se (P. Femenias).

http://dx.doi.org/10.1016/j.enbuild.2016.04.033

The purpose of this article is to quantify the economic and societal challenge of renovating and energy retrofitting buildings of the Million Homes Program by adding dimensions of tenure type, average income and rent, to a dataset of potential energy retrofitting and previous renovation investments made in the multi-family dwellings in Gothenburg. Several existing national databases are aligned using a geographical information system (GIS) including: Swedish EPCs containing measured energy usage and estimated energy reduction potentials by certified energy experts; renovation investments and geographical data of buildings from the Gothenburg City Planning Authority (CPA, Swedish translation: Stadsbyggnadskontoret) and the Swedish National Land Survey; socio-economic data from Gothenburg City Executive Office (CEO, Swedish translation: Stadsledningskontoret); and rent levels are provided by the residents' association (Swedish translation: Hyresgästföreningen). These databases are further described under materials and methods.

Increasingly socio-economically disadvantaged groups inhabit the peripheral Million Homes Program areas [28] and a number of researchers have been studying how to take these groups into account. Högberg [29] suggested that a way forward might be that tenants have the option to choose the levels of renovation and subsequent increase in rent. In most Swedish apartments the rent includes heating and domestic hot and cold water, while electricity is paid separately by the residents. In this article rent costs presented includes heating and water but not electricity. During the last 10 years volumetric billing of water has been introduced in mainly economically disadvantaged rental apartments where the water cost is still added to the monthly rent [30].

In this article, rent increases as a result of renovation and energy retrofitting projects are calculated and visualized onto geographical areas with defined income ranges as part of estimating the impact on the equity aspect of social sustainable development [31]. Impact on social sustainable development is also given as number of people that are likely to change dwelling as a consequence of increased rent after renovation projects [25].

This article first describes the data that is used, after that the assumptions are detailed to explain how the resulting description of the building stock is obtained. The results are finally discussed against findings in previous studies.

2. Materials

Working on a city scale with data in a GIS application makes it possible to estimate validity, notice anomalies and make the results presentable and usable for local authorities and stakeholders, see Fig. 1.

The datasets that are combined to describe the Gothenburg building stock are presented in Table 1. Different numbers of *base areas*,[1] are available in data from Gothenburg CEO and the Residents association. The total number of inhabited base areas in Gothenburg is 731. Due to the legal limitations to data dissemination it is not possible to access data where there are less than 10 people in a group in one base area, which causes some multi-family dwellings to fall outside of the study. Furthermore, it was also impossible for the Residents' association to provide average rent levels were only one real estate companies operate. This shortcoming was handled by assigning average rent levels from other existing records based on proximity. The total number of EPCs analyzed in this article is 5098 after the removal of: buildings built after 2005, buildings in base areas with less than 10 inhabitants, and the buildings in base areas where the sum of Heated floor area, A_{temp}[2] is less than 10,000 m^2.

The possible pitfalls and limitations with using Swedish EPC data when analyzing building stock were studied by Mangold et al. [34]. The most pressing shortcoming was found to be varying ways of deriving heated floor area, A_{temp}.

2.1. Division of areas and groups

The Swedish housing system is complex and has its current shape due to legacy regulated elements on the one hand and neoliberalised elements on the other [35]. The Swedish multi-family-dwelling building stock consist of primarily three tenure types: municipally owned rental apartments, privately owned rental apartments or resident owned apartments (Swedish translation: bostadsrätt). In the base areas in Gothenburg the type of tenure is on average 87% homogenous. Base areas in which no tenure type reach 50% homogeneity are separated as base areas of mixed tenure. When linking the tenure types with the base areas, four different tenure area groups are defined: Mixed tenure, municipally owned, privately owned and resident owned, see Table 2.

Building age is a commonly used parameter for dividing the building stock since building techniques vary between eras and the renovation needs might be different between different construction periods. Thuvander et al. [36] found the separation in 15 year construction periods useful to describe the Gothenburg building stock, see Table 3. In Table 3 and Table 4 tenure area groups are further divided into construction periods groups, resulting in some groups not being sufficiently large to be statistically representative. The period 1961–1975 is the Million Homes Program era. Building built after 2005 are outside of the scope of this study.

2.2. Renovation costs

When a renovation project is conducted that goes beyond maintenance it is registered by the Swedish Tax Agency and provided to the CPA. The cost of the renovation results in a change in the so-called *value year* of the building as described by Swedish Tax Agency [37]. The purpose of recording a value year is to have an official record of anticipated remaining service life of buildings [37]. The value year is initially the year of construction but as renovation is conducted the value year will increase depending on the cost of the renovation as described in Table 5. Registration of renovation in the tax index usually happen 1–2 years after the renovation.

$$\frac{Value\ year - Construction\ year\,[year]}{Renovation\ year - Construction\ year\,[year]} = \frac{Renovation\ cost\ \left[\frac{SEK}{m^2}\right]}{Cost\ of\ new\ building\ \left[\frac{SEK}{m^2}\right]} \qquad (1)$$

Example: if a building built in 1960 was renovated in year 2000 to a cost of 50% of the new building cost the value year after the renovation would be 1980.

The changes in value year only reflect the cost of the renovation, but do not contain what kind of renovation measures were implemented. The value year is an indicator of renovation costs, or an indicator of investments into the building. The changes in value year is an indicator with the following uncertainties:

[1] Base areas are an administrative unit defined as the smallest demographical statistics area containing 50–4000 residents (Swedish translation: Basområde).

[2] A_{temp} is a measure of building floor area specifically developed for EPC in Sweden. A_{temp} is defined as the floor area heated above 10 °C including shared spaces and footprints of walls but not including garages [32].