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Environmental assessment of rebuilding and possible performance improvements effect on a national scale

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Abstract

This paper deals with improvement on environmental significant activities related to the life supporting function "building and housing", using life cycle assessment. In the calculation, back-casting technique is utilised and implies to a future scenario, based on known technology. Besides heating, wastewater treatment is a significant issue, according to the definition of building and housing function practised. The main conclusions from the assessment are that rebuilding is an environmentally better choice than the construction of a new building, if the same essential environmentally related functional performance is achieved. Furthermore, the case study and the national estimates performed prove that the potential environmental impact can be reduced by about 70% for the heating service and 75% for the wastewater system, if the suggested measures are performed.

Keywords: Ecological sustainable building; Life cycle assessment (LCA); Back casting; Rebuilding; Multi-dwelling; Energy conservation; Wastewater conservation

1. Introduction

In the life cycle of a building, the following major activities can be identified where environmental performance can be assessed: construction of a new building, rebuilding, extension, operation, maintenance and demolition. It is obvious that most options in the design process to best reach the available environmental performance appear for new buildings. However, also the rebuilding of existing buildings has opportunities to improve building environmental performance. It is noticed that rebuilding including maintenance activities represent almost half of the environmental impact in the residential and service sectors (see Fig. 1). Since most people live and work in "old" buildings, it is of great concern to evaluate what can be done by rebuilding in order to improve the environmental performance, if major market changes shall be carried out. At least on a national perspective, it is therefore of more interest to assess possibilities and limitations associated with the existing building stock, rather than new buildings if a more sustainable building sector shall be established. In Sweden, there is a large amount of apartments from the so-called "Million Homes" programme that were built during the 1960s and 1970s and now are in great need of refurbishment. An ongoing EU project called SUR-EURO has aimed at rebuilding multi-dwelling houses from this generation since it represents a significant part of the building stock in the whole of Europe and is generally a subject for rebuilding [1].

The aim of this paper is to determine the importance and rebuilding improvement possibilities for multi-dwelling houses in an environmental perspective. Calculations are performed to compare the previous environmental performance of an existing mufti-family house with the performance after the rebuilding has occurred, and to determine the importance of rebuilding

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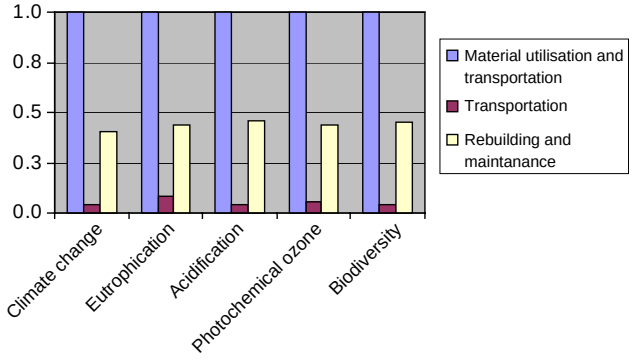

Fig. 1. Environmental contribution from rebuilding and transportation in the residential and service sectors in Sweden (1998–1999) [2].

activities in general on a national scale, and its potential positive long-term effects if some rebuilding activities will be performed. An existing building located in Stockholm was chosen as it represents a generation of multi-dwelling houses that are frequent objects for rebuilding today. A number of economical realistic possible rebuilding measures, which not only increase the comfort or aesthetic values but also improves the building (both technical and environmental) performance, are defined and evaluated.

The selected rebuilding activities for the single building object will then be enlarged by calculating a scenario where these improvements will be performed on the entire existing multi-dwelling building stock. Esthetic concerns are made in the sense that for the older generations of buildings, no major changes of facades are found convenient. In a life cycle perceptive, the improvements affect the external technical systems such as local heating plants, fertilisation of agricultural land and waste handling. All these systems and connected activities will change in the future while different scenarios describing both today's situation and future potential improvements have to be accounted for. Based on the statistical information from the Swedish Statistical Central Bureau (SCB) [2], the time span for rebuilding has increased from 30 in the 80s to 40 years today, while a rebuilding activity and its overall payback was determined to the 35 years in this study.

In the present paper, a life cycle assessment (LCA) concept is offered that makes it possible to evaluate different possibilities addressed in rebuilding in general, or to be more precise in this paper, in order to improve the environmental impact during the utilisation of the building. Traditionally, LCA concepts adopted on buildings (e.g. [3–7]) and case studies (e.g. [8–11]) have applied a *linear building perspective* typically described as:

> The buildings are constructed, utilised for its intended purpose for a defined number of years and then finally demolished.

Since rebuilding and extension are not included in this kind of linear assessment of buildings, an alternative approach has to be worked out. The alternative LCA concept offered, introduces a so-called *functional unit* that takes a *building and housing service life cycle perspective* oriented approach into account instead. In this approach, each included building and housing service accounted for in the building functional unit's start- and end-points have to be defined, as described below:

> The service life cycle will start to account for all activities that have to be performed so that all materials in necessary amounts and qualities shall be available as required for the specified service. The service will then account for all activities related to the predicted service life.

The service life approach allows the analysis of rebuilding or extension as well as a traditional linear scenario that is adequate for new buildings representing the linear building perspective defined above. Focusing on a free number of building services it also apply to a generic LCA framework applicable for buildings and constructions. This framework including a menu of building services and further development will be published in a separate paper.

2. LCA concept for environmental assessment of building and housing services

The word *service* corresponds in this concept in the system that provides something which is needed or asked for, e.g. different building facilities, compared to the facilities itself that are optional equipment, etc., which are then provided for a particular activity. The function of the system (i.e. functional unit) describes the purpose for which it is used. When analysing buildings it has been found convenient to define a *primary system* that covers the subsystem equal to the *physical building* and secondly the utilisation of and facilities related to it refereed to as the subsystem *housing* (Fig. 2). The physical building can be divided into different activities such as construction, maintenance, rebuilding, extension and demolition, while housing can more or less be compared to a continuous process including related activities to both the building and its utilisation such as heating, ventilation, water supply, etc. A consequence of this definition of housing is that, e.g., tenants transport from the building and other facilities is not included in the housing service, since it is not related to the utilisation of different construction alternatives or housings. In other concepts as in the REGENER project, this is assumed to be a part of a building service and will then give a significant contribution to the overall impact [4,12]. However, this kind of