BYGGAE – METHOD FOR QUALITY ASSURANCE OF ENERGY EFFICIENT BUILDINGS

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ABSTRACT

Policies for energy efficiency requirements in buildings have become more stringent according to EU2020 goals. Despite policy regulations, requirements for energy efficiency are not met in many new buildings. Some of the reasons for this energy performance gap are related to the building process. The aim with this paper is to describe a purposed method for quality assurance of sustainable buildings according to energy efficiency. The proposed method is called ByggaE, where 'Bygga' is the Swedish word for 'build' and E is the first letter in 'energy efficient'. It is a tool intended to lower the energy performance gap related to the building process by guiding the client and providers through the process to fulfill goals. The essence of ByggaE is the formulation of requirements by the client and the working process of identifying, handling and following up critical constructions and key issues. This working process involves all participants in the building project by using appropriate quality guidelines and checklists for documentation, communication and verification. ByggaE is a step forward ensuring that the building fulfills the defined functions and that conscious decisions are taken when goals have to be changed during the building project. The next steps are to ensure the usefulness of the method in practice by more testing and to spread knowledge about the method.
Keywords: energy efficient buildings, quality assurance, building process, energy performance gap

1 INTRODUCTION

By 2020, the global demand for energy will almost double and the demand for electricity almost triple compared to 1990 [1]. The built environment accounts for close to 40% of the annual energy use and 36% of CO_2 emissions in Europe, where a considerable large fraction is due to achieving desirable indoor climate in buildings [2, 3].

Policies for energy efficiency requirements in buildings have become more stringent since the European Union issued the 20-20-20 target with the goals to have a reduction in CO_2 emissions by 20% compared to 1990 levels, 20% increase in energy efficiency, and 20% of the energy coming from renewables [4]. The goals have been increased in the EU2030 goals to meet the EU's long-term 2050 greenhouse gas reductions target (European Council [5]).

The targets for 2030 are a 40% reduction in greenhouse gas emissions compared to 1990 levels, at least a 27% share of renewable energy consumption, and at least 27% energy savings compared with the business-as-usual scenario. Today several green building programs and certification systems such as LEED and BREEM have been established, aiming for more energy-efficient and environmentally sound building designs.

In EU, two main pieces of legislation have been issued to reduce the energy consumption and environmental impact generated by the building sector, the Energy Performance of Buildings Directive (EPBD) [3] and the Energy Efficiency Directive (EED) [6].

Through these directives, EU aims to achieve Nearly Zero-Energy Building (nZEB) for all new buildings by 2021 in order to accomplish savings in energy demand and CO_2 emissions reduction. All Member States have to set a national nZEB definition and also stimulate higher market uptake of such buildings. In Sweden, definitions for nZEB are in progress and a proposal for new regulations on nZEB for 2021 suggests that delivered energy should be less

ISSN: 2056-3272 (paper format), ISSN: 2056-3280 (online), http://www.witpress.com/journals
DOI: 10.2495/EQ-V2-N2-133-139

than 35–80 kWh/m^2 for residential buildings and 32–44 kWh/m^2 for non-residential buildings (Boverket [7]).

Even if there are regulations about the energy usage in buildings, there is a difference between predicted and measured energy usage in new buildings. This energy performance gap has been shown in several studies, both in Sweden and in other European countries [8–11]. Baseline in these studies is a calculation of energy usage for the building performed during the design of the building or at the start of construction. When there is a policy regulation, the baseline is correlated to the policy. There are many reasons for the energy performance gap. There are differences in how the building is used and the data used in the energy calculation. To handle this, SVEBY [12] has developed guidelines according to user input and models for correcting measurements according to usage. They also have formed a juridical agreement that can be used to follow up energy usage in new buildings (Sveby [13]).

There are also many other reasons for the energy performance gap (De Wilde [8], Williamson [14]). Some of them are related to quality in the different stages in the building process.

The aim of this article is to describe ByggaE, a newly developed quality assurance method for energy efficient buildings. 'Bygga' is the Swedish word for 'build' and E is the first letter in 'energy efficient'. The method aims to reduce the gap between predicted and actual energy use for buildings.

2 DESCRIPTION OF BYGGAE METHODOLOGY

ByggaE is a quality assurance method for the building process which aims to reduce the energy performance gap (De Wilde [8]). The methodology is based on (Mjörnell, Arfvidsson [15]) a methodology for moisture management in the building process, in Swedish called ByggaF. The purpose of ByggaF is to help all those involved to work with moisture safety activities and document them in a structured way. ByggaF was developed in 2008 (Mjörnell, Arfvidsson [16]) and became an industry standard [17] in 2013. In 2010, a method for airtightness in buildings (Sikander [18]) was developed based on the same methodology. The method is called ByggaL in Swedish. Handling airtightness is important for moisture safety and energy efficiency in buildings. When the development of ByggaE began (Gustavsson, Ruud [19]), the same kind of activities and documentation were a starting point but with focus on energy efficiency for the building. The similarities between moisture safety and energy efficiency in buildings were supposed to be related to quality in the building process.

The method in ByggaE is a support for clients, architects, design engineers, contractors and operators from the beginning of a building project to the operation stage of the building. In Fig. 1, the conceptual outline of ByggaE is presented. The different stages in the building process are presented on the horizontal axis and the different parties involved along the vertical axis.

The first box, in the upper left corner, starts with the formulation of the building client's requirements. Technical requirements and activities for handling and follow up of critical parts are formulated in a document called 'Description of energy efficiency requirements'. To help the client, there is a checklist to support formulation of energy efficiency requirements. The document should be a part of the contract with consultants and entrepreneurs. It is also recommended for the client to have support from an energy coordinator in the project and to involve that person in the formulation of energy efficiency requirements. In ByggaE, the energy coordinator represents the client.

A central part of ByggaE is to work with critical parts and issues. This process is described in Fig. 2. A critical part or issue in ByggaE is defined as anything that will affect the future energy use for the building. These critical parts could for example be a construction that

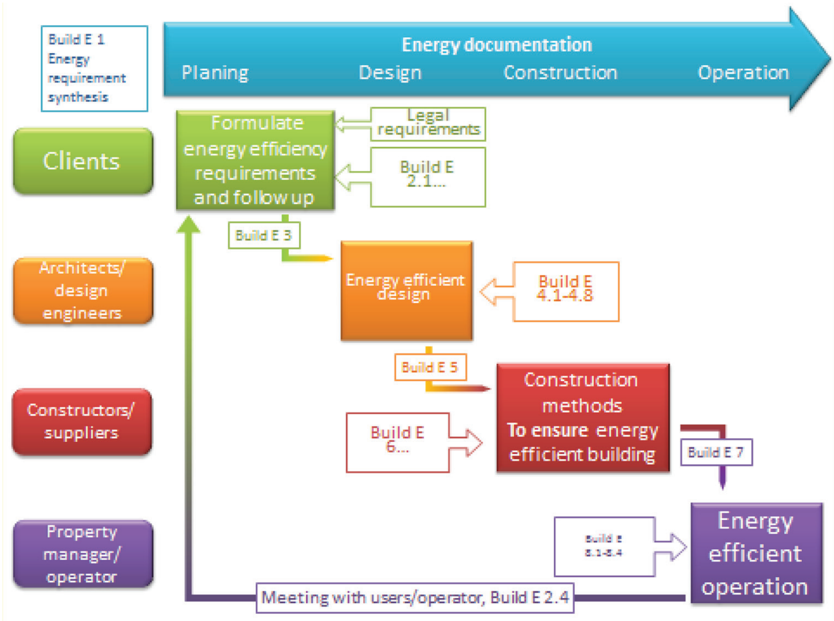


Figure 1: The conceptual outline of ByggaE.

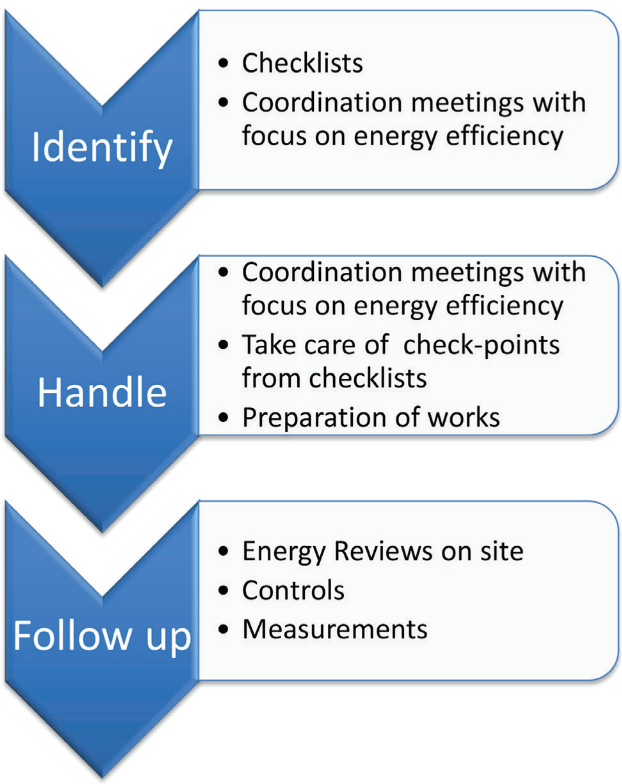
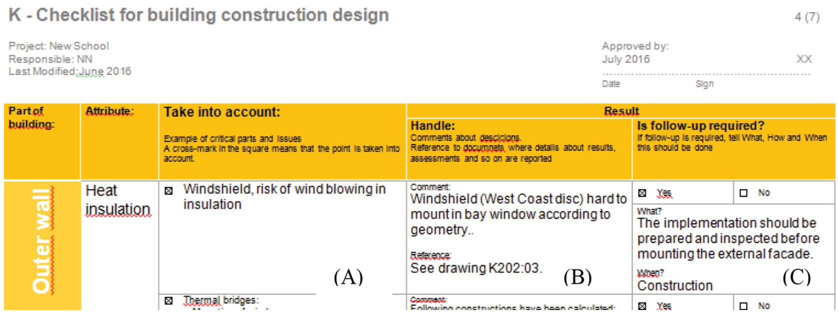


Figure 2: Activities and documents connected to the process in ByggaE with Identify – Handle – Follow up critical parts.


K - Checklist for building construction design 4 (7)

Project: New School
Responsible: NN
Last Modified: June 2016

Approved by:
July 2016 XX
Date Sign

Part of building:	Attribute:	Take into account: Example of critical parts and issues. A cross-mark in the square means that the point is taken into account.	Result: Handle: Comments about descicions. Reference to documnets, where details about results, assessments and so on are reported	Result: Is follow-up required? If follow-up is required, tell What, How and When this should be done
Outer wall	Heat insulation	☒ Windshield, risk of wind blowing in insulation (A)	Comment: Windshield (West Coast disc) hard to mount in bay window according to geometry.. Reference: See drawing K202:03. (B)	☒ Yes ☐ No. What? The implementation should be prepared and inspected before mounting the external facade. When? Construction (C)
		☒ Thermal bridges:	Comment: Following constructions have been calculated:	☒ Yes ☐ No

Figure 3: Example of completed checklist for building construction in the design stage.

results in a thermal bridge. It could also be overestimated energy calculation or lack of coordination between installations. To find the critical parts for the specific building project, ByggaE uses checklists, routines and activities as support.

Coordination meetings with focus on energy efficiency are an activity where the interaction between different parts and constructions of the building is in focus. These meetings give an opportunity to identify critical aspects and handle them.

In the design, each discipline uses a checklist to identify, handle and make activities for follow up of critical parts in their own aspect of construction later on in the building process.

An example of a checklist for building construction is shown in

Figure 3. The example shows how (A) the architect takes into account the check point 'windshield, risk of blowing in insulation'. This is to help identify a critical aspect, risk of blowing in the insulation. (B) The check point is documented and handled by a detail on a drawing, referred to as K202:03. (C) There is an action in the construction phase to follow up the quality by preparation and inspection.

3 CASE STUDIES

Recently, ByggaE has been tested in three building projects which were done by the same property manager in southern Sweden. A compilation of the test sites can be seen in Table 1. All buildings were schools or preschools. ByggaE was introduced in different phases of the building projects. In all projects, ByggaE was introduced by a researcher at an ordinary project

Table 1: Compilation of test sites for ByggaE.

	Site A	Site B	Site C
Type of building	Part of school building	School building	Preschool
Type of Project	Renovation	New building near old one	New Buildings
Phase for implementation of ByggaE	Design	Construction	Design
ByggaE Documentation	By e-mail	Papers at site in binders	Web documentation

meeting in the beginning of the implementation. Site A was a renovation project with energy savings in focus and the other projects were new buildings. The property manager had their own energy coordinator who was to prepare the documents for the specific project and follow up the use of them. The documentation was handed out in different ways according to how other documentation in the project was handled.

For analysis of the implementation of ByggaE, copies of the documentation used were collected. Interviews were performed with participants in the building projects with a semi-structured interview guide. The answers were briefly notated during the interview. These data were analyzed according to finding improvements from ByggaE.

Documents related to ByggaE were not used to the extent that was expected, but despite that, useful conclusions could be drawn. There needs to be a better introduction to the method. Some participants understood parts of the method during the interview, instead of at the beginning of the project. There needs to be more support during the project to implement the method and the method has to be easy to understand. The energy inspections during construction resulted in better performance of insulation. And there were discussions related to energy performance during design between different consultants, which would not probably have taken place without the method, which resulted in more energy efficient performance of the building.

4 DISCUSSION

According to EPBD [3], there is a need for more energy-efficient buildings. As a consequence, policy regulations for energy efficiency in new buildings are becoming more stringent (Boverket [7]). This would increase the need for support to reach energy efficiency in buildings. As mentioned above, there is still an energy performance gap (De Wilde [8]) between predicted and measured energy usage in new buildings. In this study, a methodology for reaching energy efficiency goals for buildings, called ByggaE, has been developed and tested in some building projects. The case studies showed that implementation of a new methodology met resistance in practice. Is this a sign that the methodology is unnecessary? Probably not, as there still is a problem in reaching energy efficiency goals for new buildings. The methodology needs some improvements to be easier to use. In addition, a better introduction to the method is needed. Work with improvements and introductory material is ongoing. There also has to be someone in the project who puts energy efficiency on the agenda and follows up. In ByggaE that person is meant to be the energy coordinator and the material in ByggaE is supposed to support that task.

But there are still some problems left, which are not connected to the methodology. There is lack of government control after the building is completed. In Sweden, an energy calculation may be enough as verification of the energy usage. This leaves the interest of reaching energy efficiency in buildings to the developer and landlord of the building, which probably will vary. Since energy-efficient buildings are a requirement connected to policy regulation there should be follow-up connected to the policy to get a better result.

5 CONCLUSION

ByggaE is a step forward ensuring that the building fulfills the defined functions and that conscious decisions are taken when goals have to be changed during the building project. However, there is a need for development of the method and to work with implementation in the future. There is ongoing work to improve ByggaE related to basic parts and material for introduction to the method to make a better presentation about how to use it.

Policy regulations have to be followed up by authorities, if energy efficiency in buildings is to become a reality to a large extent.

ACKNOWLEDGEMENTS

The work has been carried out under the auspices of the industrial post-graduate school Reesbe, which is financed by the Swedish Knowledge Foundation (KK-stiftelsen).

The development and testing of ByggaE was a cooperation between SP and FoU Väst. It has been financed by SBUF, LÅGAN, VGR and SP ZEB. The further development of ByggaE is financed by the Swedish Energy Agency in the program E2B2 and the cities of Gothenburg and Borås.

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