

Criteria for Sustainable Buildings in Sweden

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Abstract. To continue to be an effective guidance tool for the property and construction sectors and to meet the environmental quality objectives, the Swedish certification system Miljöbyggnad needed to be developed. Over the years, new research results have been published and political decisions made that affect sustainable building and construction. What was rated as ‘best available technology’ ten years ago has now become standard. In this project, industry and academia have collaborated to implement research findings into practice. Miljöbyggnad considers requirements of energy, indoor environment and material use. The criteria give high scores for low heating power need, low heating loads from the sun, energy efficiency, high share of renewable energy, good sound levels, low radon exposure, good ventilation performance, moisture safety, indoor comfort in winter and summer, good daylight, low risk of legionella, documentation on material used, avoidance of hazardous substances and evaluation of the framework’s life cycle effects on climate change. Compliance with the criteria in Miljöbyggnad improves the potential for sustainable building design. The criteria give special consideration to fitting in with the outdoor climate throughout Sweden as well as Swedish building regulations and practice in the property and construction sectors. The work to evaluate and improve the criteria in Miljöbyggnad has taken two years and involved over 250 people from research and industry. The criteria are based on scientific values and can be verified, and they all support meeting different environmental objectives.

Keywords: Certification scheme, Energy, Indoor environment, Material use.

1 Introduction

The housing and service sector is responsible for 40% of Sweden’s total final energy use, and meeting the long-term environmental quality objectives requires an overall reduction in energy use as well as an energy supply with low environmental impact [1].

At the same time, 1.2 million adults have health problems that they relate to one or more indoor environmental factors in the home, school or workplace. As many report that they live in homes with visible damp damage, mould or a mouldy smell, and thousands of people suffer respiratory problems as a result [2]. The ventilation in Swedish homes is often poor [3], which can lead to health problems. Examples of serious health

problems, and in the worst case death, include lung cancer caused by radon exposure and Legionnaire's disease caused by legionella bacteria. Less serious problems such as poor thermal climate, noise disturbance and lack of daylight are also important.

Health problems can also arise from chemical exposure to materials indoors [2], and chemical substances in the indoor environment can pose a health risk of respiratory illnesses and allergies in children [4]. The main substances pointed out are formaldehyde-emitting materials, softened plastics (phthalates) and newly painted surfaces. There is a national environmental quality objective for 'an environment free of poisons' [5]. Still relatively little has improved in the last decade regarding the environmental problems connected to the buildings.

En stor del av samhällets miljöproblem uppkommer alltså till följd av dess bebyggelse och relativt lite har förbättrats under det senaste decenniet trots samhällets stora ambitioner och satsningar på miljöfrågor vad gäller byggnader.

To improve this situation and support meeting the environmental quality objectives set by the Bygga-bo dialogue (a partnership between the property and construction sector, authorities and academia [6]), a national environmental classification system was produced in 2009. The aim was to provide a strong incentive for building contractors, property owners, property managers and users of the buildings to speed up development towards a sustainable property and construction sector through a practically applicable and well-established method for environmental classification of buildings. In 2011, the method was developed into a certification system called Miljöbyggnad (Environmental Building). The certification involves a third-party inspection of documents to prove the environmental rating that is applied for.

Miljöbyggnad is a voluntary system of environmental certification for buildings considering energy, indoor environment and material issues. It is used for homes and offices, for new building, renovation and existing buildings. Miljöbyggnad has been operational for certification since 2011 and has become the dominant environmental certification in Sweden, with more than 1000 certified buildings [7]. During the years that Miljöbyggnad has been in operation, new research and development results have been published and political decisions made that affect building and management. What was seen as 'best available technology' in 2011 have in many respects become standard solutions. Miljöbyggnad with its areas, indicators, methods and certification needed to be assessed in substance and revised in order to continue to drive the development. This has been done with the drawing up of the new Miljöbyggnad version 3.0.

2 Method

The work started with the collection of concrete experiences and views including of the use of the method by those who had used previous versions of Miljöbyggnad. This was done in six work seminars in May 2015 in six different locations around Sweden. A total of about 160 public and private property owners, architects, energy companies, contractors, consultants, material manufacturers, politicians, etc. took part for one working day. The results of the work seminars were used in the planning of the development work of Miljöbyggnad 3.0. Different subjects that needed to be analysed for

the continued work were identified as well as a number of basic principles for Miljöbyggnad, intended to facilitate and guide the continued development work [8].

In autumn 2015, ten expert groups were formed to work on the different subject areas in Miljöbyggnad and analyse, evaluate and propose different indicators to assess the environmental performance of a building. The expert groups consisted of one highly qualified group leader and about ten experts from the industry and academia. A further two expert groups were formed to develop the method used for verification and consolidation of the different subject areas. Their task was to balance the different subject areas into a whole in the Miljöbyggnad system. A total of 110 experts took an active part in this development. Subject-specific consultation groups with a further 120 persons were also linked to the expert groups. For more in-depth analyses, individual experts in academia and the industry were consulted. Coordination was done between the group leaders and the two main project leaders.

The expert groups' proposals were handled in parallel in a reference group consisted of 20 property owners to obtain practical views, primarily with regard to suitability and usefulness in relation to verification costs for different indicators. The work started in November 2015, and in August 2016 a comprehensive and considered proposal for a completely new system was presented at seven hearings around Sweden. A total of 36 organisations submitted comments before the consultation deadline of 30 August 2016.

All the views from the seminars were then considered by subject experts, group leaders and different consultative bodies and, at the same time, a number of specific analyses were conducted. In February-March 2007, a proposal for manual texts was presented. Ninety-six organisations responded with 1214 comments that have been considered in the final manual. These were split as follows: 23% in the energy area, 39% in the indoor environment area, 22% in the material area and 26% in methods. Approximately 25% of the responses were of an editorial nature.

3 Basic criteria for development work

The six work seminars conducted in the beginning identified basic criteria to which the development work for a new Miljöbyggnad should relate.

Building and renovation projects place huge demands on builders, property owners and building contractors as they are costly, take a long time and are often subject to great time pressures during the planning as well as the building phase. The criteria therefore need to be clear, easy to use and cost-effective. It is important that the criteria being controlled are meaningful, provide real use and clearly contribute to meeting the different environmental objectives. The criteria should comply with existing laws, rules and regulations in order to avoid duplicating work that would result from a separate set of rules and regulations. There would also be a risk of two sets of rules and regulations conflicting. It is also important that property owners can trust that the authorities' requirements are met if they comply with Miljöbyggnad. Deviating from laws, regulations and provisions as a platform for Miljöbyggnad is not reasonable as it would increase the costs of the projects and probably lead to property owners and builders lowering their environmental ambitions.

All the criteria in Miljöbyggnad therefore have three different score levels: Bronze, Silver and Gold. Bronze corresponds to the authorities' requirements or building practice. It can for example be the Swedish building regulations set by the National Board of Housing, Building and Planning, the lowest acceptable limits set by the Swedish Work Environment Authority for work places and by the Public Health Authority of Sweden for residential areas, or be an interpretation of environmental quality objectives. Silver provides significantly higher environmental performance than Bronze. Gold is the best function that can be obtained with available and commercial technology or through goal-oriented partnership between the building contractor, planners and contractors. Gold should be challenging but achievable, as the main aim of Miljöbyggnad is to get many property owners to raise their ambitions significantly. By influencing many in the right direction, a bigger contribution is made to meeting the environmental quality objectives than a few individual cutting-edge projects, which can be rewarded in other ways.

All the criteria that are set must be objective and based on science. This is to ensure that parties' pleas aimed at a specific product or solution are not successful. The criteria must therefore be expressed as functional requirements. It should also be possible for the property owner to influence a score, and criteria that the property owner cannot control should be avoided.

As it is meaningless to set requirements that cannot or will not be verified, it must be possible for all criteria to be verified at a reasonable cost. Quality assurance and verification are an important factor for the property owner to comply with Miljöbyggnad as it clearly shows that the building that has been supplied meets the requirements set when it was ordered. To make it easy and to minimise extra costs, the documentation required to verify the requirements should, as far as possible, be the same as that normally used for the building and management process.

Miljöbyggnad has three main areas (energy, indoor environment and material), each with a number of different indicators. The scores for all the indicators in an area are aggregated into an area score, which in turn is aggregated into a final score for the building. As the criteria set should be meaningful and contribute to meeting the different environmental objectives, all the criteria are considered important, and it should therefore not be possible to skip any indicators or compensate for a poor score with a good score for another indicator. All the indicators in Miljöbyggnad must therefore meet the Bronze score, and the scores from all the indicators are aggregated in such a way that the lowest score has a bearing on the score for the whole building. A building with a total Gold score can therefore not have any indicator with a Bronze score, and all three main areas must have reached the score for Gold.

Miljöbyggnad is essentially the industry's own tool to drive aims and knowledge development of environmental issues in the industry and the projects. In principle, it should therefore be possible to use Miljöbyggnad for all buildings whatever the type of owner, contract, category and stage (new production, existing and renovation). Miljöbyggnad should be usable by everyone, whatever the size and experience of the actor or property owner. This assumes that the whole system has limited scope. One of the most important principles of the continued development work was therefore not to let the system grow but to prioritise the most important issues.

4 New areas for analysis in the development work

The participants in the six work seminars initially felt that Miljöbyggnad had development potential and that each of the indicators and their score criteria needed to be reviewed. New subject areas that were proposed for continued analysis were *Land and infrastructure*, *Building stage* and *Management*.

4.1 Land and infrastructure

The expert group for land and infrastructure has proposed two indicators called Land pollution and Green area factor or multifunctional outdoor environment. The latter is intended to assess the size, quality and function of the outdoor environment and its green areas by thinking in terms of multifunctionality to deal with climate change (precipitation, rising water levels, heat waves), provide social values and contribute to biological diversity. The area involves deviating from the current principle for Miljöbyggnad, i.e. that only the building's status and that which the property owner directly controls and can influence should be assessed. Influencing this score requires collaboration with the municipality and city planners in the early stages of the building process. Miljöbyggnad also has a principle that all indicators should be assessed, which makes it difficult for buildings without land to meet the criteria. All in all, the area was considered too far from Miljöbyggnad and was recommended for consideration in other environmental certification systems.

4.2 Building stage

In the expert group for the building stage, about twenty indicators were discussed and a final three proposed for which requirements can be set and that can be verified: waste management and minimising waste, energy use on building sites and fuel use for vehicles. The construction sector generates more than 10 million tons of waste annually [9] and there are not always enough sorting fractions on the building site. Much of the energy-related environmental impact of building also occurs during the building stage compared with the operational stage [10]. There is also huge potential for energy savings and to use a bigger share of renewable energy in site offices [11]. Vehicles on the building site account for 3% of the climate emissions from the building process [10] and many of them could be replaced with vehicles that use more environmentally friendly fuels such as RME, HVO or electricity.

This area requires good planning very early on for the requirements of the indicators to be met. If the area were to be included as mandatory in Miljöbyggnad it would mean that it may not be possible to certify new production if the aim to achieve Miljöbyggnad is adopted at a later stage. The area also involves some deviations from the current principle for Miljöbyggnad, i.e. that only what the property owner is in direct control of and can influence should be assessed, as some collaboration with the contractor is required. It was established that there is a great need to somehow work on environmen-

tal issues also at the building stage but that the building stage needs a special environmental building system to be most effective, and it should thereby not form part of the standard Miljöbyggnad.

4.3 Management

The expert group for management primarily worked on two indicators: waste and self-monitoring of management. Setting requirements to reduce the amount of waste or increase sorting of waste is considered to go against the fundamental principles of Miljöbyggnad that only that which is under the direct control of and can be influenced by the property owner should be assessed, as the tenants can also influence this. However, the property owner could be responsible for preparing facilities for sorting at source. After investigating the fundamental issues, it was established that according to Swedish law it is the packaging industry that is responsible for residual material being recycled and for the provision of suitable recycling facilities together with the municipalities. The introduction of an indicator for waste sorting was thereby ruled out as it would move the responsibility of cost from the packaging industry to the property owners and, in the long term, the tenants.

Good management is not only important to maintain the performance of Miljöbyggnad but also a legal requirement. According to the Environmental Code, an operator shall continually plan and control the activity to counteract and prevent nuisance to people's health or harm to the environment [12]. A review of the Environmental Code shows that there are requirements for self-monitoring checks by the property owner for most of the indicators in Miljöbyggnad, and it was therefore deemed more suitable to include these routines with the ordinary indicators than to produce new indicators for management. The relevant indicators have thereby been expanded with requirements for management routines. Additionally, for further quality assurance, Miljöbyggnad 3.0 introduces requirements for the property owner to report results showing that the building maintains its performance according to the score requirements every five years to retain the certification.

5 Development of the energy area

Even if a building uses renewable energy with little environmental impact, high energy use is always negative as the same amount of energy could be sufficient for more buildings, and there is also a risk that the renewable energy will not be available for the lifetime of the building. As many aspects need to be considered for a sustainable system design when erecting a building, Miljöbyggnad follows the priorities in the so-called energy triangle:

1. Minimise energy losses

Miljöbyggnad's first indicator, heating power need, rewards a well-insulated and tight climate shell with few thermal bridges and an efficient system for heat recovery from the ventilation air that allows the energy losses to be minimised, i.e. lowers the

energy requirements of the building. The second indicator, heating loads from the sun, rewards passive measures such as sun protection inside and outside, choice of windows with regard to the sun factor and adapting the size and orientation of windows to reduce the need for comfort cooling or opening windows due to high indoor temperatures.

2. Meet the energy requirements efficiently

The third indicator of Miljöbyggnad, energy use, rewards the building if it is fitted with highly energy-efficient installations so the building's energy requirements can be met efficiently with low energy use.

3. Use renewable energy sources

The fourth indicator of Miljöbyggnad, share of renewable energy, rewards the building if a large share of the energy it will need can be supplied by renewable energy.

The expert groups have analysed whether Miljöbyggnad should exclude any of these indicators with the motivation that the others are so important that they should always be governing when planning a building. This has been rejected, however, as it could in itself have negative consequences for the indicators that are excluded. Miljöbyggnad therefore continues to base energy optimisation on these four indicators, which together determine the score for the energy area. For a clearer balance, the score requirement for the indicator for heating power need is tightened.

The indicator for energy use is directly related to the Swedish building regulations, which were changed in 2017 from setting requirements for bought energy and actual occupants use to setting requirements for primary energy and normal occupants behaviour. The score boundaries have changed slightly to correspond to this new way of setting the requirements. For verification, however, Miljöbyggnad requires continued accounting of bought energy for actual occupants' use.

The expert group has analysed whether resource efficiency, primary energy or carbon dioxide emissions could be used for the fourth indicator but have established that the concept 'share of renewable energy' is the best and an easy way to reflect resource withdrawal and the effect on climate change. Miljöbyggnad is divided into three categories. *Renewable flowing energy* (sun, wind and water) causes no or minimal resource withdrawal from nature. It also includes waste heat, i.e. heat that cannot be avoided and if unused would be lost and that cannot be used by the process or product itself, as this is considered important to use. *Renewable fund energy* (biofuels and waste with organic origins) causes a withdrawal of a finite resource and use of land that could be used for other purposes. Biofuel burning also leads to some resource withdrawal in connection with the transport of the fuel and handling of the ash. *Non-renewable energy* covers all other energy such as natural gas, oil, peat, coal, nuclear (uranium), waste with fossil origins and energy of unknown origins.

When it comes to mixed energy types in an energy carrier such as electricity or district heating, the Nordic electricity system considered electricity residual and district heating as the average value for the network. Miljöbyggnad permits purchases of allocated or origin-labelled electricity and district heating. This is motivated by the fact that if many buy renewable energy, in the long term it will be a driving factor for the energy

companies to convert their energy production to include a greater share of renewable energy. To also be a driving factor for the building owners to invest in new locally produced renewable energy, such as solar energy, a new requirement has been added for a Gold rating. Five per cent of the energy used should be renewable flowing energy newly locally generated. This includes solar energy from solar panels and solar cells, wind and water energy and new use of waste heat nearby, for example, in the housing area or city district to which the building belongs.

6 Development of the indoor environment area

Miljöbyggnad rewards indoor conditions in a building that maintain a certain level of operation, as this is of most interest to the buildings' users. The expert group's analysis showed that the previous indicators in Miljöbyggnad continue to be relevant but that several needed to be changed slightly and clarified. These refer to sound level, moisture safety, thermal climate in summer, daylight and legionella requirements, for which the requirements continue to be high. The exception is the indicator for nitrogen dioxide, which has been excluded as the building owner cannot usually affect the location of the building in relation to, for example, roads. It continues to be important to place air intakes to minimise nitrogen dioxide levels indoors, but this is no longer included in the score setting as analysis shows that the indicator means that a number of reports are required without promoting a more sustainable design of the building.

The radon indicator has been complemented with a requirement for gamma radiation in the residential zone as this is a growing problem with imported building materials. The requirement can be met by setting requirements for the level of gamma radiation of supplied building material and verified indirectly via radon measurements.

The ventilation indicator has been rewritten to focus on functional requirements for air quality instead of specific technical choices, and therefore fully complies with the basic principles of Miljöbyggnad. It requires control of estimated or measured carbon dioxide levels depending on the score, to show that the air quality also depends on the ventilation flow pattern and not only the flow size. The indicator for thermal climate in winter has previously been based on requirements in the Swedish building regulations but has now been made more stringent to correspond to lowest accepted limits set by the Swedish Work Environment Authority and the Public Health Authority of Sweden.

Verification by questionnaire of how the users experience the indoor environment was previously a requirement for the Gold rating for most of the indicators but has shown to have had an inhibiting effect on development. Many property owners worry that a questionnaire does not correctly reflect the actual conditions of the indoor climate but that other conditions that affect it also shine through. Many have therefore chosen the Silver rating to avoid the questionnaire, which has thereby impeded their ambitions to reach Gold also for other indicators. The questionnaire has therefore been removed from the indicator for moisture and daylight. For sound, ventilation and thermal climate it can now be replaced with control measurements.

7 Development of the material area

In the material area there is an indicator aimed at documenting which building products and materials are built into the building. This is done in a so-called logbook that should facilitate the identification of materials that are currently considered harmless but, with greater knowledge in the future, may prove to be problematic. Previous versions of Miljöbyggnad have had requirements to document building products such as construction components and other building envelope parts. This is now being expanded. The higher scores now also require heating, ventilation and sanitation products such as equipment with piping or canal systems and insulation of installations to be documented. The expert group deems that there is now good availability of environmental product declarations for these products. For existing buildings, the documentation is not needed. Instead an indicator for slum-clearance is required.

The material area also has an indicator that rewards buildings that are planned, built and managed with a minimum of hazardous materials and building products. This indicator is now being expanded from avoidance of substances that are being phased out to include also avoidance of candidate substances for the Bronze rating, endocrine disruptors for the Silver rating, and priority risk reduction substances for the Gold rating. Emissions of volatile organic compounds to the indoor environment are also considered for Gold. Much clearer deviation documentation is now also required.

The expert group has confirmed that for new production, the buildings are beginning to have such good energy management that the environmental impact of the actual operation of the building must be set against the amount of energy used for extraction, production and transport of building materials. A new indicator is therefore being introduced with a limited life cycle analysis of climate impact from the material used in the frame and basic construction. The introduction of the indicator is partly to increase knowledge and experience of life cycle analyses and raise supply and demand for environmental product declarations (EPDs) for different materials and partly to reward measures that reduce the climate impact of the frame and foundations. The indicator will in this stage mainly be informative, but the aim is to tighten the indicator within a few years to become governing.

8 Discussion and conclusions

The certification system Miljöbyggnad has undergone a fundamental overhaul, and a version called Miljöbyggnad 3.0 has been produced in collaboration with more than 250 actors from academia and the property and construction sector. It can be confirmed that Miljöbyggnad continues to be the industry's own system to ensure that the quality of a building meets legal and authority requirements and industry practice or the property owner's higher ambitions. The new version has continued to be restricted in size in order to set requirements and verify the most important environmental aspects for a building in a cost-effective way. All the requirements are objective, based on functional requirements and have criteria over which the property owner or building contractor has control. This leads to many using the system and can thereby contribute to meeting

the aim for which the system was originally produced, namely to clearly contribute to meeting national and international environmental objectives.

In Miljöbyggnad 3.0, all the indicators have been changed or clarified to correspond to the new rules and current building practice. Many of the criteria have been tightened so that Miljöbyggnad can drive sustainability further. One of the most important ways in which the criteria have been tightened is through increased quality assurance, partly through requirements for management routines for follow-up and partly through the property owner reporting the building's environmental status every five years after verification. In the energy area, Miljöbyggnad 3.0 has been restructured to clarify the links between the performance of the building envelope, the installations and the share of renewable energy. The requirements for investment in renewable energy have been tightened to achieve the Gold rating. In the area of indoor environment, the indicator for nitrogen dioxide has been removed and the requirements for thermal comfort in the winter have been tightened. The indicator for ventilation is now based on functional requirements for air quality instead of specific technical choices. All the indicators have clearer requirement descriptions. An option to replace the questionnaire with measurements has been introduced. In the material area, several requirements have been tightened. More building materials (also building services installations) must be declared and more hazardous substances should be phased out, such as endocrine disruptors, risk reduction substances and emissions from materials. A new indicator is also introduced that assesses the climate impact of the frame and foundations: the house should not only have little environmental impact when it is operational, the choice of material that is built into it should also be considered.

Miljöbyggnad has traditionally consisted of three areas (energy, indoor environment and material) and the work confirms that these three areas should not be expanded with more areas. The comments indicate that there is similar interest in all the areas. The work shows that there is also a need for an environmental system for the building stage but that it is too big and complex to fit within the scope of the regular Miljöbyggnad.

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