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Integration of Energy and Material Performance of Buildings: I=E+M

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Abstract

A new methodology is proposed to assess integral performance of building with respect to energy and materials requirement over the building life cycle. Because the method builds on existing methods for Energy Performance and Materials Performance of Buildings, as defined by Dutch National Building Code, it provides an easily applicable method that allows optimized building design with respect to environmental impacts. Two case studies, one for building renovation and one for new Near Zero Energy Building show the advantages of integral assessment. Extending this approach for building assessment to other countries seems a logical step as it gives designers a better insight in total building performance.

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Keywords: environmental impacts, life cycle assessment, building performance, near zero energy buildings, building renovation, energy performance.

1. Introduction

The introduction of an energy performance requirement in the building regulations in Europe has resulted in major improvements in the energy efficiency of new buildings. Governed by the framework of the Energy Performance of Buildings Directive (EPBD Recast [1]) each EU member state has formulated a methodology for energy performance evaluation for different building types. These calculation methods, as well as performance standards, have been implemented in the national building regulations in each country. This legislation has been very

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successful in reducing the energy demand of buildings and in stimulating technological development for energy-efficient energy systems, building insulation and renewable energy generation. As a result, the energy demand of new buildings has been reduced by a factor 10-100 since the 1970's. Moreover, from the year 2020 onwards all new buildings in the EU will have to conform to a "near-zero energy" standard [1].

Now that (near) zero energy buildings become the new standard, the role of building materials and embodied energy or related CO_2-emission is becoming more and more important. It is recognized that a focus on energy efficiency only, entails a clear risk of having buildings not necessarily performing very well with respect to other environmental criteria [2, 3]. Also the European Commission has identified the importance of building materials when it states that: "*The construction and use of buildings in the EU account for about half of all our extracted materials and energy consumption and about a third of our water consumption. The sector also generates about one third of all waste and is associated with environmental pressures that arise at different stages of a building's life-cycle including the manufacturing of construction products, building construction, use, renovation and the management of building waste"* [4].

However, a broader assessment of the environmental impact of buildings, including the building materials, is not done regularly yet. Already for a long time there exists within the building community a great demand for methods to support the selection of environmentally benign materials for buildings. Formerly, lists of "preferred materials" or "materials to be avoided" were used [5]. Although such lists are easy to use, the draw-back is that they do not allow for performance-based building design and optimization of the design with respect to materials choice.

In the research community Life Cycle Assessment (LCA) is a broadly accepted methodology to assess the environmental impacts of products [6] . This LCA method has been applied to buildings as well (see, for example, ref [7]). Also in the EU-FP6 project Super buildings different aspects of "sustainability and performance assessment" for buildings were investigated [8]. However, among architects, technical consultants and construction companies the use of Life Cycle Assessment for building design and building maintenance is no common practice yet, mainly due to the relative complexity of LCA tools. It has, for example, has been estimated that currently less than 0.5% of the buildings has received an environmental assessment certificate [3].

In order to fill this gap a process was started 20 years ago in the Netherlands to develop an LCA-based calculation method which was specifically focused on buildings and relatively easy to use [7]. Moreover, this calculation method was meant to become part of the National Building Code, just like the energy performance method. Next to a calculation method, also a national LCA database for building materials was set up, which should provide the necessary data for the assessments. And, in the third place, the software tools for such materials assessments were "harmonized" so that all tools would give the same final results for specific buildings. As a result of this development process the so-called "material performance assessment of buildings" has become obligatory for new building projects (dwellings and offices) as from the year 2014 [9]. Important to state is that the new method is restricted to *only the materials* used in the construction and maintenance of the building. This restriction to materials impacts only was applied because the operational energy consumption of buildings is already governed by the existing Energy Performance standard.

So effectively there are now in the Netherlands two different performance indicators for buildings, one for the energy consumption during building use and one for the environmental impacts from the materials used for the building. Although no required limit value for the materials performance has been formulated yet, the idea is that designers will try to adapt their building design in order to reduce the materials impact. Moreover, legally binding limit values for materials performance may be implemented in the near future.

The existence of two different performance indicators raises the problem, however, that for designers it is difficult to determine the most optimal solutions with respect to energy systems and the selection of materials with an impact on energy efficiency. For example, the installation of solar panels or the addition of extra insulation to a building will result in a negative effect on the material performance because additional materials are needed, while on the other hand they improve the energy performance of the building. As the two indicators have an entirely different way of "impact assessment" and of normalization the indicators cannot be compared or balanced against each other.

As mentioned, the need for an integral evaluation of materials impacts *and* energy performance is becoming more and more important now that the energy requirements for buildings are being reduced towards zero. In essence, the energy performance standard also has the objective to address an environmental problem, namely climate change and fossil fuel depletion. So, from a scientific point of view it would be quite logical to consider all environmental