How to promote new building products and technologies without knowing their service life

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How to promote new Building Products and Technologies without knowing their Service Life

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ABSTRACT

Every year a number of new products and technologies are developed for the construction industry. Quite often they are only slowly implemented and this is regarded to be caused by lack of service life data, lack of recommendation by research institutions, or reluctance by insurance companies to insure buildings where new products or technologies are implemented. There have also been examples of new products or technologies being recommended without thorough knowledge of their behaviour or impact on buildings. After some time, massive problems were detected and understood through building pathology which led to revised recommendations for their use. As a result, research institutions have become more cautious in recommending new products or technologies with no real-life performance record.

However, innovation is needed in response to increasing demands to buildings' technical performance from the authorities. Together with increased focus from society on sustainability and life cycle cost, the need for innovation highlights the need for knowledge on service life and preconditions for the optimum use of products and technologies.

Service life is the time from installation to dismantling of a component in the building. It is suggested that service life can be described by four types: a technical, a functional, an economic and an aesthetic one. However, there is no international standard on the actual service life of products and building components and very little documented information on their service life.

The paper discusses the practice of promoting new products and technologies with unknown service life or performance record. In spite of absent service life data, new products and technologies are implemented implying that other factors are important as well. The ease of designing or dimensioning products and technologies, to install them and to maintain and repair them is stated as decisive for a product or technology becoming a success. The hypothesis is supported by specific examples of introducing new products and technologies.

It is concluded that the lack of knowledge of service life proves not to be a hindrance for successfully promoting new products and technologies. However, success not only depends on the product or technology itself but also on how self-explanatory it is designed or dimensioned for each specific use, to install and to maintain and repair.

To detect causes of failure using building pathology and further improve products and technologies, systematic gathering of experience is needed as examples of malfunctioning products and technologies have made Danish research institutes and insurance-based systems more reluctant to recommend new products with no record from real use.

Requirements in the Danish Building Regulations in combination with government subsidised research have been a successful driver for developing new products. This corresponds with the role of authorities to set building regulations.

KEYWORDS: New products, service life, requirements, design and installation, maintenance

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1 INTRODUCTION

Each year a number of new products and technologies are developed for the construction industry. Quite often they are only slowly implemented; apparently there is a reluctance to use products and technologies with an unknown service life without the recommendation by research institutions. Or reluctance by insurance companies to insure buildings where new products or technologies are implemented. There have also been examples of new products or technologies being recommended without thorough knowledge of their behaviour or impact on buildings; after a period massive problems were detected and understood through building pathology which led to revised recommendations for their use. As a result research institutions have become more cautious in recommending new products or technologies with no real-life performance record.

However, innovation is needed in response to increasing demands to buildings' technical performance by authorities. Together with society's increased focus on sustainability and life cycle cost the need for innovation highlights the need for knowledge on service life and preconditions for the optimal use of products and technologies[3].

In spite of absent service-life data, new products are nonetheless implemented in the construction sector implying that other factors are important as well. In the paper, several examples of introducing new products are used to illustrate a hypothesis including other factors than service life. It is discussed what makes some new products a success and others not, including the role of authorities to set building regulations.

2 SERVICE LIFE

2.1 Estimation of service life

Service life is the time from installation to dismantling of a component in the building. In life cycle cost (LCC) and life cycle assessment, the usual relevant service life to be used is the mean value of service life – in short 'Average service life', as these analyses in general acts as supporting tools in the design phase of a construction project and the expected time during which the component may serve its function is relevant. Consequently, lower or higher value of service life that might occur in other usages, e.g. like insurance coverage estimation, is irrelevant.

Different types of loss in performance in relation to demands may put an end to the service life of a building component. In *Handbook of environmentally sound design of buildings* [BPS 1998, p. 4.154], four types describing the service life of a building component are suggested:

a. *Technical service life* – the time in which the component is technically and physically capable of fulfilling its original function as determined by loads and impacts on the component and its resistance to them.
b. *Functional service life* – the time in which there is a need for the components' original function as delimited by changes in demands from users and society to the performance of the component.
c. *Economic service life* – the time in which it from a LCC perspective is economically feasible to keep the component in service, closely linked to the interest or calculation rate, energy cost etc.
d. *Aesthetic service life* – the time in which the 'aesthetic' performance as determined by socio-technical and psychological factors is intact.

Although these aspects of service life are not fully independent of one another, they are regarded as a sound basis for a practical approach predicting service life of a building component. The resulting service life of a given building component – the Actual Service Life – is dominated by the type of service life with the lowest mean value [Aagaard *et al.* 2014].

[3] 'product' is used as joint term for 'product' and 'technology' in this paper.

2.2 Standards and data

As the only one of the four types of service life not influenced by social and economic factors, the technical service life should be the easiest to predict. However, no international standard exists on the actual service life of building components comprising values for specific components of given materials. The ISO Standard 'Buildings and constructed assets - Service life planning', Part 1-11, describes principles (Part 1) [ISO 2011], how to deal with lessons from practice (Part 7) [ISO 2006] and assessment of service life (Part 8) [ISO 2008]; but none of the elements of the standard suggests any figures on the actual technical service life or how to predict it. Usually it is defined by a set of factors multiplied on a reference service life; e.g. [Hovde 2005] and [ISO 2008]. In a European context, a system and a register are being developed and are over time expected to contain data on the actual service live of building components in terms of product data [Wolf 2012].

Currently very limited *documented* data exists on service life of building components or materials in the European construction industry, even for products that have been on the market for a long time. Consequently, files of such data are mainly based on experience and professional appraisal, of which the most important Danish are [Aagaard *et al.* 2012], [GI 2011], [BUR 1985], and internationally: [HAPM 1998], [IEMB 2009], [ByggForsk 2010], [Vissering 2011]. Most of these sources were developed for a specific purpose; e.g. insurance coverage or LCC assessment. The resulting data list is influenced by such purposes as they may respect an upper limit or are based on specific percentile of the expected service life distribution making it difficult to use these in another context.

3 METHODOLOGICAL FRAMEWORK

Products are often promoted at trade fairs/exhibitions for the construction industry. New products are challenged as they are without service life data or performance record, but in some cases they are promoted by authorities or decision-makers wanting to affect or change the development, e.g. towards more environmental-friendly products. The successful introduction of a new product can be measured in different ways depending on its properties, e.g. by how it makes the building process more effective or cheaper, reduces the energy consumption, or reduces the contamination of the indoor climate. Or it can be measured by the speed of breakthrough in the construction industry or by do-it-yourself people, or the number of products sold/installed, although this does not necessarily reflect whether the product functions with a satisfactory service life. Being a yes/no scale (did the strategy or drive work or not) rather than an absolute measuring scale, it is nonetheless precise enough to discuss whether the introduction of a new product had an effect or not.

Success of a new product will depend on the product itself but also on project design, installation and maintenance (see Fig. 1). Only products that work theoretically are regarded serious but if project design involving a new product is complicated it can affect the service life of the product. For instance whether it is difficult ensure that the conditions for the product to function are as assumed. A product that is difficult to install (I on Fig. 1) or is designed incorrect (D) can result in an incorrect installation, even if the product is installed as designed. It is only a question of whether the consulting engineer or the contractor gets the blame. But the product will not work as assumed and will not be regarded as a good product. Or extra control is needed to ensure properly design or installation, increasing the cost and reducing the economic benefit of using this product instead of another.

Further, a well-designed, easily installed product is not regarded as good if it needs careful maintenance as this often ends in malfunctioning products. This depends on the exposure of the building or building element in which the product is installed (red hatched ellipsis on Fig. 1). So the robustness of the product or the building can influence the perception of the product. If for instance the moisture load is lower than the design load, it might not be detected if a specific vapour barrier does not work or is installed incorrectly, while it will be very obvious with a moisture load corresponding to the design load.

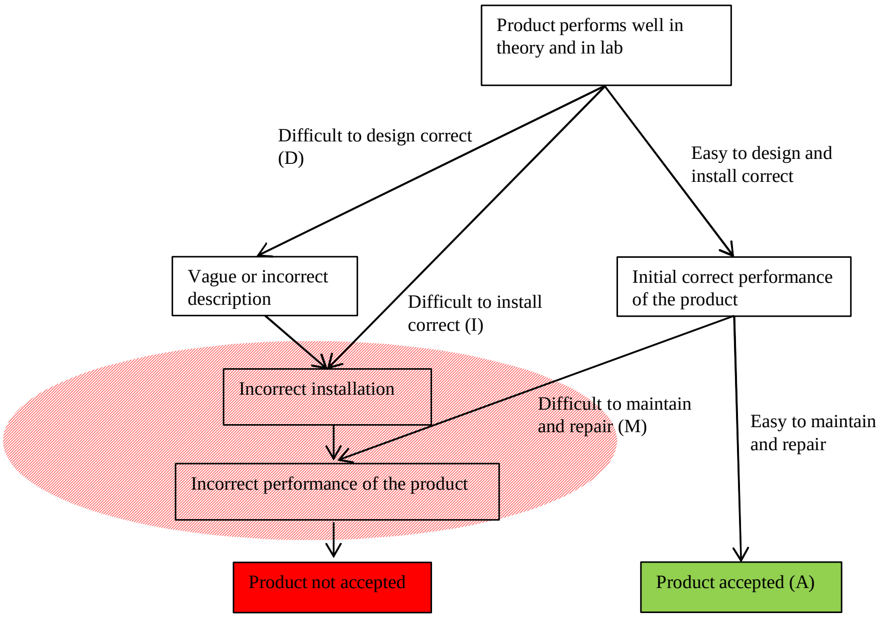

Figure 1. Parameters determining whether a new product with no record from real use will be accepted (A) or not, because design (D), installation (I) or maintenance and repair (M) is difficult. From a pathology perspective, it can also be used "bottom-up" to detect causes of failure.

4 EXAMPLES OF PROMOTING NEW PRODUCTS OR TECHNOLOGIES

4.1 Environmental-friendly insulation materials

During 1997 – 2003, the public authorities in Denmark supported research in "green" or "environmental-friendly" insulation materials, i.e. insulation materials not made of mineral wool, as at that time these were related to working environmental problems (possibly causing cancer and irritating of the skin, eyes and mucous membranes). The use of insulation materials made of recycled paper, hemp, sheep's wool or expanded perlite[4] was very limited in Denmark either because these were not known in general or because the knowledge of their hygro-thermal properties and service life was limited. The construction industry and clients were therefore reluctant to use them. The outcome of the research programme [Pedersen *et al.* 2003], improved the general knowledge of the properties and behaviour of these materials and their market share has increased especially for single-family housing although there is still an open question concerning their service life.

4.2 Smart vapour barriers

A specific smart vapour barrier has been used in Denmark since 1990, developed for large, unventilated, wooden, low sloped parallel roof constructions [Byg-Erfa 2005] and in 1993 in their guideline on moisture in buildings the Danish Building Research Institute recommended this vapour barrier without reservation [Andersen *et al.* 1993]. However, in the next edition of the guideline the limitations by using the specific vapour barrier was highlighted as it was not recommended in all situations [Brandt 2009]; limitations that the producers of the vapour barrier have realised. For instance that the vapour barrier should not be used on roof areas in permanent shadow, e.g. due to trees or other buildings, that the roof area is sunlit in the summer half year, i.e. maximum slope of 30° for north-oriented roof surfaces, and that the maximum moisture load in the underlying building correspond to humidity class 2 according to EN ISO 13788 [2012].

[4] Perlite is an amorphous volcanic glass that expands to 10-15 times when heated to 850-900 C

4.3 Windows with a reduced risk of condensation

During 10 years the Danish Energy Agency supported research aimed at inspiring and helping the Danish window industry to develop modern, energy-efficient windows with a significantly reduced thermal conductivity and reduced risk of condensation or mould growth [de Place Hansen *et al.* 2013]. Since 2010, the Danish Building Regulations (DBR) requires a minimum acceptable surface temperature on the window frames [Danish Enterprise and Construction Authority 2010]. Since 2003, the Association of Danish Window Manufacturers had recommended a minimum inner surface temperature, which in 2010 was increased when introduced in DBR. The introduction of a minimum acceptable surface temperature in DBR has been an important driver for the development of new window solutions, especially for the design of the sealing system for window panes as this is the critical point in relation to surface condensation [de Place Hansen *et al.* 2013]. In some cases, window types not fulfilling the requirement to surface temperature were withdrawn, even before the minimum inner surface temperature became a requirement.

4.4 Green roofs

Since 2010, the City of Copenhagen has mandated green roofs in most new local plans [City of Copenhagen 2010] 150.000 m^2 of roofs are to be covered as part of the city's goal of becoming CO_2 neutral in 2025. Green roofs are regarded as a way to relieve the pressure on the sewage system, reduce the CO_2 emission and reduce the urban heat effect. In Denmark, experience of green roofs is at present limited while they have been used extensively in Germany since the 1960s and 1970s. However, no systematic gathering of experience takes place, i.e. no record of the number of cases where the green roof did or did not work as planned, and why.

4.5 Renewable energy technologies

In the 2010s, PV panels have become extremely popular on single-family houses in Denmark due to tighter requirements for energy consumption, lower cost of PV panels and favourable payment for the surplus energy produced not used in the building itself. PV panels were installed on more than 20.000 houses during two years but in 2012 it was assessed that most of them were made by companies without proper knowledge of roof constructions. It was not ensured that the roof truss construction was strong enough to support the PV panels. German experience of mounting the PV panels was transferred to Denmark without considering that the dimensions of Danish roof trusses are smaller than the German ones. Further, the screw holes used for fixing battens to rafters were in some cases used also for fixing the PV panels resulting in leaky roofs.

4.6 Capillary active insulation materials

Capillary active interior insulation systems are often promoted because of their ability to prevent interstitial condensation, while a drying out remains possible [Scheffler & Grunewald 2003]. As they make no use of a vapour barrier, the installation of such systems should be simpler than traditional interior insulation systems, but knowledge of their long-term performance outside the lab is still limited. Vereecken and Roels [2014] found that a capillary active system is more sensitive to small modifications of the wall structure than a wall with a vapour-tight system, like wind-driven rain can hamper good hygro-thermal behaviour of a capillary active insulation system.

5 DISCUSSION

In Table 1 the examples from Section 4 are characterised according to the frame work in Fig. 1. Further it includes the driver for introduction of the products or technologies.

Table 1. Examples of new products or technologies and their driver for introduction. Accepted (A) or failed because of poor design (D), installation/execution (I) and/or maintenance/repair (M).

Example	*Driver for introduction*	*Type cf. Fig. 1*
Environmental-friendly insulation materials	Governmental supported research	A
Smart vapour barriers	Avoid moisture to be trapped in unventilated roof constructions	D
Windows with reduced risk of condensation	Building regulations and governmental supported research	A
Green roofs	Requests from municipality	I, M
Renewable energy technologies (PVpanels)	Favourable payment by government for energy produced	I
Capillary active insulation materials	Less complicated building components	To be seen

Governmental support proved to be decisive in the case of environmental-friendly insulation materials and PV panels; as soon as the support stopped, development stopped or public interest disappeared. Although environmental-friendly insulation materials have gained some market shares, mineral-wool-based thermal insulation is still by far the most used in Denmark and no systematic collection of experience with other insulation materials takes place. The extent of damage and defects on PV panels remains to be seen; installation stopped because government subsidies ended, not because the media wrote about predicted damage and defects. Technical service life is expected to be low due to the incorrectly designed installation, although a solution for securing the panels has been suggested, but without public support, the economic service life seemed to be even shorter. The new windows with a reduced risk of condensation on the other hand became a success, probably because they were a real improvement compared with older types and because requirements in DBR banned the old ones from being used at construction or renovation.

The smart vapour barrier case has made research institutes and insurance-based systems less willing to promote specific products or technologies, e.g. green roofs. Knowledge of service life or robustness of the membrane placed below the growth layer is limited in spite of many years of use in Germany as there has been no systematic gathering of experience. The risk of a high water content below the drainage layer in combination with organic materials [Stöckl *et al*, 2014] and the cost related to location of leakages are among the arguments for not recommending green roofs by the Danish Building Defects Fund [2012]; an insurance-based system for social housing projects, although mandated in the local plans from the City of Copenhagen.

Whether a product is accepted or not seems not to be related to service life as this was not known in most cases when the product was introduced. This indicates that ensuring robust, repairable and maintainable solutions is more important than service life data. Recalling the four types of service life (Section 2), only the technical service life is related to the technical and physical performance of the product. This could explain the small amount of publicly available service life data, as the technical service life is often not decisive; other mechanisms play a role as well: Until the economic crisis hit in 2008, Danes were much more prepared to install new kitchens or bathrooms than additional insulation although the latter had a much shorter payback period. The motivation for building owners was probably aesthetic more than economic and technical.

Another argument for the limited amount of service life data could be that establishing reference service life of a product – often requiring many years of exposure – is almost impossible, even for products used for many years as exposure (e.g. pollution or climate), requirements (e.g. ban on using asbestos) or properties (e.g. clay for brick tile from another source) changes over time. As a result there is very little documented information on service life of building components independent of how long they have been on the marked. Apparently other factors are more important, and probably easier to obtain.

So promotion of new products without service life data and many years of in-use experience is not necessarily a problem as long as design, installation and maintenance/repair are considered carefully. However, if a product or building element - in which it was installed - fails it is important to use building pathology to determine whether the failure was due to the product itself or design, installation or maintenance/repair issues. Only when this is known, is it possible to pinpoint how the product or its manuals for design, installation or maintenance should be improved.

6 CONCLUSION

Very little *documented* information on the service life of building components or materials is available in the European construction industry, even for products having been on the market for a long time. Most information is developed with a specific purpose in mind. Examples have shown that lack of service life data is not a hindrance for promoting new products or technologies, if they work theoretically and are easy to design or dimension for specific use, to install and to maintain and repair.

Requirements in Danish Building Regulations in combination with government subsidised research have been a successful driver for developing new products.

To detect causes of failure using building pathology and further improve products and technologies systematic gathering of experience is needed as examples of malfunctioning products have made Danish research institutes and insurance-based systems more reluctant to make claims about new products with no record from real use.

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