

## FROM CUSTOMER VALUES TO PRODUCTION REQUIREMENTS – IMPROVING THE QUALITY OF WOODEN HOUSING

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### **Abstract:**

*The industry of wooden single-family houses in Sweden faces several challenges; both with regards to production but also with regards to the market conditions. In order to avoid uncontrolled price increases of wooden single-family houses, an act regulating the cash contribution when purchasing a house has been introduced. This has led to an increased focus of the house price as well as on the individual producers to control its processes and thereby its costs. The purpose of this paper is to give an overview of existing research related to product and production developments related to the industry, identifying research gaps, and suggest research activities. This research has been carried out as a literature study focusing on these concepts. It concludes that existing research is fragmented and that the linkage between the consumer and the product is neglected as well as the holistic approach is missing in development activities. The authors propose that in order to study how the industry could come closer to their consumer markets and the aligned requirements as well as to facilitate product development, the Means-End Chain approach may be of use and that the approach could further be linked to Quality Function Deployment.*

**Key words:** customer requirements; wooden housing; product development; production development; means-end chain; quality function deployment.

## INTRODUCTION

The market for single-family houses in Sweden is traditionally dominated by wooden houses, which possess about 80 to 90% market share (Nord 2005), both on-site erected and in-door prefabricated houses being included. From year 2001 to 2007, the number of finished single-family houses increased from 7 884 to 12 083 (SCB 2012a). After that, the economic crisis and its effects led to an enormous decrease of the number of houses produced. From 2007, the number of finished single-family houses decreased by almost 70% to estimated 4 000 houses in 2013 (TMF 2013). One consequence of the latest economic crisis was that the Swedish National Bank tried to avoid a future bubble on the loan at interest market, by introducing restrictions on how much home loan a household is allowed to lend with their property as security. Now, 15% of the property's purchase-sum has to be paid as a cash-contribution by the consumer. This affects especially younger households that often cannot contribute with such an amount of money, which in turn affects sales numbers in the industry of wooden single family-houses (TMF 2013).

Besides the above named market-related challenge the industry has to face, other more production-related challenges appear. According to e.g. Eliasson (2011), firms producing wooden single-family houses are lagging behind other industries in terms of production development. Streamlining production activities towards more effective ways of working would decrease costs and raise a firm's productivity. This argumentation gets affirmed by the development of the production costs for single-family houses per square meter. Between 2001 and 2011, square meter costs increased from 16 258 SEK to 28 221 SEK, which equals 58% (SCB 2012b), which somehow could be explained with an increased number of employees from 3 629 in 2001 to 5 467 in 2010 (TMF 2011). Yet, as the number of produced houses decreased during that period of time, the above figures prove serious problems in production productivity. In addition to that, the accumulated consumer price index, i.e. inflation rate, increased by 18% from 2001 to 2011 (SCB 2013). This means that consumers, or potential buyers of wooden single-family houses, had to pay a much larger proportion of their income for that product in 2011, compared to 2001. In this way, production-related problems are affecting the market and the consumer.

In order for firms in that industry to survive, market-related and production-related problems need to be solved. Some eight to ten wooden single-family house producers and municipalities are planning to join forces and to establish a regional network in southern Sweden. They are e.g. aiming at exerting influence on decision makers concerning the restricted home loan policy mentioned above (Windborg 2012). Another example is the attempt of bypassing the home loan restrictions and 15% cash-contribution by a firm called Snickarhus. They market their idea as the delivery of a house that the consumers can finish by themselves; a private work input worth 15% of the total purchasing price (Snickarhus 2013).

Convincing potential consumers and winning their trust on a sensitive market is one crucial factor to increase sales. Therefore, the consumer has to be treated in a corresponding way. As stated above, consumers have to pay a much higher proportion of their income for the product a wooden single-family house. According to Schauerte (2009), this kind of product belongs to the category of durable products, which means e.g. a higher involvement from the consumer, since the product is more important, e.g. due to capital or risk involvement. Specific product attributes and characteristics are evaluated more carefully by the consumer in a more complex decision making process (Kotler *et al.* 2010), i.e. consumers' requirements play a crucial role in being successful. As the consideration of such requirements ought to happen in a firm's product development process, which in turn most often is linked to a firm's production technology (Reinertsen and Thomke 1998), long-term success requires the identification of consumer requirements and how these can be met by product development processes and production technologies (Bergman and Klefsjö 2010).

According to consumer behaviour literature, consumer requirements are reflecting consumer preferences, which in turn are conditioned by consumer values or higher goals (a.o. Fennell 1978, Gutman 1982). This means that, in order to be favoured by consumers, a product has to perform in a way that matches consumers' personal values or helps consumers to reach their goals. Consumers learn to demand products and services, whose attributes, in the case of product usage, have consequences that will help consumers to obtain their values (a.o. Coolen and Hoekstra 2011, Mossberg 2003). This is in line with Ashby and Johnson (2003), who divide the requirements of a successful product into three stages: functionality, usability and satisfaction. A product must work and has to be easy to understand and use and it must enhance the life of its user. For firms producing and, in particular, developing products, it is therefore important to identify consumer values and requirements posed on the product. Such work on product quality improvement is vital, as it is the foundation for internal quality improvements, i.e. the elaboration of a firm's production requirements and their fulfilment (Ljungberg and Larsson 2007).

As described above, product and production development are crucial for firms' long-term success. In order to suggest improvements in these development areas, mapping those activities and comparing them to existing theoretical aspects can be seen as a first step. This in turn necessitates an exposition of existing research and literature in these areas.

## OBJECTIVES

This paper aims at shortly presenting theoretical aspects of product and production development, giving an overview of existing research related to product and production development related to the industry of wooden single-family houses in Sweden, identifying research gaps, and based on that, suggesting further research activities.

## THEORETICAL ASPECTS RELATED TO PRODUCT AND PRODUCTION DEVELOPMENT

Product development is a key component for companies' competitiveness, independently of the position in the value chain. When developing new products Reinertsen and Thomke (1998) mean that all factors necessary for the production of the product should be included. Based on customer requirements or market needs, the product development must include the product design, the constituent materials, the production processes, and plans for distribution, operation, support and disposal. According to Browning (2002), all these activities are supposed to accumulate value, where value is determined by quality aspects in relation to price (Harmon and Laird 1997, Olhager 2000).

The quality aspects according to, for instance, Hansen and Bush (1999) are a function of both product quality and service attributes. Price is a quantified issue, whereas product quality and services are objective and dependent upon the individual customers. Here, consumer preferences come into play, which play an important role in product development (Hsu *et al.* 2000), as already elaborated on above.

Product development from idea to product launch has often been described as a linear flow in the industry. However, to become effective, a cross-functional work is crucial (Säfsten *et al.* 2010). Antoni (2002) further discusses learning aspects in the development process and imply that the organisational structure is important for enabling reflection of the conducted work. A system perspective in project management is further described as crucial. To receive effective interfaces between product development and production, several tools have been developed such as Design for Manufacturing and Design for Assembly (Ulrich and Eppinger 2000). Many products, such as a house, consist of several sub-products mounted together. This also implies a system approach to the product development. Here, challenges in both assembling procedures and the possibilities of different materials to co-exist must be considered.

As mentioned by Ashby and Johnson (2003), consumer requirements can be divided into functionality, usability and satisfaction. The choice of material affects all three factors. The material helps the product to function properly and it affects the usability through both visual and tactile features. The main aspect of the material selection is however related to user satisfaction created through aesthetics and the perception of the products. Here, the material in the product plays a significant role in creating the conception of the product's quality. As summarized by Johansson (2008) the most important properties required of the material wood in wooden products are:

- Aesthetics and tactile properties
- Accuracy in dimensions and geometry
- Material free from cracks
- Controlled movements in the wood material with changing humidity
- Strength and hardness
- Above-ground durability (considering mainly weathering and biological attack)

In the development of products, the material characteristics must be considered in relation to both technical manufacturing aspects and design (Lenau 2002). A good product design utilises the potential to shape and manufacture a specific material.

Sundberg (1999) also points out that consumers are often driven by fashion and trends. In the selection of materials for products the designers and architects become important. Lenau (2002) states that it is not always clear to these occupational groups how different materials should be used. This is especially important in the case of new materials and implies a need for information considering material use (Wiklund 1991, 1992, Baudin 1999). Lenau (2002) mentions as well that, already in the design stage, the material should be considered as a part of the product in order to avoid costly changes in later stages of the development process and also to inspire the use of new technological possibilities. Knowledge of material properties then becomes essential, and a close cooperation between production and the design stage is necessary in order to reach the market.

## STATE OF THE ART - PRODUCT AND PRODUCTION DEVELOPMENT FOR WOODEN SINGLE-FAMILY HOUSES IN SWEDEN

Research on product and production development for wooden single-family houses mainly focusses on two areas. First, issues on production technology and second, topics related to raw-material quality and supply and the business relation between construction companies and sawmills.

Production development processes in this industry are on a rather low level, especially compared to other industries. Methods and materials applied in the industry leave much to be desired, e.g. when it comes to effectiveness and efficiency of ways of working. In the case of prefabrication, several companies still have to seize the benefits of in-door manufacturing, entailing a distinctive raise of productivity (Eliasson 2011). According to Brege *et al.* (2004), the centralised actual work performed when prefabricating house elements in-door still is the same, compared to a decentralised on-site construction. Hence, production developments toward industrialised prefabrication techniques get inhibited and are thus only utilised to a small extent. A production requirement, and a big challenge to be mastered, is to cut costs by means of modularisation and at the same time being able to use a flexible production system (Andersson *et al.* 2007). This means that a balance has to be found between production efficiency and customer requirements (Lessing 2006). Eliasson (2011) argues that one possible way for construction companies of cutting costs is to purchase wooden components ready to be assembled, as it is the case for many other assembling industries.

Höök and Stehn (2008) argue in a similar way, pointing on the need for a change in organisational culture in construction companies in order to better utilise the advantages of industrialised housing production. Knowledge on how to approach and implement such production methods needs to be created and spread amongst employees. This is in line with Stendahl (2009), who found that well educated employees have a positive impact on innovation activities; yet, the educational level within the industry is relatively low. Stendahl (2009) found as well that the increasing need for more industrialised prefabrication requires more effective supply chains and business systems, which, however, have been left relatively unattended by both practitioners and researchers. Nord (2008) regards industrialised prefabrication as enhancing customer value, requiring the strategic management and marketing focussing on the customer, alongside with already existing technical developments and construction management. Such customer involvement, e.g. in the product development process, was named to affect product development positively, however, it was shown as well to have a more complex influence on product development than expected. This, since internal resource constrains often set boundaries and thus, the perceived effectiveness of the product development suffers. Therefore, product development processes are rather informal and often not prioritised due to daily operative work taking focus (Stendahl 2009).

Other customer studies mainly focus on the construction companies as customers of sawmills, yet, the linkage to the consumer, i.e. the inhabitants of a house, is missing. Eliasson (2011) argues that in order to improve the quality of Swedish wooden single family houses, a mutual quality perception within the value chain, even to the consumer, is important to ensure. However, natural characteristics of wood are difficult to describe and thus, the translation of the often visual perception by the consumer to a potentially measurable form becomes as challenging as the discovery of where and why in the value chain quality deviances occur (Johansson 2011). Whilst Brege and Överberg (2000) mention that a market orientation of sawmills is a necessity for survival, many raw-material suppliers anyhow suffer problems of profitability. New requirements for system products and building systems from sawmills' customers, in this case the single-family house construction industry, need to be met (Flinkman and Eriksson 2004), however, sawmills have to expand their knowledge about such requirements. Furthermore, adopting methods about customer analysis has been neglected (Roos *et al.* 2012) and as a result, Eliasson and Gustafsson (2012) found that timber quality deficiencies occurred, when the raw-material was delivered to construction companies. A dialogue between construction companies, as customers, and sawmills, as suppliers, was missing. One possible explanation for this fact might be that the cost for timber, relative to the costs for the complete house, is negligible (Eliasson 2011, Brege *et al.* 2004). Another explanation, suggested by Roos and Nyrud (2008), is that methods dealing with the utilisation of consumer preferences simply need to be applied in a more frequent way.

## **ANALYSIS - PROPOSING A RESEARCH AGENDA**

A systematic and integrated approach from idea to consumer in product development is suggested in literature. Anyhow, research studies within the wood industry only give a fragmented picture concerning the field of wooden house industry. Most studies have had a business to business approach. The studies mainly have focused on specific production steps, which means that the linkage to the consumer is missing. Yet, the market perspective is important from several aspects, since consumers are driven by several factors, e.g. the functionality of the product. Moreover, aesthetical aspects, relations to trends, fashion and usage of the products ought to be considered in the design stage, to fulfil the complete picture of consumer values.

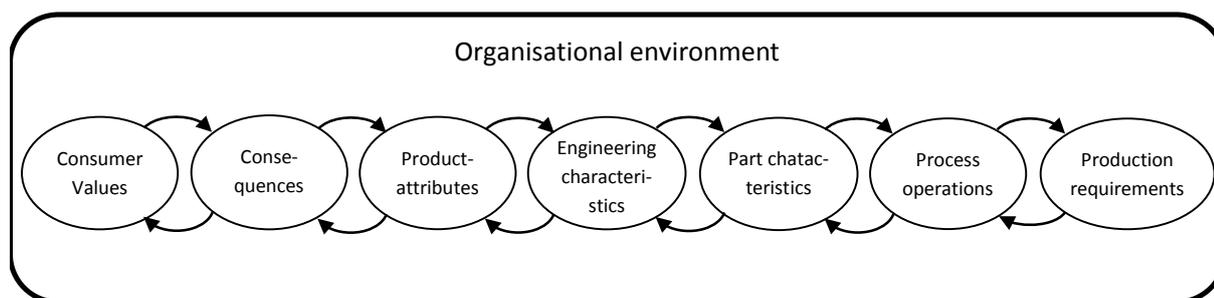
In product development, various organisational aspects are described as key issues for running through a learning process. In the wood industry, however, the product development process is often performed informal and may be set aside due to operational work. As pointed out, the positive effects of bringing the consumer closer to the development process is challenging, since it may compete with internal resources. This approach may imply that organisations do not promote development activities. In a long-term perspective, this probably will influence the competitiveness of the industry. As is described by e.g. Bergman and Klevsjö (2010), the management commitment is a cornerstone in the Total Quality Management

perspective and their role in signalling importance of topics will be crucial for obtaining an organisational environment striving for development.

Concerning the production perspective, it is described that the Swedish industry for wooden single-family houses has developed from an outdoor to an indoor production. However, the real benefits from this change can, as it occurs, not be discerned. Keeping the flexibility in the production at the same time as increasing the effectiveness of the production is a key issue to be solved in this industry. Modularisation and increasing the prefabrication of components directly from deliverers are proposed as development paths. Yet, these changes must be mastered without losing the possibility of adjusting the product according to consumers' requirements. To accomplish this development, the value chain and the business system must be developed. Communication possibilities between different actors and tools for this must be utilised. Here, an increased use of computer integrated manufacturing tools (CIM) is probably advantageous for this type of industry (Marri *et al.* 2003). This, however, sets high requirements on the staff and thereby increases the need for education, which is also highlighted as an issue for innovative thinking.

The house as a product, consisting of several sub-products, implies a holistic view on the development and manufacturing process. Here, raw material characteristics and production requirements must co-exist for adding value to the product. Yet, the intrinsic value of a product and values of consumers are often not clearly in line. Consumers' values are a complex mechanism. For these values to bring a physical meaning to the product, a translation is needed. A possible way of doing so is the way proposed by the Means-End Chain approach, which distinguishes three levels in how consumers express their relations to products. The three levels are called attributes, consequences and values. Thereby it is possible to understand, why consumers prefer one product over another (Gutman 1997). As an example, Schauerte (2009) shows a Means-End Chain between consumer values and product attributes in the case of wooden multi-storey houses in Germany. Consumers consider a multi-storey house as *energy saving* (attribute). This has the consequence of *being positive for the environment*, which leads to the personal consumer value *concern about the environment* (Schauerte 2009). The attributes must then be transformed to get impact on the product and the manufacturing process.

The performed literature review reveals as well what parts of the value chain towards production requirements are missing and what parts need more attention, since great development possibilities exist. Brought together in a cohesive picture, these parts constitute figure 1. The chain from consumer values to product attributes is called the Means-End Chain, whilst the whole chain from consumer values to production requirements is called the Extended Means-End Chain (Gustafsson 1996). Including the organisational environment in figure 1, the authors want allow for factors embedded in the remaining organisational environment, and possibly affecting the Extended Means-End Chain, to be considered.



**Fig. 1**  
**The Extended Means-End Chain according to Gustafsson (1996), upgraded with an embedding Organisational Environment.**

As described above, the Means-End Chain approach is one possible way of translating consumer values into product attributes. For a further translation into production requirements, more translation steps are needed. One method that converts customer requirements to engineering characteristics and further to production requirements is Quality Function Deployment (QFD). This often used method in product development was developed in Japan during the late 60ies (Akao 1990).

## CONCLUSIONS

The aim of this paper was to shortly present theoretical aspects of product and production development, to give an overview of existing research related to product and production development related to the industry of wooden single-family houses in Sweden, to identify research gaps, and based on that, to suggest further research activities.

The overview revealed research gaps, like the disregarded linkage between the consumer and the product, and a missing holistic approach to development activities. Existing research is too fragmented. In Fig. 1, the authors propose a logically connected chain of parts that cover both product and production development activities, as an attempt to respect that integrated holistic view, including possible organisational aspects that might affect the core development activities in various ways. This proposition should guide future research as a research agenda in the area at hand to enable an improvement of the production efficiency of the industry.

In order to study how the industry could come closer to their consumer markets and facilitate product development, it was suggested that the Means-End Chain approach may be of use. That approach could further be linked to Quality Function Deployment, taking consumer requirements into the production process by different steps of translation. Those two methods combined would cover the core of Fig. 1, the Extended Means-End Chain.

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