

# INDUSTRIALISED HOUSING: DEFINITION AND CATEGORIZATION OF THE CONCEPT

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## ABSTRACT

A new and developed concept of industrialised housing is emerging in the Swedish building industry today. The general opinion is that industrialised housing contains the answer to many of the problems in the building sector. The paper presents a comprehensive definition of industrialised housing, points at its corner stones and key characteristics and discusses how it relates to the paradigms of lean and agile production. Eight characteristic areas are identified: Planning and control of the processes, Developed technical systems, Off-site manufacturing of building parts, Long-term relations between participants, Supply chain management integrated in the construction process, Customer focus, Use of information and communication technology, Systematic performance measuring and re-use of experiences.

A categorization model is developed that allows an assessment of the degrees of implementation and fulfillment for each area. The categorization aims at pointing out the areas of strengths and weaknesses of companies working with industrialised housing. The categorization model is tested on two leading Swedish industrialised housing companies working with different frame systems and different organisational set up.

## KEY WORDS

Industrialised housing, Agile Production, Process, Industrialisation

## INTRODUCTION

Several concepts emerging from the manufacturing industry have in later years been successfully adapted in the housing industry. In Japan the lean production concept is applied to industrialised housing through balancing customisation and standardisation while developing efficient production processes (Gann 1996). Other concepts for housing are logistics and supply chain management (SCM) that are demonstrated as disciplines with the potential to increase efficiency in the construction process (Agapiou et al. 1998; Naim and Barlow 2003). A method for customer orientation in industrial construction that can be used to meet the varying demands on a market is mass customisation (Krajewski & Ritzman 1999). However, to achieve efficient mass customisation

in housing, a re-engineered construction process through new technology (e.g. prefabrication) combined with changes in products and processes, is needed (Roy et al. 2003). The most promising way to improve the construction supply chain for customised housing is to apply and combine lean and agile principles (Naim & Barlow, 2003).

Swedish construction and housing industry have been thoroughly investigated the last couple of years by both governmental and private commissions (SOU 2000:44; SOU 2002:115 and Sveriges Byggindustriers Bygghögskommision 2002). It is in consensus stated that the housing sector is in need of change in numerous areas and industrialisation is mentioned as a step towards solutions to some of these problems, e.g. cost development, productivity and quality. The hous-

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ing industry has responded to the criticism and at present there are many initiatives claiming that they are working with industrialised housing. Industrialised timber frame detached housing has increased in popularity on the Swedish market over the last years e.g., through increased customer focus, demonstrating the potential of process-orientation and construction process efficiency. The experiences from the detached house market, having had an open competition for a long time, indicate that an industrialised and process-oriented production approach could have a potential also for the whole housing industry (Bergström & Stehn, 2005).

Hence industrialised housing is a frequently used term in Swedish housing industry today. Furthermore, literature indicates several similar philosophies and methods that aims towards a "general" industrialisation of construction. One problem is that there is no clear definition of the concept and therefore the meaning may vary from one person to another. This stresses a need for a clear definition of the concept and a categorization of levels of implementation and fulfilment of the definition.

This paper presents a comprehensive definition of industrialised housing by pointing out its corner stones and key characteristics. A categorization model is developed considering lean and SCM literature and practical knowledge that allows an assessment of the degrees of implementation and fulfilment for each area of the concept. A case study of two totally different, but leading, Swedish house manufacturers was performed to investigate the categorization model.

## PRODUCTION CONCEPTS

Industrialised housing is not new as a concept, but the substance and the context of the concept is new for the construction industry. During the 60s and 70s, the production-focused and non-customer oriented systems building approach was developed and used in countries like Sweden and Great Britain. Systems building is one kind of industrialised housing where ingredients like pre-fabrication, standardisation, and methods for production and quality control were central (Gann, 1996). However, this mass production like approach failed for various reasons, a salient factor was the lack of customer orientation. The new industrialised housing approach must include an increased customer-orientation and improved processes for integrating design, production, information and management, to be accomplished through change and innovation.

There are several manufacturing paradigms and production principles that share essential proper-

ties but as we will show, most of them focus on a certain part of the production activities and leaves some important aspects.

Lean Production as a manufacturing paradigm has its roots in the car manufacturing industry (Womack et al., 1990). The principles of Lean Production include: *teamwork, communication, efficient use of resources and elimination of waste and continuous improvements*. Karlsson and Åhlström (1996) have formed a developed model with nine variables identified as the main characteristics of lean production, focusing on the production and the supply chain with the aim to create an efficient production and deliver high quality products.

- Elimination of waste
- Zero defects
- Pull instead of push
- Just-in-time
- Integrated functions
- Decentralized responsibilities
- Vertical information systems
- Continuous improvement
- Multifunctional teams

The agile and lean production paradigms have many linkages, both aim to reduce assembly time and produce according to customer demands. Hormozi (2001) describes agile manufacturing organizations as striving for integrating design, engineering and manufacturing with marketing and sales in such way that the products are customized to the exact needs of the customer. Information and communication technology, ICT, is a key enabling technology in achieving this integration (Eastman 1999). The agile principle uses and is to a high degree dependent on an integration and adaption of ICT (Sahin, 2000). Changes in relations to customers and suppliers along with closer integration between market, design, and production and improved information processing are identified by Barlow (1999) as ways of reaching a level of flexibility in production processes allowing mass customisation in housing.

Barlow (1999) has identified a number of significant requirements for agile production; 1) Concurrent engineering, interdisciplinary design and computer integrated manufacturing, 2) Just-In-Time supply of components, 3) Improved capture of individual customer requirements and increased customer input into the design process and 4) Customer-centred, rather than cost-accounting, performance measures.

The manufacturing industry has achieved productivity gains throughout the entire supply chain via the SCM concept and the use of lean and agile production (London and Kenley, 2001) and the most significant contributions are linked to

organisation and management of production where comprehensive resource planning methods have a major role (Crowley, 1998).

SCM can be viewed as the management and integration of key business processes across the supply chain, i.e. a process-based perspective (Ho et al. 2002). From a logistics and transportation perspective, SCM is seen as the management of materials, products, and information flow. It can also be considered as the simultaneous integration of customer requirements, internal processes, and supplier performance (Tan et al. 1999).

Four roles of supply chain management in construction are described by Vrijhoef & Koskela (2000), where one role points at the necessity of transferring activities from the site to the supply chain in order to decrease cost and duration. Prefabrication is mentioned as a structural change of the production chain. Nevertheless, Olsson, (2000) states that actors in the construction process must share information with actors in the supply chain at an early stage if the supply chain shall be able to meet demands in the construction phase.

In a recent study, a change process of a Swedish timber frame manufacturer was investigated using SCM tools by Bergström & Stehn, (2005). Changes regarding inventory and materials management, production processes, factory layout, and organisation were performed and improved working methods and equipment was established.

## INDUSTRIALISED HOUSING

Inspired of the paradigms and concepts above we have put together a frame for the concept of industrialised housing in order to make it clear and create a base for further research. Eight characteristic areas constitute the concept:

1. Planning and control of the processes
2. Developed technical systems
3. Off-site manufacturing of building parts
4. Long-term relations between participants
5. Supply chain management integrated in the construction process
6. Customer focus
7. Use of information and communication technology
8. Systematic performance measuring and re-use of experiences

## PLANNING AND CONTROL OF THE PROCESSES

The design, manufacture, assembly and other related processes requires a coherent structure and management from start to end in order to reach the goals and deliver maximum value to the customers. A thorough planning of all activities is there-

fore required especially in the early stages of projects where extra attention must be paid to design (architectural as well as engineering), planning and preparation. By well prepared processes, complete design when the production starts and the use of separately developed technical systems, supported by structured planning methods, the execution of the processes will run smooth and with a low amount of defects and errors. The strive is towards zero defects and minimum amount of waste.

## DEVELOPED TECHNICAL SYSTEMS

In order to minimise defects and create an effective process, technical systems are developed in separate product development processes, where the design is tested, adjusted and developed to a high level of completion. These systems are then used in the design and production of unique housing projects. The technical systems include frame solutions, electrical and sanitary installations, façade systems etc with different levels of flexibility. Experiences from projects are used as input to the further development of the individual system, as explained below.

## OFF-SITE MANUFACTURING OF BUILDING PARTS

Building parts are manufactured in an environment suited for effective production, where advanced equipment can be used and the working conditions are good. The manufactured elements are of a high level of completion in order to minimise work at the building site. As many parts of the building as possible are manufactured in off-site production and finally assembled at the building site.

## LONG-TERM RELATIONS BETWEEN PARTICIPANTS

The participants in the processes are engaged on long-term basis in order to develop the relations between the participants and thereby perform better and create an effective production where maximum value is created. The team of participating firms is put together based on certain criteria to establish good conditions for the cooperation and the common ability to achieve goals and create value for the customer. Long-term relations mean that the team can start projects rapidly since they have a structure for their co-operation and hence valuable time is saved since no efforts must be done in bringing in tenders and evaluate different contractors and designers. This approach has many similarities to strategic partnering.

### **SUPPLY CHAIN MANAGEMENT INTEGRATED WITH THE CONSTRUCTION PROCESS**

By moving construction activities upstream from the construction site to factories where pre-assembly is carried out, high demands will be raised on the management of the supply chain and logistic activities. The supply chain is divided into two main parts, the pre-assembly factories and the construction site which have different demands on the supply chain. The pre-assembly involve purchasing, materials handling, supplier involvement, transportation and supply patterns etc. Activities on the construction site have the structure of final assembly and the deliveries of elements and components must be thoroughly planned where JIT is implemented in close relationship with component and element suppliers.

### **CUSTOMER FOCUS**

A clear focus on the customer is a necessity to ensure that the right products, with the right quality to the right cost are produced for the end-customer. This approach means that thorough surveys and investigations must be done in order to catch the customers' needs and priorities.

### **USE OF INFORMATION AND COMMUNICATION TECHNOLOGY**

Industrialised processes require accurate and reliable information. Modern ICT (Information and Communication Technology) provide tools that effectively handles updates and changes of digital material and provide solutions for information exchange and data storage. An extensive use of modern IT-tools supports the different processes by enabling more accurate documents and hence good conditions for an effective production where errors are discovered early and problems in the manufacturing and assembly phases are avoided.

### **SYSTEMATIC PERFORMANCE MEASURING AND RE-USE OF EXPERIENCES**

Industrialised housing is about using and improving effective methods and solutions for house building. In order to get information about the

processes and the technical solutions extensive, continuous measuring and follow-ups are needed, regarding as well soft as hard parameters. Experiences and measures are analyzed and the results are input to the development process and to coming projects. Staff from all participating companies should be part of these activities since experiences from all parts of the processes are important and it is important that all participants feel responsible for improving.

### **LEVELS OF IMPLEMENTATION**

The strategic choice or level of implementation of the eight areas can be different for a company or cooperating group of companies. The company might have focused on some area, resulting in a high level of implementation for that and lower levels in the other areas. Some areas are closely related which means that a low level in one area will lead to a low level in the related area as well. Differences in levels can be of various reasons depending on the company's strategic business choices, history, main activity (e.g. contractor, developer, and construction management), maturity in IT use and implementation etc.

In order to establish a categorization model for assessing levels of implementation and achievement in the different areas, key factors for the development of the areas are presented in Table 1 below. Generally we have distinguished the levels from 0 to 4,

Level 0 No efforts in the area.

Level 1 The area is identified. Implementation is planned for.

Level 2 Efforts in the area in some aspects. Partly implemented.

Level 3 A clear strategy for the whole area. Implemented.

Level 4 The area is fully implemented and integrated with other areas.

The different areas are presented with examples for each level, where complexity and implementation are increasing with higher levels. The examples are based on the authors' practical experiences from various projects, and are presented to elucidate the difference between the levels.



Table 1: Industrialisation characterization and exemplification of level of achievement

Area	Levels	Characteristics
Planning and control of the processes	0	Scarce structure of process planning and control. Time schedules are not definite, unclear responsibilities and management has poor control of the process.
	1	A clear holistic structure of the project processes. All participants respect delivery dates and schedule.
	2	Developed planning in early phases of projects where key participants collaborate to give input to schedule. Developed structure for design delivery.
	3	Clear gates between sub-processes where certain tasks must be fulfilled. Detailed planning of all processes supported by structured planning system. All tasks in manufacture and assembly are thoroughly prepared.
	4	Planning and control systems supported by advanced ICT-tools and integrated with planning of supply chain activities. Performance measures give important input to planning.
Off-site manufacturing of building parts	0	No off-site production
	1	Simple parts of the building are manufactured off-site. Examples are roof trusses and concrete elements.
	2	More advanced parts are pre-assembled off-site. It can be façade elements, complete wall- and slab-elements and stairs with ready surfaces.
	3	Advanced parts are pre-assembled and integrated with other pre-assembled parts. It can be volume-elements with all surfaces completed, completely equipped bathroom modules and pre-assembled service elements.
	4	Advanced parts are pre-assembled, design and manufacture are supported by IT-tools, advanced logistics principles and planning system.
Developed technical systems	0	Minimal use of developed technical systems. Hand craft methods dominate.
	1	Developed technical systems are used occasionally but without a clear strategy. Systems can be frame-, façade- or service systems.
	2	Developed technical systems are designed and used for certain parts of the building, based on a technical strategy.
	3	Complex technical systems used for a majority of the parts of the building. Systems are designed to fit each other and developed in partnership with suppliers.
	4	Complex technical systems are used, continuously developed in partnership with other participants, based on experiences from projects and supported by IT-tools
Long-term relations between participants	0	No long-term relations are established.
	1	Some relations are identified as more important than others. Relations are established but not in a systematic way.
	2	Long-term relations are established with key participants. Activities to strengthen the relations are done. The partnering concept is used occasionally
	3	All participants are involved on long-term basis. The participants work together as a team. Strategic partnering with key participants
	4	A structured program is used to work actively to develop the relations and cooperation. Evaluation is supported by IT-tools. Strategic partnering is thoroughly used.
Supply chain management integrated in the construction process	0	Logistic activities are not on the agenda.
	1	Solutions for better materials handling are used. Sufficient storage, delivery patterns and information exchange with key suppliers are examples of efforts.
	2	Just-in-time principles are applied. Strategic work with low storage levels, adjusted deliveries, packages and developed relations with key suppliers.
	3	Supply chain activities integrated in the construction process. It includes developed supplier services and information flow enabling advanced technical solutions.
	4	Supply chain activities are fully integrated as natural parts of the construction process. Supported by ICT-tools for planning, purchasing, scheduling and design.

Table 1: Industrialisation characterization and exemplification of level of achievement

Area	Levels	Characteristics
Customer focus	0	The customer is anonymous and un-known.
	1	General insight about basic end-customer priorities, e.g. equipment preferences, apartment size. Clear perception of who the company's customer is.
	2	Basic investigations about end-customer needs and priorities for different cost levels and customer segments. Topics for investigation can be equipment, service needs and apartment layout.
	3	Systematic investigations about customer needs and priorities, follow-ups with moved-in tenants. ICT-tools supporting investigations and analysis of the material.
	4	The customer investigations and follow-ups are integrated with other areas, e.g. the technical development, manufacturing and assembly process and the project planning. ICT-tools make the information transparent in the whole process.
Use of information and communication technology	0	No ICT-tools are used.
	1	ICT-tools are used by some participants in the process.
	2	All participants are using ICT-tools to support their own activities. No common strategy is used.
	3	All participants are using ICT-tools integrated with each other. A common strategy is applied for the area.
	4	Advanced ICT-tools used by all participants to support other developed areas. ICT-tools support and integrate design, manufacturing, planning, performance measuring and purchasing.
Systematic performance measuring and re-use of experiences	0	No measuring and no systematic re-use of experience.
	1	Experience exchange in some parts of the process like regular meetings with manufacturing staff or the design team. Limited documentation.
	2	Measuring of tasks in some parts of the process. It can be key activities in manufacturing, assembly time, follow-ups in design. Documentation handled by individual participant.
	3	Performance measuring in all parts of the process but limited co-ordination. Experiences well documented by process owner.
	4	Performance measuring in a number of areas, experiences collected and spread systematically, with developed ICT-tools. This supports work with customer focus, relations, planning and the industrial manufacturing.

The categorization model is tested on two leading housing companies working with industrialised housing for multi-storey dwellings but with different modulation concepts, one based on steel frame and one based on wood frame.

The model was tested by performing case studies in the companies, where qualitative interviews were carried out, combined with the researchers own observations. The collected information was analyzed and an assessment of the companies' levels of implementation in the different areas was made by the researchers.

#### COMPANY 1—INDUSTRIALISED STEEL FRAME HOUSING MANUFACTURER

This housing company was founded in 2003 and has its own production of volume elements, initially started to develop a new housing area with 1200 apartments. The company has a dominating role in the project and acts as client, manufacturer and project manager. About 25% of the construc-

tion work is done in the company's factory where the volume elements are manufactured and 75% of the work is done at the site, mostly by sub-contractors hired by the company. The strategy is to move more work into the factory where they believe they have better control of the work processes.

The volume elements are built up by steel studs, plaster boards and mineral wool and pre-assembled in the factory and finally assembled in an exterior steel frame at the site.

#### COMPANY 2—INDUSTRIALISED WOOD FRAME HOUSING MANUFACTURER

The company started in 1924 as a family owned (still is) construction company and has expanded to a medium-sized enterprise with a turnover of over €13 M. The company produces and erects customised multi-storey timber frame buildings using volume element production and offers student lodgings, hotels, multi family dwellings

Table 2: Level of implementation for company 1

Area	Description	Level
Planning and control of the processes	The company has good control of the processes in the factory, the tasks are well-known and the work follows a structured process where each task is given a certain time. The design process is to some extent integrated with the manufacturing process since the company has its own architects and engineers. The same control is not achieved at the building site due to a high number of sub-contractors and less possibilities of structuring their work. A structured process design is lacking for this phase.	2
Developed technical systems	The volumes always have the same exterior measures and the interface between modules and exterior steel frame is highly standardised. The building system has integrated sub-systems for piping, separate bathroom modules, and kitchen equipment.	3
Off-site manufacturing of building parts	The volumes are completed with floor, painted walls, windows, doors, complete bathrooms, complete kitchens, piping and electrical installations and façades. Still 75% of all costs are located to the building site, where all foundation, exterior frame and complementing works are done.	3
Long-term relations between participants	The strive is to work with the same people and companies. No developed programme for partnership. Close business relations with some suppliers and consultants. No criteria for assessing new partners.	1
SCM integrated in the construction process	Close relations with key suppliers. Some suppliers deliver adjusted material and packed to fit the manufacture. No JIT-deliveries, the company have buffers both in-house and at suppliers. Deliveries to the factory are working well since the work flow is steady, at the site there is less structure.	2
Customer focus	The company sees client companies as the customers which mean that they see themselves as customers in the on-going project. The tenants are not seen as customers. No investigations about priorities are done, no investigations with tenants after they have moved in. They have planned to do it but have not prioritised it yet.	1
Use of information and communication technology	All designers use CAD but different CAD-applications are used. The company is preparing for an ERP-system with integration facilities. Some machines in the manufacturing are supplied with digital data from drawings. The company strives towards transparent information flow with real time update of performed tasks.	2
Systematic performance measuring & re-use of experiences	No systematic use of performance measurement. Experiences are collected on weekly meetings between production staff, designers and site staff. By the use of a quality program based on ISO 9001 discrepancies are documented and adjusted. No structured system for experience collection.	1

(often four storeys) and senior dwellings. Building element production and assembling of inner doors and fixed equipment, as well as on site erection, are done by the company’s own staff. Typically, subcontractors paint the interior and exterior, finishes surfaces, do technical installations, and fixation of heating and water equipment, in the volume completion process. Fifty percent of the production is based on skeleton contracts with real estate trustees.

In 1994, the company performed two large-scale changes regarding the main product and production method. The company shifted from a timber building element production for houses up to two storeys to a volume element production of multi-storey houses. The driving force for the change was a need for controlling and incorporating customisation.

**CASE RESULTS**

The result of the two case studies is presented in the diagram below, company 1 is represented by

the solid line and company 2 the dotted line. A significant difference between the two different companies is notable.

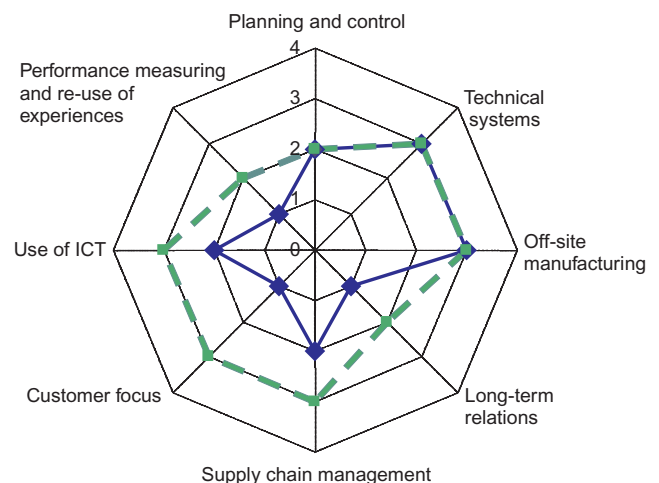


Figure 1: Level of implementation of industrialisation for company 1 and 2

Table 3: Level of implementation for company 2

Area	Description	Level
Planning and control of the processes	The company has good control of the process in the factory and is continuously developing the internal logistics. New work methods and production machinery is developed together with specialised manufacturers. The case company also issued a development project to integrate SCM with an increased use of ICT tools for production control; purchasing and structural design. The complete production process is well known to the workers and sub-contractors.	2
Developed technical systems	The volumes always have the same exterior measures and the interface between the timber frame modules is highly standardised. The only limitations are the physical dimensions set by transportation and structural demands for the volume elements. The building system has integrated sub-systems for piping, separate bathroom modules, and kitchen equipment.	3
Off-site manufacturing of building parts	Building element production, assembly of inner doors and fixed equipment, as well as on-site erection, are done by the company's own workers (wherever the site is located in Sweden). Typically, subcontractors paint the interior and exterior, finish surfaces, do technical installations, fixation of heating and water equipment in the volume completion process. Roughly 40 % of all costs are located to the building site	3
Long-term relations between participants	Fifty percent of the production is based on skeleton contracts with real estate trustees. Long-term business cooperation's exists with material timber and other raw material manufacturers and the same subcontractors are used although no formal contracts exist. Some criteria in use for assessing new partners.	2
SCM integrated in the construction process	Close relations with key suppliers. All material and component suppliers deliver adjusted material, packed to fit the manufacture, most use JIT-deliveries, the company have well organised, small "kanban-type" buffers. Site deliveries are highly structured. Return transports bring in materials from suppliers through an ordered SCM structure	3
Customer focus	The strategy is to involve customers early in the building process (cooperation with architects or clients' architects). Two persons are dedicated to this work. Several ICT based tools for tenants' choices of extras and to involve real estate trustee in the customisation process without reducing the production effectiveness have been tested. Several follow-ups and R&D projects of customisation offers have resulted in an ever developing customisation strategy directed both to tenants and real estate trustees.	3
Use of information and communication technology	All in-house designers use CAD but different CAD-applications are used by subcontractors. An Enterprise Resource Planning system is presently under installation. The company has issued several R&D projects to integrate ICT and develop a progressive information strategy in almost all areas (seen in this table). This has taken over 10 years of development and preparation, and is still in focus and on-going.	3
Systematic performance measuring & re-use of experiences	Some systematic use of performance measurement. An in-house developed control and quality assessment system is utilised. A semi-structured system for experience collection is used and checked after each project and brought on an ad-hoc base back into the production.	2

## DISCUSSION

The concept industrialised housing is shown to be complex and can logically be represented by eight interdependent areas in which a company can have reached, or deliberately chosen, different levels of implementation. In order to increase industrialisation, all areas of the concept must be developed to some extent and companies with ambitions in developing industrialisation must strive for a balance in implementation levels, based on the individual company's strategy, in analogy to how Tan et al (1999) claim that SCM can be considered.

As Barlow (1999) also states, the pre-assembly area is a key factor for industrialisation even though it is only one of the eight areas of our concept. The interdependence between the areas means that if one area has a very low level of implementation, a related area cannot get a high

level. Typical linkages are between the Planning and control and the Supply chain management areas where planning and process control are fundamental factors in both areas. The interdependence can not be thoroughly judged from this study though; only preliminary relationships between different areas are visible from the results, since the information gathered in the two case studies is not enough to make valid analyses of the interdependences. Further studies in determining needed requirements for one area in order to imply a change in other areas, linkages between areas and strategies for how to achieve higher company performance and more effective processes, are needed and of interest for further investigations and research.

There is a significant difference between the two companies in the case study, where company 2 generally has higher levels of implementation. The possible reason is the fact that this company



has worked strategically with industrialisation matters during the last 10 years while company 1 has been on the market for two years only. Still, company 1 has high levels of implementation in some areas which indicates what focus the company has had during the start-up phase. With the help of the categorization model it is possible to identify in which areas efforts should be made, in order to increase the over-all level of industrialisation. None of the companies reach level 4, in any area, which indicates that it requires very focused efforts and integration work to achieve full implementation and integration.

The production system and industrialisation direction for company 2 has many similarities with agile production, while there is a strong focus on customization combined with well developed manufacture of the building elements, which relates to the findings of Naim & Barlow (2003). Company 1 has not developed the customer focus area, while company 2 has worked thoroughly with it in order to increase the ability to fulfill the customers' needs. This is likely also a sign of maturity on the market, since company 1 has only produced apartments with their own company as client, while company 2 delivers to many different clients on the market, and hence have had to be more sensitive to customers requirements.

Both companies have poor implementation in the area of Performance measuring and re-use of experiences. This area has been developed thoroughly in other industries and shown to be a key factor for process development. It is important for industrialised housing companies to develop this area in order to increase learning, knowledge and control of their processes. If a continuous strive for improvements and efficiency/effectiveness is sought we judge the area performance measuring controlled by the use of proper and adapted ICT tools the two most important. Both case companies show low fulfillment in these areas, by focusing on these dimensions a more customized and balanced industrialized housing business is possible.

Industrialised housing, in this definition, differs radically from traditional house building while it offers a new way to tackle housing. It has few similarities with the large-scale housing programmes carried out during the 1960:s, especially since customer focus is included as one of the key areas, with great importance for housing today, since customers are sensitive to design, costs, location etc. Industrialised housing also has more linkages to agile than lean manufacturing, (Naim & Barlow, 2003) which is shown especially in the case study of company 2. The concept presented in this paper means a comprehensive view of housing, requiring a paradigm shift regarding the

fundamentals of traditional housing processes, where all the eight areas must be developed to certain levels, supported by a clear process ownership from start to end to achieve industrialisation with the context presented in this paper. Radical changes in the whole process structure is required to achieve this paradigm shift and cannot be done only by making the work at the building site more efficient. The eight areas presented herein is thought to work as a "cook-book" guiding this transformation.

Industrialised housing is a concept well suited for building of apartment houses and homes, but cannot be directly transferred to other parts of the construction industry due to some key aspects, e.g the use of technical platforms and pre-assembly of building parts. For other parts of construction some areas from this concept can be used together but must be put in its context based on other key issues e.g, large contractors partnering etc.

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