

# THE HOUSE AS A PRODUCT



Andreas Vogler

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# THE HOUSE AS --- A PRODUCT

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## THE HOUSE AS A PRODUCT

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# PREFACE



Mick Eekhout (© Nadine Maas)

Industrialized housing is a phenomenon that has been alive in the building industry since the industrial revolution; the casting of iron components enabled Victorian iron casters to prefabricate entire buildings and to export them to all British colonies. It got a second boost by Modernist architects such as Ludwig Mies van der Rohe, Walter Gropius and Konrad Wachsmann. A third boost happened in the United States when US soldiers came back from the Second World War in 1945; In the later decades of the last century, composite prototypes were built. Timber frame houses have become extremely popular in low-density areas worldwide. For densely populated areas housing is now firmly attached to reinforced concrete. The contracting industries have developed efficient building methods for the concrete structures on which separate systems of claddings are fixed to form a house. Since Dutch architect John Habraken in his seminal book *Supports, an Alternative to Mass Housing* divided concrete 'support' and lightweight 'infill', structure and cladding now form two main and different building parts. In the recent decades a third element has become increasingly important and independent from the pure infill, the services.

However, in the coming decades we - designers, builders and scientists - must keep the world a sound environment within sight, prevent the exhaustion of materials and be for the minimization of embedded energy and energy usage. In the coming age, low ecological footprints, as renewed values will have an influence on the building technology of the future. This will lead to a reformation of the building vocabulary. Sustainable materials will have to be chosen and developed to function in building elements and components.

In the Concept House research group in my Chair of Product Development at TU Delft, in which Andreas Vogler participated for a few years, the focus was on industrialized, customized, energy-positive, low carbon footprint buildings, specifically multi-story apartment housing. In the last 8 years studies were made, of which can be found in this

book, and designs were developed for the Concept House Urban Villas of 4 stories, which indeed has a low footprint. It has been realized as a plug & play in an industrial mode and is customized and energy positive. In 2012 the first Concept House DELFT Prototype of 7,5 x 15,0 m<sup>2</sup> was realized in Rotterdam in the Concept House Village. In the years up to 2016 the Concept House DELFT Prototype will be employed as a living laboratory to study cases such as occasional dwelling, comparable dwelling, experimentation, testing and evaluation.

The next phase would see further development garnered from the evaluation data, and then make possible improvements on a single prototype within an urban villa and consecutively in a small series of 16 apartments. Then, came the realization of the Concept House Urban Villa. In the mean time regular publications and dissemination ensures the contribution from the academic side. In publishing and collaborating with the building industry, the hope is that academia will stimulate industry.

To work and research efficiently, the first few years of the research group between 2005-2008 were spent on historical and existing prototypes. In the research group Sannie Verweij did historical research as well as the Munich, based architect, Andreas Vogler. Apart from the futuristic designs in his office, 'Andreas Vogler Studio', Andreas has spent some time on the history of industrialized housing and its difficulties in an else highly industrialized world. During his studies the need for a wide overview of historical examples of industrialized housing became apparent as he recognized the need to not make the same mistakes made by others before him . The many examples in this book show that there are different reasons why industrialized housing did not mature in the same level or degree of industrialization as the automobile or aeroplane industry. Many of those reasons of failure are based in marketing and financing, not so much in technology. Smaller serial effects also play a role. The amount of repetition is nothing compared to the automobile industry. The housing industry is, for the larger part, still to be compared with the turn of the century automobile ateliers in which cars were assembled by hand and in very many different types. Only in the Netherlands some 5.000 contractors are working in producing houses. And most of them are built on the base of handicraft.

Before making the jump from the Concept House DELFT Prototype as a single apartment towards the serial Concept House Urban Villa, it is good to look back and see whether all necessary steps have been taken to determine that we have not made the same mistakes as our historical colleagues did. That is the reason why this book has its value. The windshield is larger than the rear view mirror, but you need both when moving towards the future.

A handwritten signature in black ink, reading 'mick eekhout', with a long horizontal flourish extending to the right.

Prof.dr.Mick Eekhout,  
Chair of Product Development at TU Delft 1991 - 2015

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# INTRODUCTION

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Driving through a typical single-family house neighborhood in the beginning of the 21<sup>st</sup> century, one will notice how similar the houses look. One might think single-family houses are a bastion of individual expression, but based on this stereotypical neighborhood, they are not. One might think, they look so similar because they are factory-made. But, upon closer inspection, they are actually built-on-site. They are individually contracted houses, expensive, time-consuming weather dependent. However, they are made on a similar design preset. So what is wrong with the industrialization of the housing sector?

Cars, computers, nearly all products have become cheaper, better working, better looking and better performing through the process of industrialization. In contrast, houses – and even factory-made houses – have not. The factory-made house has a nearly 200-year-old history. However, site-built construction never has been so successful as today. The house-building sector produces the highest value worldwide and represents the biggest market, but house builders are poorly organized with limited political influence. Small construction companies with less than 20 employees and a minimal capital investment build 85 percent of the houses worldwide. The prefab house industry produces whole houses in factories, yet, with the exception of Japan, automation and industrialization is very low compared to other industries. Most of the prefab housing industry was established in the 1950s and 1960s, but not very much in the way they are produced has changed since then. Prefab housing industries are often associated with mass production. However, especially in Europe, there are many companies who work profitably producing less than 100 houses per year. The mass production of houses has always been an argument that it will bring prices down, but prefab house prices instead follow the market only a little bit under an 'architect's designed house'. Architects have been the main promoters of industrialized building. However, they lost interest in collaborating with the industry and in turn, the industry lost interest in the collaboration with architects.

The list of sometime paradox problems can go on and there is no easy solution to any of them. But the status quo, where construction industry and architects arranged within their positions, is paid for by the price of a landscape full of houses, which are technological, cultural and aesthetical underachievement's of our societies, which else gleam with spacecraft, aircraft and cars of the highest quality and performance. The soon to be hundred year old question "Why can't we build houses like cars?" has not been answered yet. The prefab house may be a wicked problem, and for sure is a complex problem. This report will look into the development of the factory-made house and its current situation to create a basis for discussion, based on knowledge rather than preconceptions and wrong assumptions. Indeed, the prefabrication of houses is not very well researched. Key books are out of print and hard to get. The latest are from the early 1980s. Only recently, there seems to be a new interest in prefabrication. On the one hand from the side of the newly styled designer architects who coined the term 'prefabulous'. This expressed a new type of life-style architecture that went towards prefabrication. On the other hand from the UK where inefficient building sites run rampant and yet, there is a forecasted need for more housing as the population increases. Prefabrication of houses seems to be becoming a 'hot topic' again not only for the speculative builder but also for architects. It is estimated, that less than 5 percent of houses built, are built with the involvement of an architect, something that would not be possible in other industries where designers play an eminent role in the industrial process. An important note that any future architect should pay attention to.

This report will describe the industrial process and look into some sample industries, which have often been referred to in connection with the building industry, such as automotive, aerospace and shipbuilding. These industries have understood early-on that not only production and technology are important, but also the understanding of marketing and selling. Thus, we will also look into marketing and discuss resistances and potentials. It will also identify the behavior and initiative of the main market players: the client, the industry and the architects.

The framework for this research was a one-year research professorship at the Royal Academy of Fine Arts in Copenhagen in 2003-2004, which has been accompanied by teaching and lectures. The aim was to create an overview important for further research. It is argued that a clearer understanding of the situation needs to be created where a higher degree of collaboration from participants of the housing sector must be achieved to create a better product and in turn, a higher client satisfaction.

# 01 THE DEVELOPMENT OF THE INDUSTRIAL HOUSE

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Mass fabrication of houses started with settlements in mid-19<sup>th</sup> century colonies. Since then houses have been prefabricated with more or less success. While Henry Ford started the mass production of cars in 1913 introducing the conveyor belt, architect's like Walter Gropius or Le Corbusier demanded the industrial fabrication of houses at the beginning of the 20<sup>th</sup> century. The Henry Ford Syndrome was born: "Why can't we mass-produce houses – standard, well-designed, at low cost – in the same way Ford mass-produces cars?" (Herbert, 1984). Since then many efforts have been taken to establish the produced house. A big growth of the industry occurred in the 1960s, which sharply ended in the 1970s with the oil crisis. However, since then the prefab home industry developed to be a consistent part of the house building industry, although it always experiences a stiff competition by traditional on-site house building.

## 01.01 HISTORICAL OVERVIEW

*"For whatever profession, your inner devotion to the tasks you have set yourself must be so deep that you can never be deflected from your aim. However often the thread may be torn out of your hands, you must develop enough patience to wind it up again and again. Act as if you were going to live forever, and cast your plans way ahead. By this I mean that you must feel responsible without time limitation, and the consideration whether you may or may not be around to see the results should never enter your thoughts. If your contribution has been vital, there will always be somebody to pick up where you left off, and that will be your claim to immortality."*

Walter Gropius, letter to a group of students, 1964

Gropius wrote the above letter at a time when the industrial production of homes started to take off and become a substantial part of the home provision worldwide (explained more in chapter 1.2). However, it was also the time when beliefs of architects who wanted to change the world with architecture hit its peak and a decoupling of architecture history and the history of prefabrication of houses took place. As the basic housing provision after the Second World War was again guaranteed during the 1960s, architects were not interested in factory-made houses anymore and in turn, prefab companies found they didn't need architects as they could directly contact clients. Why this happened and why we lack now the expertise of the 'industrial architect', such as Peter Behrens for AEG, or Konrad Wachsmann for Christoph & Unmack, would be worth further investigation. The history of the prefabrication of houses is very rich and complex. What we do know comes from the history of failure, linked to the few projects of famous architects like Le Corbusier, Gropius, Wachsmann and Buckminster Fuller. These failures, and especially the failure of Gropius and Wachsmann's General Panel System, are usually taken as 'proof' by today's architects, that the successful prefabrication of houses is not possible. Or if it is – as the existing prefab companies demonstrate it – the design quality of the buildings turn out so poor, that it is not worthy of being called 'architecture'.

But by fostering pre- and misconceptions, we do not help the development of the house as an industrial product. Rather it is important to learn from failure and success and to understand the often-complex circumstances, which can make a house a successful product or not. Unfortunately the analytical and historical literature looking into this problem is scarce and not much has happened since the key books of Herbert [1978, 1984], Russell [1981] and Bernhardt [1980]. In Germany it was Junghanns [1994], who thoroughly investigated the German development in the first part of the 20<sup>th</sup> century. All of these books are out of print and sometimes difficult to find in libraries. But, there are many indications that 'Prefab' has come into fashion again. The forecasted shortage of houses in the UK caused much of discussion and government reports. In this context Colin Davies [2005] just published a critical history of the prefabricated home. The following overview shall just give some examples of the amount of energy, which has gone into the topic over the years. It is far from being complete.

### The Colonization of the World

While traveling today, one would minimally pack a suitcase to take with you. However, there are times where people even take their houses with them. The mass colonization of the world in the 19<sup>th</sup> century was driven by new means of transportation: the railway and the steamboat. The mastering of the weather independent longitude navigation with the chronometer at the end of the 18<sup>th</sup> century started a fast development of colonies along with a global trade [Sobel, 1995]. The colonies needed people for local presence and also attracted those looking for a better future. This became especially true with the outbreak of the 1848 gold rush in California, which resulted in a 'mass-production' of houses in the thousands, delivered to California from the Eastern United States, Europe, but also China and New Zealand. In New York alone, the early 1850s saw more than 5000 prefabricated houses produced [Wurm, 1966]. The migration of people to colonies caused an increased

need for housing in an environment with very low infrastructure. The settlers of the new colonies had to live in inadequate, improvised shelters provided by tents and flimsy huts. There was a great need for such buildings in places where rapid increases in population, scarcity of materials and high labor costs made prefabrication more economical and convenient than building on site. During this period Britain was the main producer of these prefabricated buildings, and exported a great variety of building types, including houses, hospitals, churches, warehouses, schools, theatres and shops, around the world [Figure 1]. Around 1830 prefabricated houses were offered to potential migrants in a new settlement in Australia:

“Gentlemen emigrating to the New Settlement, Swan river, on the Western Coast of Australia, will find great advantage in having a comfortable dwelling that can be erected in a few hours after landing, with windows, glazed doors, and locks, bolts, and the whole painted in a good and secure manner, carefully packed and delivered at the Docks, consisting of two, three, four, or more roomed Houses, made to any plan that may be proposed; likewise Houses of a cheaper description for laboring men, mechanics, &c..” [Manning, ca. 1830]

Passages to Australia were advertised by presenting the speed and sailing qualities of the ships and offering prefabricated houses ranging from a small settler’s hut to a sixteen-room residence. Also churches and bank buildings were offered for shipment [figure 2].

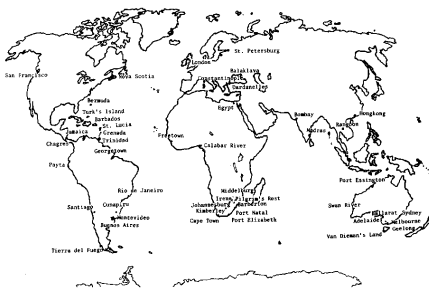


FIG. 01 Some locations of prefabricated structures exported from Britain during the nineteenth century. [Source: Herbert, 1978]

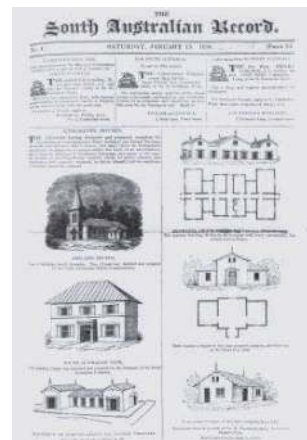


FIG. 02 Emigrants’ houses, 1838. Advertisement, the South Australian Record, 13 January 1838, offering passages to Australia by advertising the ships and the houses, including a church. [Source: Herbert, 1978]

Commonly used material for prefabricated huts was initially timber. As early as 1830, the company John Manning offered the 'Portable colonial Cottage', a two-room hut consisting of a timber frame construction with infill timber panels (Figure 3 & 4). The house kit would be flat-packed and erected within "a few hours after landing". The cottage was offered in catalogues as to be erected and taken apart for transportation with ease to the convenience of the settler. The Manning cottage is one of the early cases, where a house was offered as a finished 'product'. Peterson [1948] even mentions a first newspaper advertisement for timber houses in 1819 in a St. Louis newspaper in the United States.

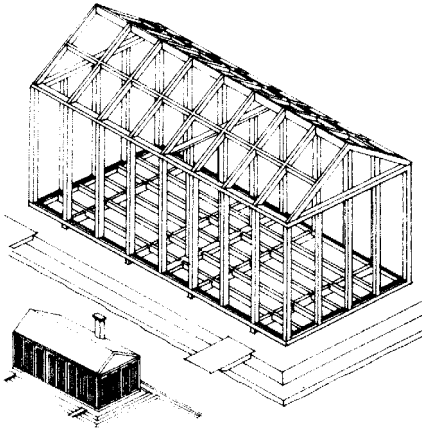


FIG. 03 Portable Colonial Cottage by John Manning, c. 1833. [Source: Herbert, 1978]

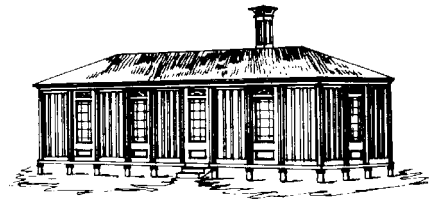


FIG. 04 John Manning. House for Captain Hall, Wargrave, near Henly-upon-Thames, ca. 1833. [Source: Herbert, 1978]

Although, up to today, timber is one of the main materials used for the prefabrication of houses, new materials have always been extensively explored as soon as they were available, such as papier-mâché, which had been exported and tried in Australia. Iron had also become an element of pre-fab during the 18<sup>th</sup> century. Apparently, first prefabricated iron houses have been delivered along the water channels, providing housing for the sluice guards [Wurm 1966]. Especially cast iron proved well for prefabrication and had the considerable advantage of a fireproof structure. Within a short time a powerful cast iron construction industry was building up in Great Britain, which was able to deliver all types of buildings within a short time. Nevertheless, given the weight of the cast iron elements, most of these buildings were delivered closest to the coast. A big step forward happened in the 1840s as iron became cheaper and the processes of corrugation and galvanizing became commercially viable. The invention of galvanized corrugated sheet iron and its cheap production in 1844 further revolutionized metal housing and provided for the first time in history a durable, fire-proof, corrosion-resistant, waterproof, pest-free material that was economical to produce and lastly, lightweight. Iron sheets could be screwed on an iron structure and clad over an entire story of a house. Houses of 4,10 x 6,10 m in plan could now be packed in two cases of 31 x 62 x 275 cm. In 1853 6.369 packages of iron buildings

with a total value of £111.380 were imported to Australia, mostly from Britain, though this was still less than half the value of the prefabricated timber buildings imported. By 1854 this had increased to 30.329 packages. Prefabricated iron buildings were put into use as schools, stores, warehouses, churches, station buildings, banks, police stations, lock-ups and gold depots, as well as houses. However, the boom lasted only a very short while. By the second half of 1853 it was already declining. While sales were still high, prices had dropped, with owners trying desperately to sell their iron buildings onto an already glutted market [Australian Heritage Database, 2005]. The houses were offered in newspapers and catalogues [Figure 5]. Some of the few remaining structures in the world can still be found in Australia [Figure 6].

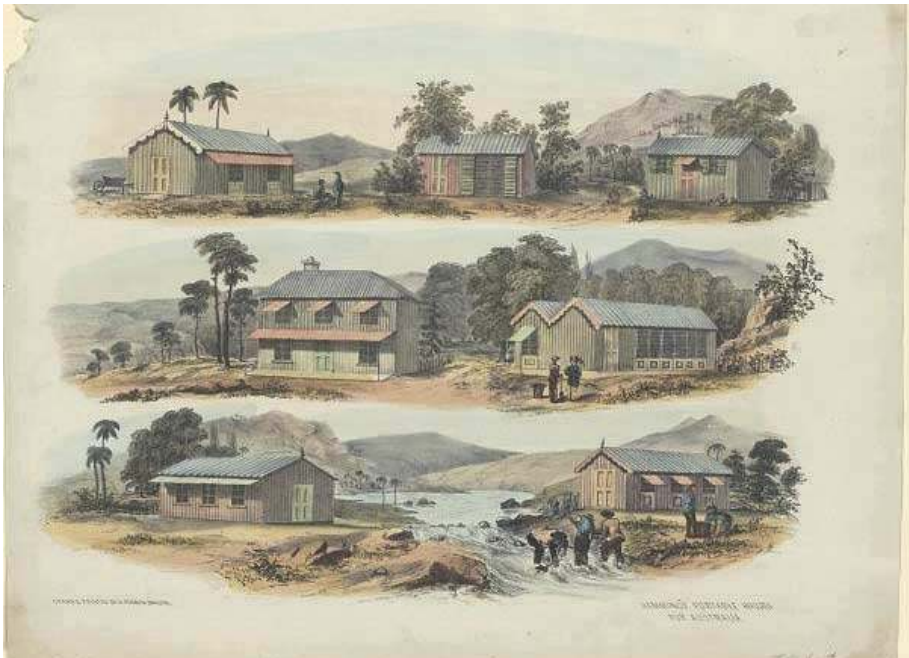


FIG. 05 "Hemming's portable houses for Australia." Hand-coloured lithograph by A. Pocock. Bristol 1855 [Source: National Library of Australia]



**FIG. 06** The Portable Iron House was imported and erected in 1853-54 for local speculator Robert Patterson is still located on the original site, fronting 399 Coventry Street South Melbourne. The portable iron structure, of utilitarian design and unknown manufacture, is constructed of a tee and angle section wrought iron frame clad with five inch pitch corrugated sheet, which is partitioned and lined internally with horizontal boards to form an attic cottage of six rooms. [Source: [www.onlymelbourne.com.au](http://www.onlymelbourne.com.au)]

Corrugated steel was a highly innovative material at the time and even kings ordered iron houses. The negative image came later by run-down factory sheds, war shelters and shantytowns. There is a considerable influence of this 'root' of Australian architecture on today's generation of Australian architects like Glenn Murcutt and others.

### Leader in Production: The Victorian Building Sector

There were several factors contributing to the decline in popularity of iron building after 1853 in Australia: the import glut of 1853 followed by a recession in 1854 associated by the steady decline of wages; the Crimean war, which created a surge in orders from the British War Office and so diverted the attention of manufacturers; and a rise in the price of iron, which resulted in an increase of about fifty percent in the retail price of iron buildings. These factors had a great effect on the importation of cheaper houses, but not on those structures where cost was less important, and several more pretentious villas were imported after this time. The Crimean War [1853-56] was the first war of the industrial era and very ambivalent in attitude. The military tactics and techniques proved to be tragically anachronistic and technology of the weapons were not up to date. In stark contrast, British industries was at its best in war logistics. The electric telegraph was introduced the first



time in a war, a new generation of steam-powered ship formed a 3.000 mile supply chain as well as a 15 mile railway system, a mobile floating flour-mill secured bread supply for the soldiers and over 1.400 huts were shipped just for the British Army. The siege of Sewastapol also turned out to be the first modern static warfare. Numerous wounds were exacerbated by cases of cholera, which caused an unforeseen demand in hospital huts and barracks.

The provision of mobile soldier and hospital huts became an important concern of modern warfare. In 1885 the Red Cross (founded in 1864) held an international competition for Portable Hospitals in Antwerp (Langenbeck, 1886). Among the many interesting submissions, the 'Doecker-System' by Christoph & Unmack got awarded. Christoph & Unmack later became one of Europe's largest prefabricated building manufacturers in the 1920s. The successful Doecker System is a highly rational, standard size, modular panel system (Figure 7 & 8). An ingenious, but simply operated metal coupling system using hooked catches, bolts, and wing nuts to secure and unite the component elements, allows flat-packed transportation and quick setup and disassembly.



FIG. 07 The Doecker System: An early standardized, modular panel system [source: Langenbeck, 1886]

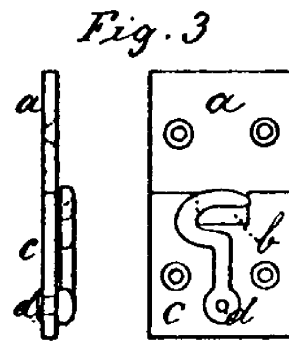


FIG. 08 Detail from the German Patent for a military tent by Christoph & Unmack, 1884 [source: Herbert, 1984]

In the same time, when the British industries delivered thousands of factory-made houses all over the world, Joseph Paxton introduced the on-site factory and on-site assembly lines to build the famous Crystal Palace in 1851 in London. Paxton developed with the glass industries the largest and lightest glass panels ever produced at this time. Together with the engineers Henderson & Co he designed and built special steam-powered machines for sash bars, drilling, sash bar painting and assembly. The sash bar milling machine allowed producing over 1.000 1,20 m long sash bars in ten hours. Special 'glazing wagons', which were covered, allowed the assembly of the roof without the need for scaffolds and allowed continuous weather independent work. It was more than 50 years later, when Henry Ford introduced the assembly line, but also then houses were built in factories and assembled on-site (figure 3 & 4). In housing it was the 'Balloon-Frame-System', which led to a turning

point in housing in the 19<sup>th</sup> century. Much of the powerful growth of the United States is owed to this system. The person generally credited with the invention of the balloon frame was Chicagoan engineer George W. Snow [Giedion, 1992, pp. 233-237]. Snow built a balloon-frame warehouse in Chicago in 1832. This building employed the now classic two-by-four inch [5,08 x 10,16 cm] vertical building stud, and established the standard 16-inch [40.64 cm] spacing between them. The studs supported two-by-ten inch roof and floor joists. A year later, carpenter Augustus D. Taylor used the balloon frame in the construction of Chicago's St. Mary's Church [Figure 9]. The church was taken down and reassembled three times during its existence. The introduction of the circular saw and the industrial production of nails enabled the introduction of a cheap, effective timber building system, which enabled unskilled laborers to erect houses within a short period of time. In 1855, The New York Tribune reported that without the balloon frame system, neither Chicago nor San Francisco would have been able to grow from villages to cities within one year. Estimates say, that in the second half of the 19<sup>th</sup> century 60-80% of the whole housing stock was based on the balloon frame system. Balloon frame construction of residential and commercial buildings increased in the twentieth century and continues to be the standard building form for ranch houses, although the use of balloon framing vanished during the last 50 years. The long, straight wall studs needed have become increasingly rare and expensive. Also, carpenters find shorter platform-frame walls easier and safer to build. The early 1900s marked the height of popularity for balloon frame construction when Sears, Roebuck and Company in the United States offered frame house kits in its mail order catalogues. Between 1908 and 1940 the big US department store sold nearly 100.000 houses offered in catalogues [Figure 10]. The offer has long been discontinued, but thousands of the neat, white, two-story Sears and Roebuck houses remain in towns and cities throughout Illinois, Iowa, and other Midwestern states. It was the base for the two-by-four wood-frame 'pre-cut' kit houses, which still can be bought in American DIY supermarkets today.

The end of the 19<sup>th</sup> century was full of first experiments of a fast developing society. Many of these would deserve more research, like the little signalman huts built by Hennebique for the French railroad company "Compagnie d'Orléans" in 1896. The little huts were prefabricated concrete modules, probably the first of their kind. The walls were made of 5 cm concrete with 4 mm of reinforcement. The huts were mass-produced and delivered by train to their final destination [Figure 11].



FIG. 09 St. Mary's Catholic Church, built in 1833 with the balloon frame system. (source: Chicago Historical Society, ICHI-37096)

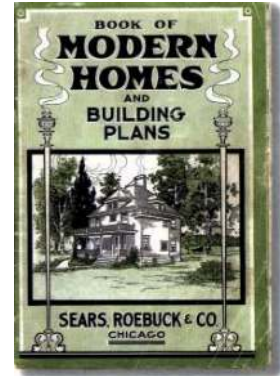


FIG. 10 Sears, Roebuck & Co. of Chicago sold about 100,000 mail-order kit houses from 1908 to 1940. Catalogs featured a selection of models that the buyer could customize to his own specifications. Sears goal was to make ordering a home as simple as ordering any other household product.

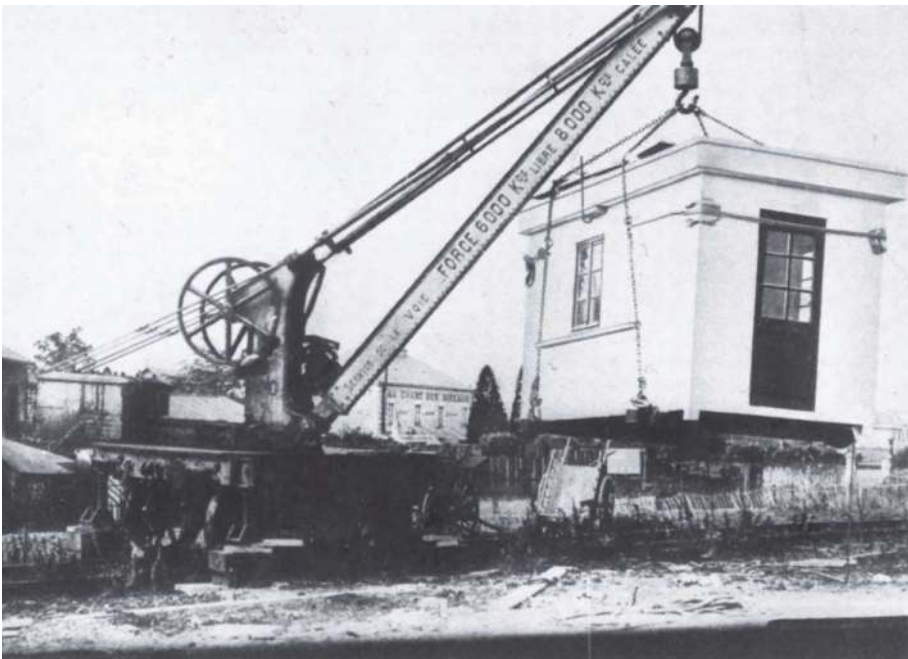


FIG. 11 Hennebique's prefabricated concrete signalmen huts from 1896 were delivered by train. (source: Huberti, 1964, p. 121)

## Intellectual Postulation and Industrial Reality in the 1920s and 1930s

Walter Gropius postulated in 1910 the industrialization of housing, but the First World War absorbed industrial production. The conveyor belt construction of cars introduced by Ford became a new icon of industrialized production, admired by many architects. J.J. Oud invented the term 'WohnFord'. With the Cultural Revolution in the 1920s many 'concept' houses had been built. Le Corbusier had the unique chance with the Pessac Houses not only to realize his architectural ideas of mass production, but also to initiate the necessary factories and their production lines. Also different and new materials were investigated. Especially metal in all its forms seemed to be the best material for durable construction and fast, flexible production process. The type houses by Hirsch-Kupfer and Messingwerke Finow AG were shipped worldwide. Some of them still last even today [Kupferhaus, n.d.]. Herbert [1984] notes, that in the century-long prehistory of prefabrication, when British manufacturers led the world in new techniques of industrialized building, architects played an insignificant role. In no instance did an architect initiate a new system of prefabrication or even play a creative part in its conception. This changed with the formation of modern architecture. It was in Germany that the first constructive links between architects and industry were examined. The founders of the 'Deutscher Werkbund' - twelve artists and architects and twelve manufacturers - accepted in 1907 a program whose first operative clause called for "encouragement of the fruitful cooperation of art, industry and craft" [Satzung, n.d.]. One of these architects was Peter Behrens, who became the principal designer, and architectural consultant of AEG [Allgemeine Electricitäts Gesellschaft] in Berlin. Behrens not only designed electric appliances like fans and lamps, but also was responsible for a whole new corporate design of AEG, spanning from the graphic design of letters to re-organizing the workshops and housing for employees. In 1910 the young Walter Gropius working under Behrens presented a memorandum on the industrial production of buildings: Program for the Founding of a General Housing-Construction Company Following Artistically Uniform Principles [Programm zur Gründung einer allgemeinen Hausbaugesellschaft auf künstlerischer einheitlicher Grundlage, m.b.H.]. In a bold endeavor Gropius tried to capture the essence of industrial building. He was the first architect on this route, influenced by Henry Ford's introduction of mass production and the mail order catalogues of Sears, Roebuck & Co., which also circulated in Europe [Isaacs, 1983]. Gropius [1910] proposed a system of different house types based on component parts, which themselves were based on standard dimensions: "Of objects there exists a choice of designs in different execution and pricing level, but in identical size. All parts fit without exception since they have been produced according to one and the same standardized size, and thus can be exchanged at will. The builder now can compose a house after his own personal taste from this wealth of material and diverse forms." Gropius thought of everything in the program, including marketing strategies. He developed a concept that eventually allowed for the substitution of the architect by a program.

Although Gropius worked together with Mies van der Rohe under Behrens, he left before Le Corbusier arrived. During his time in Berlin Le Corbusier was involved into the discussion in the Deutscher Werkbund about industrialization and mass production of houses. He soon expressed his thoughts in design projects like the Domino houses of 1914, along with the Monol and the Citrohan houses. In 'Vers un architecture' in 1923 he proclaimed:

*A great new epoch has begun.  
There exists a new spirit.*

*Industry, overwhelming us like a flood which rools on towards its destined end, has furnished us with new tools adapted to this new epoch, animated by the new spirit.*

*We must create the mass-production spirit.  
The spirit of living in mass-construction houses.  
The spirit of conceiving mass-production houses.*

Conceptually Le Corbusier adds nothing new to Gropius statements. But Le Corbusier influenced the imagination of a generation of architects by the stimulative force of his visual images and the evocative power of his prose [Herbert, 1984]. Captured by this prose, M. Frugès, an altruistic Bordeaux industrialist appointed Le Corbusier in 1923 to realize his ideas about industrial building by the use of machine. Le Corbusier had the unique chance with the Pessac Houses not only to realize his architectural ideas of mass production, but also to initiate the necessary factories and their production lines. Initially Le Corbusier wanted to involve the local builders, but they completely resisted and a contractor from Paris built the houses instead. After finishing, they were empty for more than three years. The local architects made such bad press against the houses, that nobody wanted to take the risk to buy one. It wasn't until the minister Louis Loucheur changed the laws to enable poor people to acquire the houses [Boudon, 1989]. Pessac was the first "Waterloo" of factory-made houses. It was neither cost nor technology, which led to disaster; it was the local social, cultural and economic environment [Figure 12, 13].

"I am going to enable you to realize your theories in practice – right up to their most extreme consequences – Pessac should be a laboratory. In short: I ask you to pose the problem of a house plan, of finding a method of standardization, to make use of walls, floors and roofs conforming to the most rigorous requirements for strength and efficiency and lending themselves to true Taylor-like methods of mass-production by the use of machines which I shall authorize you to buy."

Monsieur Frugès to Le Corbusier, 1923

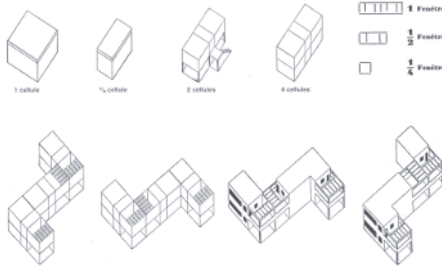


FIG. 12 The aim of Pessac was to achieve low cost by standardization, industrialization and Taylorized mass-production. Reinforced concrete was chosen as building material.



FIG. 13 The Pessac-colony today [Source: Fondation Le Corbusier].

But, also Gropius continued his influence by numerous articles and especially by the foundation of the Bauhaus, which had its own marketing organization to establish industry contacts. The Bauhaus understood clearly the home and its furnishings as mass consumer goods. They should be designed on the basis of reason and become cheaper and better than hand-made goods by the means of industrial mass-production.

Behind the intellectual postulations for industrialized mass-produced housing, was the severe problem of providing healthy and affordable housing for the poor. This stayed a key problem until the 2<sup>nd</sup> half of the 20<sup>th</sup> century. The industrial revolution and the growing population caused dramatic situations in housing conditions for the working class, especially in cities, where the rents increased steadily [Figure 14]. The working class lived under extreme social and un-hygienic conditions, but was selectively relieved by publicly funded workers' settlements. The potential of cost savings by industrialized building was a main driver to solve the 'housing problem'. The demand for industrialized housing was supported by a high shortage in housing, especially in post-war Germany. One of the main drives of the modern movement in architecture for mass-production was to create houses for the Existenzminimum [subsistence minimum]. The architects aimed for a first step in a consequent standardization of the plan, to enable efficient construction with prefabricated elements. The call for industrialized building was countered by the worry about architectural and urban monotony, which was already well known by the English brick-stone row houses of the second half of the 19<sup>th</sup> century [Figure 15]. In Germany often the 'Fuggerei' in Augsburg, a charismatic housing project for the very poor from the 16<sup>th</sup> century, was used as a positive example, as well as the standardized elevations of urbanism in absolutism. German architect Martin Wagner [1918] was one of the first who pointed out the work of Taylor disciple Gilberth about the rationalization of the traditional bricklaying. But already then an unsolvable conflict existed between the social economy and the predominantly small and medium size contractors, who were operating in the housing business, who feared to loose their flexibility in the competition by 'prescribed' rationalization. Junghanns [1994] points out the resistances of the building industries to react on the extreme shortage of housing in Germany by innovative products. Even though there was no shortage

of timber as with other materials after the First World War, the timber industries pushed up prices and sold most of the wood abroad, earning hard currency. This fact even brought well-established companies like Christoph & Unmack into trouble, who initially realized the potential for timber houses and increased their publicity. Germany, being far away from the practical self-made balloon-frame and mail-order house culture of the United States, nevertheless was forced by the conservatism of the industries to react by self-help groups and building societies on the housing shortage.

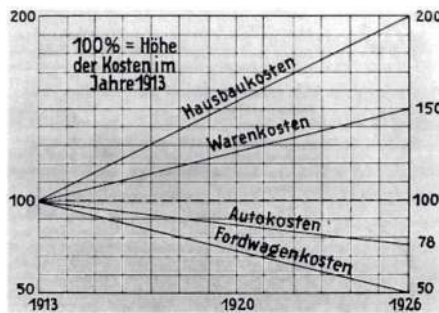


FIG. 14 Comparison of cost development in housing and automobile production [source: Junghanns, 1994; Original source: Beratungsstelle für Stahlverwendung, Stahlrahmenbau System Spiegel]



FIG. 15 Example for housing found around British cities at the end of 19<sup>th</sup> century [source: Benevolo, L., 1990, Die Geschichte der Stadt. Frankfurt: Campus]

Christoph & Unmack was at this time probably the largest and oldest manufacturer of prefabricated wooden buildings in Europe. The company was established in 1887 in Niesky, Germany. The company manufactured single- and multifamily houses, and entire housing schemes; workshops and office buildings; exhibition and sales pavilions; children's, recreation, and convalescent homes; and standardized classrooms and school buildings. Other branches of the company included steelwork, motors and train wagons. In 1927 Konrad Wachsmann became chief designer at Christoph & Unmack on recommendation of his professor, Hans Poelzig, and undertook the reorganization of the firm's catalogue on a modular basis, providing a squared grid upon which customers could plot out their own plans. In his time as chief architect from 1926 – 1929 he had a great influence in refining the block and panel systems of the company in terms of construction and architectural appearance. Although he was not able to fundamentally change the traditional building methods of the company, he realized for the first time Gropius' ideal of a strict dimensional order in the industrial fabrication of houses [Junghanns, 1994, p. 167].

"I developed new types of catalogues," wrote Wachsmann, "which I believe for the first time in Europe did not offer finished buildings but instead all components to build with. Modular grids had been printed in those catalogues in which clients could draw their own

approximate floor plans. Those were then transformed into professional drawings by my office, using only numbered predetermined parts to build the whole.”

In this way the emphasis changed from the production of a range of building types to a set of standard building components, which could be freely combined according to the purchaser’s needs. Notwithstanding this emphasis on the part, every building to leave the factory [components packed in crates which could also serve as floor panels] was fully equipped in every way: prefabricated foundation piers were supplied, electrical and mechanical equipment fully installed, and all necessary furniture included, even – so Wachsmann upheld – the chalk for the school blackboard and the surgical instruments for the hospital [Herbert, 1984, p. 93]. Christoph & Unmack also had a strategy of employing well-known or local designers to enhance the sales of their blockhouse system. In Bavaria for example, German architect Franz Zell was employed, who became well known by his book “Local Building Traditions in Upper Bavaria”. Engineer Friedrich Abel, who led the department for housing at Christoph & Unmack also made contact with Hans Poelzig in 1926 and thusly joining the circle of progressive Berlin architects. The “Professor-Poelzig-House” was a main point of attraction of the weekend house exhibition in Berlin 1927. Further, it was highly modern in appearance with a very functional and clever plan. Hans Scharoun designed a very advanced house in 1927, commissioned by the ‘Deutscher Werkbund’ for the Garden- and Industry Exhibition in Liegnitz [Figure 16 & 17]. He broke with the closed building block tradition in timber buildings and organized the service spaces and the bedrooms as separate building volumes, which where then joined by the living room. The pavilion was built using Christoph & Unmack panel elements, demonstrating the potential of such a factory-made system. The integration of user participation anticipated by Gropius in 1910 and realized by Wachsmann was, incidentally, later to be used by Hans Scharoun in his project for the Growing House exhibition in Berlin, in 1931-32.



FIG. 16 Hans Scharoun, Berlin, 1927: Single family house in panel construction (made from Christoph & Unmack panels. [source: Junghanns 1994, p. 159]

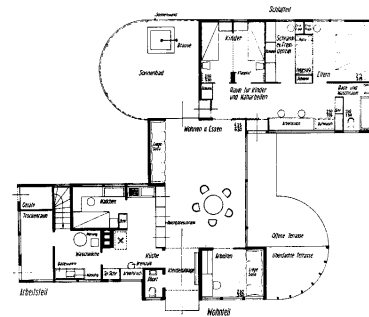


FIG. 17 Plan [ibid.]

The late 1920s and early 1930s were a heroic period charged with enthusiasm, energy and courage. People were open for change and identified themselves with the new products changing their lives at an incredible speed. Nevertheless, in the United States the ‘housing



problem' came about a decade later, than in Europe. By 1921 construction activity in the United States was well above the pre-war index, and by its peak year, 1925, it was 2.6 times as great. Then the great depression came and by 1932 housing production had declined precipitately by 84% from the 1922-28 average. Catherine Bauer [1934, *Modern Housing*, as cited in Herbert, 1984, p. 217] summed up the housing situation in 1934, in these depressing terms:

Throughout the country, then, there are not more than twenty thousand dwellings erected since the war on a permanently nonspeculative basis, and with any pretensions to large-scale planning or fundamental change in the quality of house production and neighbourhood environment. Twenty thousand to set against 4'500'000 in a section of Europe with only slightly more population than that of the United States. Moreover, not more than half of the twenty thousand really achieve a degree of permanent amenity and freedom from congestion which is the minimum working standard for 'modern housing' in Europe. And of the remaining ten thousand few or none were available to the lower-paid half of the population who need the houses the most.

By 1935, some 33 prefabricated systems were offered on the market. Gunnison Housing Corp. As an example started production in 1935, and has perfected prefabrication on a true mass production, assembly line basis. Gunnison was the first prefabricator to use a moving production line (Figure 18). The factory in New Albany has sent out prefabricated houses to every state, and is working at a rate of 600 units a month.

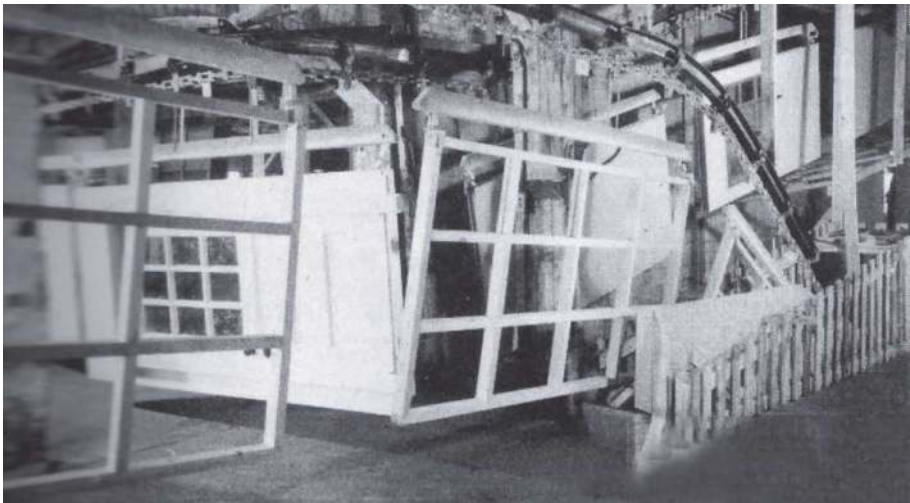


FIG. 18 The Gunnison Housing assembly line. [source: Bruce, A., & Sandbank, H., 1972]

Although, there was a lot of inventiveness in concepts, the housing crisis continued to be so dire that U.S. President Harry Truman had to launch a program in 1946 to stimulate the

production of houses as part of the Veteran's Emergency Housing Program. Between 1935 and 1940, prefabricated homes accounted for about 10,000 houses, or just less than one percent of the nation's total production for that period. By 1940, there were still only 30 firms manufacturing houses.

Wachsmann and Gropius would have their second chance in the United States after emigrating and joining together in Boston, Massachusetts, USA. Wachsmann brought two sets of drawings with him arriving in the United States. One of them contained all details for a modular universal building system, which was the basis for the General Panel System developed during the war with Gropius. Wachsmann with his constructive brilliance and enthusiasm and the support of the Harvard professor Gropius managed to get funding for a first prototype in 1943.

In 1947 the advanced General Panel factory in California (Figure 19 & 20) was ready for a maximum production of 30,000 houses a year, but ended up not building more than 15 by 1948. As an initial private investment General Panel ran into severe financing problems, with no industrial empire behind it and production was held up by lack of working funds (Herbert, 1984). When General Panel went into liquidation by the end of 1951, it hadn't sold more than 200 houses and the dream of the factory-made house found its second "Waterloo" in architecture history after Le Corbusier's Pessac.

The General Panel System, a dream of two outstanding architect personalities of the last century, failed by mismanagement, lack of funds and a missed time-to-market window. Another prefab house company named the Lustron Corporation, had also designed an enamel-coated house for returning GI's from the Second World War. However, they too went bankrupt in 1950 after only selling 2,500 houses (Lustron Corporation, 1947). The market was meanwhile covered by local, small and more flexible building work (Ludwig, 1998). Herbert (1984) had brilliantly documented the rise and fall of the General Panel Corporation.



FIG. 19 General Panel, California, components being shipped by truck from factory, c. 1947 [source: Ludwig, 1998]

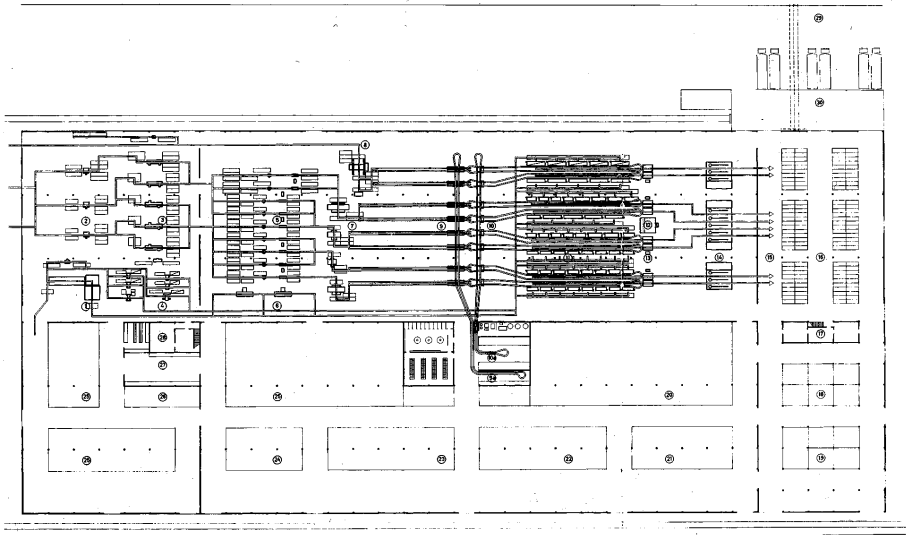


FIG. 20 General Panel, California, layout plan of factory in Burbank, 1947 [source: Ludwig, 1998]

### Homes Instead of Aeroplanes: A Substitute Production

Again, now the Second World War absorbed most of industrial production. This resulted in an incredible production surplus at the end of the war. Most especially, aerospace industries suffered from underused production lines. On the other hand the destruction of many buildings in Europe and the returning soldiers and refugees, caused a big need for housing, both in Europe and the United States. In Germany, two attempts of cross-industry production from aerospace industries still stand, but now forgotten. Named the MAN Steel House, the Dornier House and the never built Dornier Wohnzeug [Figure 21], these post-war metal houses did not create their own identity like the Lustron Houses did in the U.S., but instead simulated a traditional German house. The sales were never high and as soon the economy in Germany recovered, they all went out of production. However, several houses still do exist within the Munich area.

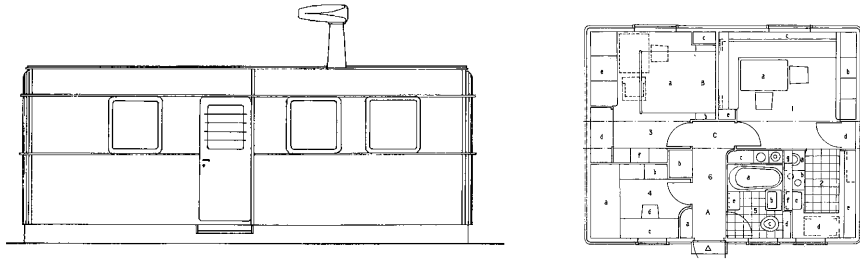


FIG. 21 The Dornier-Wohnzeug was an innovative concept for a 7,5 ton aluminum house with 38,5 m<sup>2</sup>. Dornier Aerospace, 1947 [source: Ludwig, 1998, p. 63-64]

In the United States, it was American inventor and architect Buckminster Fuller who took a much more radical approach with the famous and brilliant Wichita House [Figure 22 & 23]. The Beech Aircraft Corporation announced it would be able to produce 60.000 houses a year and by 1946 no less than 37.000 unsolicited orders for the Wichita houses were received by the 'Fuller Houses Inc.' Although the pre-marketing and financing went well, the story is as sad as with the General Panel System and the Lustron Houses: only one prototype house was built. Here it was Fuller's refusal to comply with his investors' guidelines and delaying the production by not releasing a final design.



FIG. 22 Beech Aircraft factory with house parts in the foreground. [source, Pawley, 1990]



FIG. 23 Exterior, front view of "Wichita House," constructed near Wichita in Rose Hill, Kansas, in 1948. A 1948 Packard automobile is parked at right. [source: Wichita Photo Archives]

Another attempt was made by Vultex Aircraft in 1947, which commissioned designer Henry Dreyfus and architect Ed Larnabee Barnes to design a prototype affordable house. The walls of the house consisted of single full-sized panels made from paper cores skinned with aluminum [Figure 24]. Manufactured off-site, these lightweight, large-scale panels were to be transported to the building site and then erected. The project was funded by the federal government's Guarantee Market program, created to provide housing and employment for worker. However, the house never went into production [Arieff, 2002].



FIG. 24 Aluminium Panels with paper core being constructed at the re-purposed Vultex Aircraft factory in southern California in 1946. [source: Arieff, 2002, photographer Julius Shulman]

A more successful and well-prepared program was started in the United Kingdom. During the war, when Britain was strongly affected by the destruction of German V2 rockets, the government started the 'Temporary Housing Program'. In the post-war period of 1945-1949 nearly 160.000 state-subsidized houses have been provided to people in need and for returning soldiers. In essence the program was a public success and some of the 'bungalows' survived past their anticipated design life of 10-15 years. The British government accompanied the program by a range of surveys and studies, which not only reflects the housing dreams of post-war Britain, but also give insight on the depth of the dream of the 'house with a garden'. In one survey as much as 93% opted for a house with a garden, even if they would have to invest considerable time for commuting to their working place. As the person conducting the survey commented,

*"...nearly everybody wanted the house and garden, and were willing to sacrifice quite a lot to get them."* [Whittick and Schreiner, 1947]

Also in terms of design and planning, government studies and the press intensively discussed the program. Such criticism like "Why should English prefabricated houses look like wooden huts while the Swedish ones have the appearance of pleasant homes." [Picture Post, 1944 March 18, p. 3, as cited in Vale, 1995]. Authorities were well aware of potential problems of mass-production of temporary houses like monotony of neighborhoods and repetitive design. However, it was not necessarily felt a problem, provided always that a

competent architect is in charge of the scheme” [Ministry of Health/Ministry of Works, 1944, Temporary Accommodation: Memorandum for the Guidance of Local Authorities. London: HMSO, as cited in Vale, 1995].

The user-response of the bungalows was very positive after years of use most likely due to intensive studies and surveying done beforehand. In contrast, the individual house-wife at that time must have felt that her opinion counted for every little in living space design. One woman discussing her flat said:

*There’s no space... I have to put all the rubbish in the bathroom, brooms and wood and my husband’s tools. And I’d like a coat rack. There’s nowhere for the children to hang their coats and mackintoshes when they come home from school. [Mass Observation, 1943, p. 151]*

Thus, the British working class, having extensively missed the social housing programs governed by the modern movement, which took place on the continent in the 1920s and ’30s, was charmed by the functional and well-equipped 1-storey bungalows. They consisted of 2 bedrooms, living room, bathroom and a fully equipped kitchen. Main wardrobes and cupboard were built in. It was a wave of revolutionary modernity which came into Britain, who well knew the problem of monotony and repetition in design, but was limited to the 2 story masonry terrace house, which provided built-by-hand homes ranging from slum to middle-class [Figure 15].

The very use of the abbreviation ‘Prefab’, which had recently become popular again suggest the familiarization with the temporary house at that time and the ‘product identity’ created, by providing more than just a ‘roof over the head’.

*I moved into a prefab in 1947 and it was marvellous. I’d go back into one tomorrow if I could. The design quality was far above what working class people were used to. It had a built-in fridge – real luxury in them days – and a boiler, both fitting neatly under the work tops. It had two big bedrooms with fitted wardrobes, a lovely big bathroom with heated towel rail and a good sized lounge – all for 14/7 a week. Of course we had the usual condensation problems but the prefab’s efficiency far outweighed them. We lived there for 18 years and when we moved to our first council house there was no comparison. We’d to start buying bedroom furniture for a start. [Hubbard, 1985, as cited in Vale 1995]*

In this program three products were particularly prominent: Uni-Seco structures, utilizing timber framing and asbestos cladding; the Arcon house, designed by a consortium of architects and comprising an open system based largely on a wide range of existing materials and components; and the most sophisticated and completely industrialized system of all, the Aluminum Bungalow [Figure 25 & 26]. This latter house was the result of the initiative of AIROH [Aircraft Industries and Research Organization on Housing], an organization sponsored jointly by the British Ministry of Aircraft Production and the aircraft industry. The objective was to utilize the over-capacity in manpower and manufacturing-plants of the wartime industries. The house was made in four segments,

or modular units, each 7'6" [2,3 m] wide [to comply with road transport regulations], which were joined together on the site. At the heart of the house was a mass-produced service core comprising kitchen and bathroom. Despite minor technical defects, which later developed – the eternal problems of corrosion and condensation – White [1965] was of the opinion that “the Aluminium Bungalow must be recorded as a great historical achievement in prefabrication.” This of course was a qualitative judgment of what was designed to be a house of limited lifetime. Equally impressive was the quantitative performance of the program: 29.000 Uni-Seco houses, 40.000 Arcon houses, and 55.000 Aluminium Bungalows, in the ten years of the program. To put this in perspective, we must recall that during the war, 104.826 family dwellings were built under the Lanham Act by all American prefabricators, and of these only 1.428 were regarded as permanent [Herbert, 1984]. In addition the UK Temporary Housing Programme also ordered 30.000 packages and prefabricated houses from USA, drawing on the American experience and the active American prefabrication industry. At the end only 8.462 were delivered, because the cancellation of a lend-lease agreement. Note that at that time customs duties were over 1/4 of the £800 unit price. [Vale, 1995, p. 141]



FIG. 25 Aluminium Bungalow, assembly line production, 1947 [source: Herbert, 1984]



FIG. 26 A Type B2 aluminium bungalow, built in 1947, now re-erected and displayed at the Museum of Welsh Life, St Fagans. [source: National Museum of Wales]

Nonetheless, also this ambitious program came to a halt and did not lead into a continuous industrial production of houses. R. B. White [1965], a British historian of prefabrication, gives the consensus view, which applies to the end of all systems in the post-war period:

*“Out of all the verbal confusion and the years of experience, there is perhaps one outstanding fact that emerges: the illusory character of the assumptions that lower costs would inevitably and immediately follow the mass production of houses (or other buildings) through widespread standardization and prefabrication. Circumstances have not so far combined with sufficient benevolence and constancy to warrant these assumptions. So far as this country is concerned, if experiments in alternative methods have proved anything positively, it is rather that “traditional” methods in building (particularly in house building) still commands a wide measure of support....”*

## Walking Cities and Crawling Suburbs

*“Genuine variety without monotony could have been attained if we had taken greater interest and influence in the development and design of an ever more comprehensive production of standardized, component building parts which could be assembled into a wide diversity of house types. Instead the idea of prefabrication was seized by manufacturing firms who came up with the stifling project of mass producing whole house types instead of component parts only. The resulting monotony further deepened the horror of a nostalgic, sentimental, unguided public of a prefabricated future.”*

Walter Gropius, 1964 [Source: Herbert, 1984, p. 318]

With the economic growth in the 1960s the spirit of the pre-war era was picked up again. Although, less ideological and more industrial. An incredible growth started and technological success and fast growing markets supported an unshaken belief in technology as the main source of wealth. Everything seemed possible: Flying to the moon, walking cities as proposed by Archigram, and avantgarde architectural group formed in the 1960s, was thought to be no problem. Factory-made houses of plastic, they were conceived and built in the 1960s. The increasing wealth of people led to a sharp growth of the suburb around cities, since whoever could afford it, wanted to realize the dream of a detached single-family house. But with economic growth came also higher land prices. In Germany, the cost of land increased between 1960-1965 by 40% [Quelle-Fertighaus-GmbH, 1965]. This opened the market for prefabricated housing as it offered a less-expensive option. Schäfer [1998, p. 88] sees the reason for the prefabricated housing boom in the 1960s by the enormous rise of housing prices and a bottleneck of production in traditional building industries, so that many clients started turning towards prefabricated housing. Many companies were started then and are still active today, although the market reached its peak by 1973 and has waned since.

In 1962 Europe’s largest mail-order house ‘Quelle-Versand’ made in Germany started its own prefabricated house company. The modest, elegant bungalows were advertised with all benefits of a prefabricated house and delivered all-inclusive. The large windows, flat roof and the modern technical equipment indicate the spirit of a newly forming prosperous society, which adopted the modern life-style also in its architecture [Figure 27 & 28].



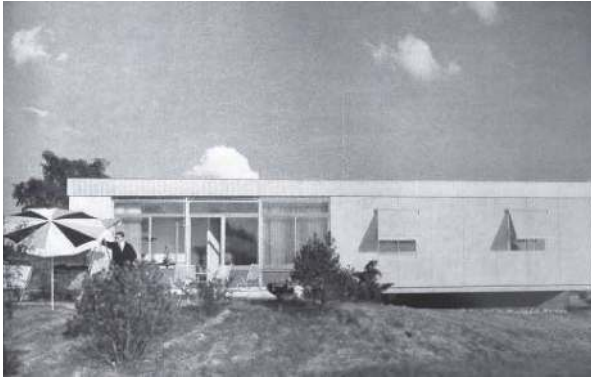


FIG. 27 The Quelle prefab bungalow represented a new modern life-style, postulated by architects since the 1920s.



FIG. 28 The kitchen was functional, yet provided a lot of space for new electric kitchen appliances, which became the symbol of the modern house-wife.

Twenty years after the post-war housing programs, the world was ready for the prefabricated single family home under economic, free-market conditions. Most of the companies still active in Europe started at this time. The United States experience a gradual and successful growth of the 'Manufactured Home', based on a trailer platform. In Japan, big industry conglomerates like Sekisui Chemicals decided to enter the housing market. Sekisui House is one of the largest house producer today.

Although clients often preferred a 'real' house, if it hadn't been for costs and availability, the acceptance of prefab houses was high. But, the Prefab House – especially in Europe and the United States – still never succeeded to lose its negative, low-end touch. Occasional quality problems and light constructions created the 'poor-man's house' image, which the companies still try to correct even today.

The technologies in concrete prefabrication and concrete fiber products opened the market for the 'stone' house. At the same time plastic started to be the new cheap material for new consumer products. Several valuable plastic concept houses had been built, but none of them in a series. Problems of fire-protection and aging under UV light were the main hurdles that created a decline in demand, and the oil crisis of 1973 caused plastic prices to triple, essentially killing production of plastic prefab houses.

However, in terms of integrated product character, plastic houses were the most advanced. As seen already Buckminster Fuller's Wichita Houses, there was an emphasis on the round, circular plan and shape, which became suddenly possible by plastic moulding. The spaceship appearance of these houses still makes them appear modern by today's standards. The Futuro House [Figure 29] was designed by M. Suuroen and J. Ronkka from Finland. The 8m diameter elliptic house was originally designed as a ski hut and provided 50 m<sup>2</sup> in one open room, which small kitchenette and bathroom on the periphery. Despite

the tremendous international attention of the Futuro House, it never became a commercial success. A large order for the Olympic Games of 1980 in Moscow was cancelled due to lack of funding after the boycott of the games by Western Nations as protest against the Soviet Unions raid in Afghanistan.

A similar concept saw the Swiss 'Rondo' house designed by architects Casoni & Casoni in 1968 (Figure 30). The house had a diameter of 7,8 m and only weighs 2.800 kg. The interior was well organized and all furniture built-in.



FIG. 29 The Futuro Home was originally designed as a Ski Hut. 20 houses have been build and are spread all over the world. [source: Image still from Futuro – A New Stance for Tomorrow 1998]



FIG. 30 The Rondo house on exhibition in Basel. [source: Casoni & Casoni architects]

An intriguing fact of many of the Plastic Houses built in the 1960s is that they convey – still today – a strong product character. This may be because of their 'unconstructed' appearance with rounded corners and smooth surfaces.

The economic growth of the 1960s also resulted in a high level of prefabrication in apartment buildings. The cities seemed to face an endless growth. Architects designed Mega- and Meta-Cities – cities for an excess of 10 million people. Archigram even suggested a walking city, a massive robotic structure with its own intelligence able to move wherever resources or manufacturing was needed. An idea that is seen today through aircraft carriers and space stations – a definite symbol of the modern time. Currently, several experiments with prefabricated modules like the Habitat 67 based in Montreal, Canada have been realized (Figure 31).

Although the claim was that serial production would bring prices down, the costs of the Habitat exploded. The Meta-City Wulfen in Germany, which was built by Europe's biggest prefab manufacturer Okal located in Poing, Germany, had to be torn down due to severe corrosion problems. In Tokyo, architect Kurokawa's Capsule Tower is under discussion for destruction (Figure 32). The complex combination of prefabricated modules was intended to be an answer to the monotony created by the slab building in many housing projects in the 1960s. But the multitude of joints and the high outside surface area, made

it susceptible for heat loss, cold bridges and subsequent construction problems. Only by today, with much improve insulation and joining technology, such concepts may be worthwhile reconsidering.



FIG. 31 Moshe Safdie's Habitat for Montréal under construction in 1967. [source: Fine Arts Image Library, University of Toronto, photographer James Acland]



FIG. 32 Kisho Kurokawa's Capsule Tower in Tokyo form 1972. [Source: Andreas Vogler Image Library]

### The Oil Shock and a Growing Ecological Consciousness

The oil crisis of the 1970s brought construction to a halt. Especially some pre-fabricated houses proved to be poorly insulated, which added to their negative reputation in Europe, where a growing understanding of limited resources started a development towards green building. The prefab industries reacted adding winter gardens and solar heating into their designs. They also gradually improved insulation in the houses. Especially in Germany, many of the Prefabs today achieve top values in energy conservation.

Whereas the first slump after 1973 was followed by a seemingly stable recovery, the second slump of 1981/82 saw a major turning point for prefabrication industries. Most companies in Germany – the worlds third biggest housing market – slumped into a region of 500-1.000 units per year (Figure 33). As many builders went into bankruptcy, the prefabrication industry managed by mergers and diversification to move along this line up to today. The introduction of 'Fertighauszentren' (Prefabricated Housing Centers) in the 1980s helped to keep ongoing interest in their products. The centers were a display of sample houses of different manufacturers.

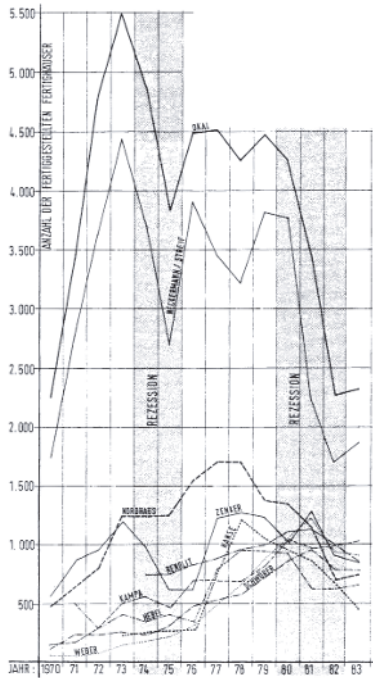


FIG. 33 Development of the ten largest German Prefab House companies from 1970-83 (Number of units manufactured per year), [source: Schäfer 1998]

The reasons for the slump lie in the economic situation of the consumers [Schäfer, 1998]. The increasing energy costs translated to increasing prices of consumer products. Also unemployment rose. This resulted in a much lower increase of the net income of people, than in the 1960s. Paired with high interest rates and sharply increased land prices and construction prices, the whole construction and especially housing sector was in trouble. A social re-evaluation of the building boom of the early 1970s followed.

Much of architecture came into disrepute as the waste of land by the sprawling single-family house colonies was criticized by a growing environmental concern. Living in the city was considered as more attractive again and people started investing into the refurbishment of old buildings. The generation of 1968 further saw the detached single-family house as a symbol of a 'petty bourgeois' life. The fast change of the cities and the often ruthless destruction of old buildings by investments also resulted in a much more severe discussion about the protection of historic buildings and monuments. Today many buildings are listed under protection by law. Also the self-understanding of architects changed. Whereas in the 1960s, the political and social impacts of architecture in a mass-society were strongly discussed, the failure of several experiments was followed by the insight, that even good intention and design can completely counter-balance the potential negative effects on the individual. During the 1980s

many architects were blamed for their apparently 'inhuman' design of mega-structures in the 1960s. Modernism was over. Followed by such cul-de-sac developments like 'postmodernism' and 'deconstructivism', which were highly praised at the time, but ended up in pure formalism. In turn, architects completely turned away from prefabrication, detesting the 'cheap' design of the prefab manufacturers, who were just serving clichés to their clients like the 'Black Forest House', the 'Alpine Land House', the 'Finca', not matter where its projected site was intended to be.

### The Re-Engineering of the Production in Industries and the Age of the Consumer Individualist

In the early 1990s, a crisis in car industries forced a change in production towards lean-production and 'just-in-time' delivery. With the introduction of industry robots the high manual labor proportion was further reduced. With new medias and a growing competition, marketing became more elaborate. This widened the gap between consumer products industries and construction industries even more. Today we live in an accelerated, computerized high-tech society. Especially computers and the development of environmentally clean technologies have changed the perception of technology. The Western world is on the one hand flooded by consumer products, and the other hand, the situation on the labor market has become much more competitive by globalization. This pressure in professional life translates into current trends of 'cocooning' and 'wellness', where the value of the 'home' as a personal grounding becomes much more important. The prefab housing industries were able to maintain production or even grow by the steady demand from 'baby-boomers', who came into an age of starting families. Although land and construction prices continued to rise, decreasing interest rates and an increasing wealth of the Western societies supported the housing market. In Germany, the industries were also supported by a growing acceptance of timber frame houses. Timber construction was promoted in the 1990s, when severe forest damage created a timber surplus and first ecological evaluations stated timber was one of the building materials with the lowest environmental impact. The industries reacted on the growing consumer individualism by offering basic plans, which can be adjusted individually. Unfortunately this 'individualism' is often the reason for a fairly arbitrary design. Recently, well-known architects have been approached again by the prefab housing industries, although this seems to be more the initiative of modern marketing, than the search to provide a truly better product. In 1997 architects like Diener & Diener, Ingenhoven and Kollhoff were invited to present a prefab house design [Figure 34] at the Architekturforum Vienna. These houses should be part the 'New-Standard' program of the German company Allkauf, but never even a prototype was built. According to Allkauf [2005] the program was stopped, since it didn't meet their target clients. However, there is a current trend to have a 'designer' house in the prefab company programs. In Germany, Hanlo Haus has a house by Austrian architect Gustav Peichl, Elk Haus collaborated with Italian car design firm Pininfarina, and the Hanse Haus with German industrial designer Luigi Colani, to make the Rotorhaus. Often seen in magazines is the 'O Sole Mio' house by Matteo Thun, manufactured by Austrian company Griffner Homes [Figure 35]. The glass and timber construction provided good energy values, however, despite the house being highly published, less than 10 have been built. This is due to the relatively high price of EUR 2000/sqm, making it difficult to compete with site-built houses on the market.



FIG. 34 Prefab by Swiss architect Diener & Diener, designed in 1997, never built. [source: madiba ag]



FIG. 35 'O Sole Mio' house by Matteo Thun, 1997. Often published only a few ever built. [source: griffner homes, Austria]

It is interesting to note, that designers rather than architects plan most of these houses. However, facing the problem of continuously increasing building costs, many architects have started to get involved in prefabrication once more. They did this not with the objective to design a mass product, but rather to make the individual construction process easier and cheaper. This development is increasingly facilitated by the now ubiquitous use of CAD and CAM systems. Mass customization with modern, more flexible computer controlled production processes can open a new potential for the prefabrication industry.

### Success and Failure: High Investments and Long Time-to-Market

The history of prefabricated houses is not just a history of failure, but also a history of failure and success. The main driver for architects was to bring down costs of mass production and thus solve the 'housing problem', which persisted up to the 1960s. On the other hand throughout the years the industry proved to be very quick and efficient, when there was a considerable increase on the demand side, which the traditional construction industry was not able to cope with. This has been the case as much for Australian based, transportable Victorian iron cottages as it was for the prefabrication boom of the 1960s. Traditional and industrialized house building is still in competition up to today and is unlikely to change in the near future. Nevertheless, there is a consistent worldwide prefabrication industry, which stays in business [see next chapter]. In a time, where furniture of the 1920s of top architects sell for top prices and still produced today, one wonders why the product 'house' is not offered as a design classic. Why is there no company, which offers a 're-edition' of the General Panels System of even the highly avant-garde Wichita House? Architecture history made out of the failure of famous architects, a failure for the whole industry, also because the industry as it exists today failed to offer a real competitive design product and usually serves the lowest common denominator. One the other hand, architects seem not to be able anymore to really design for production. However, there are no easy answers. Where Le Corbusier's Pessac failed because of the bad press the local architects gave it, the case with the General Panel System is more complex and has to do with time-to-market and financing problems, which have not been considered enough. Herbert [1984] used Bernhardt's diagram [1980] describing the complex system of production, the supportive environment and the regulatory environment

to point out areas of problem for the General Panel System [Figure 36]. The failure of the General Panel System was dramatic for the future architectural involvement into prefabrication. Although architect's continued to design houses, which they claimed to be designed for mass construction, they usually were not interested in real production and the constant disputes with production industries. Especially in the 1960s, when the industry was booming, it became very 'fashionable' for architects to design 'factory-made' houses or implementing the looks of a highly industrialized society into their architecture as Archigram did. Interestingly, the industries reached their highest outputs then, but none of the 'famous' architects would have a house design in production, but only found in magazines and publication. The farewell of architects from industrialized housing is pointed out by Davies [2005] in his recent book 'The Prefabricated Home'. What Davies doesn't point out though, is that on the other hand the industry had a strongly declining interest in having architects involved. They 'label' some of their buildings with designer names, but don't want to have to work with architects in the design. But talking about industrialized building, it does not seem, that the conflict between architects and the industry is the problem. No single profession has been promoting industrialized building like the architects. No other profession has been blaming itself for the poor design quality of the environment like the architects either. However, architects would not lose much business, if houses were industrialized. Less than 5% of the 150.000 detached and semi-detached houses built annually in Germany are planned by an architect [Hoffmann, 2003]. The market does not want architects.

The real conflict is to be found within the construction industry, in the difference between traditional builders and prefab builders. As we will see in the next chapter, the factory-made house cannot drive the traditional handicraft builder out of the market as it has happened in any other industry. The reasons for this are manifold and it is not useful to blame different parties, but instead attempt to collaborate, since the problems and inefficiencies of traditional construction are obvious to everybody.

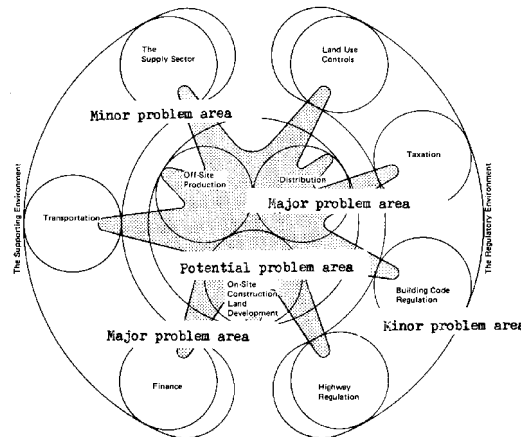


FIG. 36 Bernhardt's diagram applied to problem areas of the General Panel System [source: Herbert, 1984]

## Bibliography

Allkauf, 4 October 2005, Telephone conversation with Mrs. Meyer, Allkauf.

Arieff, A., & Burkhart, B. [2002]. *Prefab*, Salt Lake City: Gibbs Smith.

Australian Heritage Database. [2005]. *Portable Iron Houses*, 399 Coventry St, South Melbourne, VIC. Retrieved 27.10.2005, from [http://www.deh.gov.au/cgi-bin/ahdb/search.pl?mode=place\\_detail;place\\_id=105828](http://www.deh.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;place_id=105828)

Bernhardt, A. D. [1980]. *Building Tomorrow : The Mobile/Manufactured Housing Industry*. Boston, Massachusetts: The MIT Press.

Bruce, A., & Sandbank, H. [1972]. *A History of Prefabrication* [Technology and Society]. New York: Arno Press.

Davies, C. [2005]. *The Prefabricated Home*. London: Reaktion Books Ltd.

Ehltling, D. [2001]. *Vorfertigung Komplexer Ausbau-Bausysteme für offene Bauweisen*. Universität Dortmund, Dortmund.

Giedion, S. [1992]. *Raum, Zeit, Architektur*. Zürich: Artemis Verlag.

Gray, G. H. [1946]. *Housing and Citizenship*. New York: Reinhold.

Gropius, W [1910]. "Programm zur Gründung einer allgemeinen Hausbaugesellschaft auf künstlerisch einheitlicher Grundlage m.b.H." in: Probst, Schädlich [Hg] Walter Gropius. Bd. 3 Berlin 1987

Herbert, G. [1984]. *The Dream Of The Factory-Made House*. Cambridge, Mass.: MIT Press.

Herbert, G. [1978]. *Pioneers of Prefabrication : the British Contribution in the Nineteenth Century*. Baltimore: Johns Hopkins University Press.

Hoffmann, H. W. [2003, January 8]. *Schöner klonen. Karikatur des Eigenheims: Warum gibt es kaum vernünftig gestaltete Fertighäuser*. Die Welt. Retrieved November 5, 2005, from <http://www2.welt.de/data/2003/01/08/30837.html>

Hubbard, J. [1985]. *We Thought It was Heaven Tomorrow, 1945-1955*. People's History of Yorkshire, Volume XIV,

Huberti, G. [1964]. *Die erneuerte Bauweise*. In G. Huberti [Ed.], *Vom Caementum zum Spannbeton* Wiesbaden: Bauverlag GmbH.

Isaacs, R. R. [1983]. *Walter Gropius I. Der Mensch und sein Werk*. Berlin: Gebr. Mann.



- Junghanns, K. [1994]. *Das Haus für alle - zur Geschichte der Vorfertigung in Deutschland*. Berlin: Ernst und Sohn.
- Langenbeck von, B., Dr., C. v., & Dr., W. [1886]. *Die transportable Lazareth-Baracke*. In B. Langenbeck von [Ed.], *Archiv für Klinische Chirurgie*[33] [pp. 781-934]. Berlin: Verlag von August Hirschwald.
- Langenbeck von, B., Dr., C. v., & Dr., W. [1886]. *Die transportable Lazareth-Baracke*. In B. Langenbeck von [Ed.], *Archiv für Klinische Chirurgie*[33] [pp. 781-934]. Berlin: Verlag von August Hirschwald.
- Ludwig, M. [1998]. *Mobile Architektur*. Stuttgart: Deutsche Verlags-Anstalt.
- Manning, J. [ca. 1830]. *Swan River*. London.
- Mass Observation [1943]. *An inquiry into People's Homes*. [Ed.], *The Fourth of the "Change" Wartime Surveys* London: John Murray.
- Möser, K. [2000]. *Das Auto und die Autogesellschaft*. In Brockhaus-Redaktion [Ed.], *Brockhaus Mensch, Maschinen, Mechanismen* [pp. 375-409]. Leipzig, Mannheim: Brockhaus.
- Peterson, Ch. E. [1948]. Early American Prefabrication. *Gazette des Beaux Arts* 90, Bd. 33, 37-46.
- Quelle-Fertighaus-GmbH. [1965]. *Die neue Quelle-Fertighaus-Fibel* [The New Quelle Prefabricated Home Guidebook] [8. Auflage]. Fürth, Bavaria, Germany: Quelle-Fertighaus-GmbH.
- Russell, B. [1981]. *Building Systems, Industrialisation, and Architecture*. London: John Wiley and Sons.
- Sobel, D. [1995]. *Longitude*.
- Schäfer, I. [1998]. *OKAL - Pionier im Fertighausbau 1928-1998* [Eine Studie zur Wirtschafts- und Technikgeschichte]. Lauenstein: OKAL.
- Vale, B. [1995]. *Prefabs : A History of the UK Temporary Housing Programme* [Studies in history, planning, and the environment ; 17]. London: Spon.
- Wagner, Martin. [1918]. *Neue Bauwirtschaft, ein Beitrag zur Verbilligung der Baukosten im Wohnungswesen*. Schriften des Deutschen Wohnungsausschusses, Heft 5,
- White, R. B. [1965]. *Prefabrication: A History of its Development in Great Britain* [National building studies. Special reports; no.36] H.M.S.O.
- Whittick, A., & Schreiner, J. [1947]. *The Small House: Today and Tomorrow*. p. 202-215.
- Wurm, Heinrich. [1966]. Vorgefertigte Bauwerke des 19. Jahrhunderts. *Technikgeschichte*, 33[3], pp. 228-255.

In Europe, often the mobile home industry from the USA or the robot construction of Japanese house builders is taken as examples for industrialized building. Since globalization in the housing industry is very low compared to others, comparative studies of these three major markets and their prefabrication industries couldn't be more interesting. However, few international comparative studies have been done and many preconceptions survive in this field. A description of the current economic situation and the structure of the housing industry allow seeing it in its context. The single-family house is the most favored form of living in all three economies. In this chapter, the difference of housing quality will be investigated, what has a strong impact on the expectations of the client and what strongly relativizes price differences, and what are between these major economies. Finally the largest companies of the housing industry – traditional and prefab – will be described..

### Europe

The construction market in Europe is both large and complex. 'Europe' [depending on the definition that one uses] is a collection of up to 35 countries, with a total population of 775 million. However, while this represents a very large market, it is a highly fragmented one, fractured by both language and culture. Materials in use, construction practices and market profiles all differ widely, both between Eastern and Western Europe, the North and the South and between individual countries within these areas. In Europe about half of the population lives in houses, the other half in flats. At the extreme end is Ireland and the UK with nearly 90% of the population living in houses where in comparison, Germany, Greece, Spain and Italy are at the lower end. More than half of these people own the houses they are living in, with the exception of Germany where only one third of the population owns their own living space. This already shows, that the treatment of the European Union is more complex, than if one were to look at the United States or Japan, both countries that do provide relatively good statistical data. Although the European Union has made great steps in unifying laws and regulations, it is still very important to look at the national markets, which historically have a much stronger difference. It is difficult to find a common denominator between, for example, Sweden who has a traditional timber housing production, the lowest population density and a high owner percentage and compare it to Switzerland, where not only the land is scarce and expensive, but also the traditional brick-stone building methods prevail including a fully heated basement. Interest in EU housing markets has expanded considerably in recent years. So, there is a growing need for information on housing in individual countries and for comparative housing market analysis across the expanding EU [Ball, 2005].

#### *Economic Situation*

A rising euro, a deflating housing market, new pollution limits and reservations against the new EU constitution govern Europe's current economic situation. However, Europe, with the exception of Germany, has been doing pretty well on the housing market compared

to the booming United States. Germany, the world's third largest housing market, stays the problem child of Europe as over the past decade, employment has raised an average of only 0.2% a year in Germany, against a rate of 1.3% a year in the rest of the EU, exactly the same pace of increase as in America. It suffered the biggest fall in share prices after the stock market bubble burst in 2000, and house prices have been falling for much of the past decade – just as in Japan. In the late 1980s Germany's GDP per head was 20% higher than the average of the European Union. But estimates by the Economist ["Odd European Out", 2004] suggest that Germany's GDP per head fell 1% below the EU average in 2003. Often the burden of the re-unification has been made responsible for Germany's sluggish economy, but also many homemade problem accounts for it.

Despite Germany's dismal performance, the European homebuilding market remains relatively buoyant, supported by historically low interest rates. It is growing in value at a significantly higher rate than both the global average and the Asia Pacific average and is only marginally behind the United States, the world's best performing region at the moment. The Economist's global house-price indices show that, with the exception of Germany, house prices have been rising as fast in the euro area as in America, drawing the specter of a housing bubble, which may be followed by a crash. The market reached a value of \$144 billion in 2002, having grown with a compound annual growth rate (CAGR) of 6.3% in the 1998-2002 period. This growth was somewhat stronger than that of the global market itself, leading to the European market's share increasing by 0,9 percentage points between 1998 and 2002, accounting for 22,3% of the global market by the end of this period. The volume growth of the European homebuilding markets grew at a relatively steady rate between 1998 and 2002, from 2,2 million units to 2,4 million units, representing a growth of 2,6%. The volume has been forecasted to increase by 5.5% in the period 2002-2007, equivalent to a CAGR of 1,1%. [Datamonitor, January 2003]

Carney (2004) reports that the end of Europe's housing bubble may be at hand. Home prices in Britain have doubled over the past five years, but that could be about over. Indeed, some signs show that it already is. Halifax, Britain's biggest mortgage lender reported that prices fell slightly in October and November, and the bank warned of a 2% decrease in the coming year. Others paint a riskier scenario. Andrew Lilico, an economist with independent consultancy Europe Economics, expects British home prices to plunge by 30% over the next two years as investors pull out of the housing market. "The opportunity for a quick buck won't be there anymore," says Lilico. "Prices can fall very quickly." Other property hotspots that could see prices leveling off or cooling down in 2005 include Ireland and Spain, which have also experienced unusual booms. An unlikely welcome spot for homeowners might be in Germany, says Lloyd Barton, a European economist at PricewaterhouseCoopers. There, prices are actually lower than they were in the '90s, but are starting to see some upticks in western cities. In the UK the rising construction costs were also related to the low industrialization and efficiency of the construction sector and the government started a several programs for innovation and industrialization after the Egan report "Rethinking Construction" (1998).

The favorite form of living is the detached house, although Europe has a high rate of rented apartments [Figure 37]. The costs for housing differ strongly through the European Union. In Scandinavia the costs for housing are more than 25% of all consumer spending, whereas in Spain and Portugal, they are below 15%. In Germany the costs for single-family houses are nearly double as high as in the EU average in relation to the average income [Figure 38]. This is part of the cause why also ownership in Germany is at the lowest end of the European Union [Figure 39].

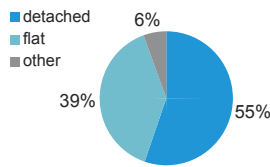


FIG. 37 Housing stock in Europe (EU-15) 2001. [source: Eurostat 2004]

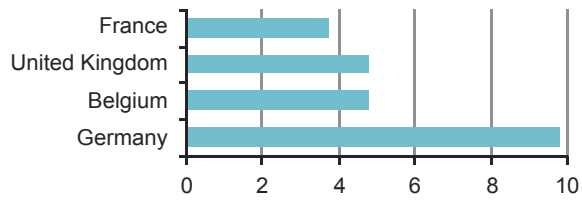


FIG. 38 Number of average annual salaries needed to finance a single-family home. [source: Post, Welters, 1998]

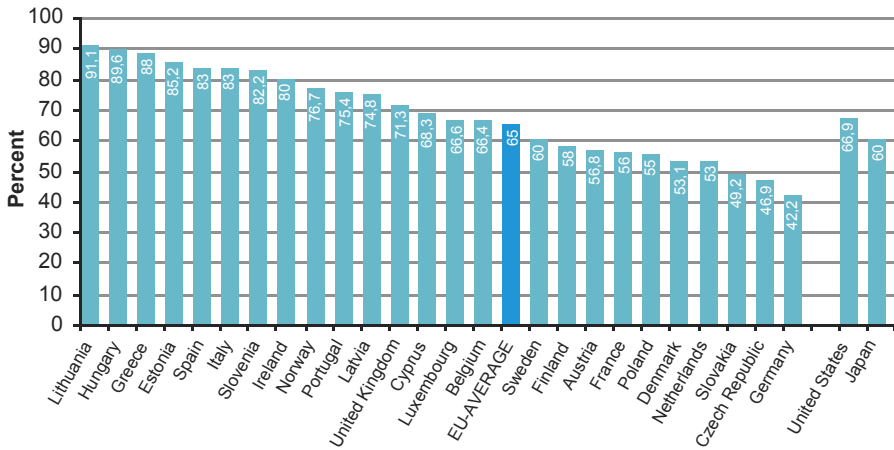


FIG. 39 Owner occupied share in housing stock in EU countries circa 2002. [source: United Nations Economic Commission for Europe, 2004 and Bell, 2005]

In Europe about half of the population lives in houses, the other half in flats (Figure 40). At the high extreme is Ireland and UK with nearly 90% of houses and Spain, Germany and Italy at the lower end. The very diverse and mixed markets in Europe with different market cycles in the countries, seems to offer a good environment for a prefabricated house industry.

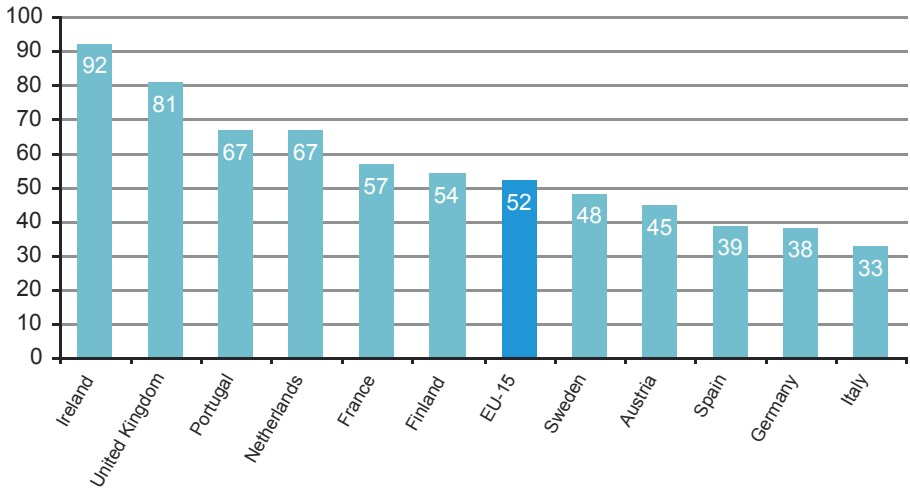


FIG. 40 Percentage of households in single-family houses, 1998 (source Eurostat)

### Structure of the Housing Industry

The principal sectors of the housing industry include site-built housing and prefabricated housing. To take a pan-European view is more demanding than getting data from the United States or Japan, where the official national statistics are pretty detailed. The European Commission is publishing comparative data, but more distinguished data to identify construction material, building methods (panelized, modular etc.) have to be researched nationally. Although member countries of the European Union are in the process of harmonizing their building codes into a single European code, housing markets are still fairly national. Germany alone still has 16 different building codes for each of its countries (Länder). Despite high labor costs in Germany only 5% of the prefabricated homes are imported, most from Austria and Scandinavia, 1% from Canada (Forintek Canada Corp., 2003). This indicates, that the mobility of the product in Europe is not achieved to extend, which can be found in the United States or Japan. This is a further advantage for the site-built construction, since there, the mobility of (cheap) labor within Europe is very high.

### *Site-Built*

Home building has historically been dominated by the construction of new homes on site through sequential fabrication and assembly of products, materials and systems into finished homes by skilled craftsman and general laborers. Activities are planned and coordinated by experts [architects & engineers] with regulatory oversight at the local or state level of government. The resulting "site-built" sector of the home building industry is large and very diffuse. It encompasses not only the construction of houses but ancillary activities, including land development, infrastructure planning and sale of the finished product as a complete package. 97% of firms are small and medium-sized enterprises, aka SMEs, with less than 20 employees. Minimizing fixed capital investment and making extensive use of subcontracting arrangements, which makes them very flexible on the market, characterize these small enterprises. Also in Europe – different to other industry developments – the small companies grow in number, whereas big ones became smaller during the 1990s. Datamonitor [2003] reports that in 2002 the five biggest companies account for 9% of the whole housing market. UK firms have proven to be the market leaders in Europe. The same four firms that dominate the UK market have the privilege of each representing 2% of the European construction market, something that no other firms can claim. The leading house builders in the UK are Wimpey PLC followed by Persimmon PLC, who builds more than 12.000 houses a year, and Barratt Plc. During the 1990s the big companies started to considerably increase their market share by takeovers. Now, Britain's top 10 PLC house-builders produce around 44% of all new homes in Britain [Birkbeck, 2000]. Leaving the rest to 18.000 house builders registered by the National House Building Council [NHBC]. In other European countries the concentration is much less on the home building market. In Germany Hochtief AG and Bilfinger Berger AG seem to be the only big players left, after the recent collapses of Phillip Holzmann AG and Walter Bau AG. But their main business is general construction. Hochtief's involvement into house building was only 6% of its revenues. In France, Bouygues is the leading provider of home construction, concentrating on the Paris market, which account for 60% of its sales. The degree of prefabrication and mechanization on the building site differs from country to country [Clarke & Wall, 2000]. Especially the United Kingdom is well behind in this development and recently launched several programs to catch up.

### *Factory-built*

Factory-made homes have a long tradition in Europe and have been an important part of intellectual discussion between architects during the 20<sup>th</sup> century. Europe also had many periods of housing shortages, especially after the World Wars, where programs for factory-built houses have been initiated. Nevertheless, with the exception of the Nordic countries, Eastern Europe and since recently Austria, the level of prefabrication is relatively low. Having said that, the level of prefabrication and mechanization on the building site itself can be relatively high, especially in Germany and the Netherlands [Clarke & Wall, 2000]. The big time for factory-made houses started in the late 1960s, when growing wealth and mobility

led young families to leave the city and start their own single-family home in the suburban agglomeration. The prefabricated home, was a cost-saving alternative to the traditional home then. Although the quality of some of these houses was outstanding, prefabricated building continues to have a negative reputation, associated to low quality. This was mainly fostered by the light building materials used, which caused problems in insulation, heat storage properties and noise. The negative image was fostered by the oil crises in the 1970s and the growing environmental awareness through the 1980s. But it was exactly the environmental awareness, which brought the factory-made home back into scene in the 1990s. Timber frame construction lends itself perfectly for manufacturing houses in the factory. Most of European housing manufacturers derive from carpenter firms. In the Nordic countries with an existing timber house tradition, these factories quickly gained a market share of over 70%. In countries like Switzerland, Austria and Germany prefabricated timber housing started regaining ground in the last ten years. This is due to several circumstances: domestic timber surplus by environmentally damaged forests with nationally supported programs for the use of timber, increasing concerns about re-growing resources, improved building technologies, insulation and fire-proof quality and last not least the cost and time advantage of the prefabricated home. Table 1 shows the relatively small share of housing starts being prefabricated with the exception of Sweden, which also export to the other Nordic countries as well as Japan and Germany. The largest manufacturer in Northern Europe – Älvsbyhus – sold a total of 1.500 houses in Finland, Sweden, Norway and Denmark in 2004. Also the Austrian prefabricated Housing Association reports a market share of well over 30%. Austria also has a strong presence on the German market although in Germany, more than 85% of prefabricated homes are German wood-frame constructions. There are more than 200 prefabricated house manufacturers in Germany, though the 30 members of the major prefabricated housing trade association “Bundesverband Deutscher Fertigbau e.V.” account for the majority of the production. The percentage of prefabricated houses has been slowly increasing reaching 13% in 2004 [Figure 41].

	GERMANY	UK	FRANCE	SPAIN	SWEDEN
Housing starts	485.000 ('00)	187.000 ('99)	317.000 ('00)	540.000 ('00)	23.000 ('03)***
Prefabricated starts	54.300 ('00)*	26.000** ('02)	11.500** ('02)	4.500** ('02)	16.500 (est.)
Prefabricated	11,2%	10%	3,6%	1,5%	72%
Wood-frame proportion	14,3%	10%	4%	1,5%	N/A

Sources: \*Canadian Embassy in Berlin; \*\*Forecast by Freedonia; \*\*\*www.sweden.se

TAB. 01 Prefabricated Houses in the major market of Europe. [source: as cited in Forintek Canada Corp., 2003]

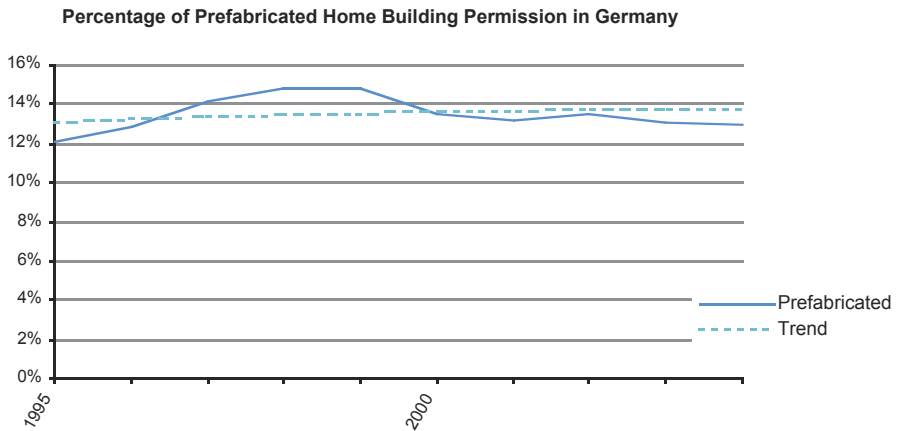


FIG. 41 Percentage share of building permissions for prefabricated houses. (Germany, 1995--2004) with logarithmic trend line. [source: Bundesverband Deutscher Fertigbau e.V.]

### *Building types*

There are four common construction methods in prefabricated housing: Timber construction, concrete construction, brick and block construction and combined construction. Timber construction can be subdivided into timber frame construction, panel construction and log construction methods. Although all possible building systems are offered on the prefabricated house market, timber frame buildings are predominant. Timber allows very straightforward computerized machining and does not require expensive tools. The frames are assembled in whole wall pieces and sided with plasterboards. For a modern carpentry, it is not so difficult to offer prefabricated houses. Also log houses are occasionally offered. The industry in many regions of Europe still fights against a negative perception of – not only the factory-made house – but also the timber house. It is especially all the environmental advantages of the timber as building materials, which kicked-off evolving changes in the building mentality, especially in Austria, Switzerland and Germany. Modern timber-houses are by no way of less quality, than any traditional house. However, the second sector of the prefabricated housing industry is offering systems based on concrete and bricks. Systems range from full concrete wall systems to large element gaseous concrete systems. Combination of concrete and brick stone is often used.



### *Quality of the Single-Family House*

European houses are traditionally built in solid construction using stones and brickwork. The exception being the Nordic countries, where wood was the main building material. In the rest of Europe brick stone and its high heat storage mass proofed to produce a very comfortable climate. In the 1920 a lot of innovation to improve the house quality was done. First double glazed windows were developed and then insulation material such as straw and cork were tested. Europeans, and especially in Germany, Austria and Switzerland, continuously improved the quality of their houses, with the exception of the post-war period until the oil crisis, where fast housing supply and later speculative and environmentally-ignorant building led to poor quality. Since the 1980s, increasing environmental awareness and new environmental building laws, led to substantial development in building technologies, which resulted in the 'passive house' standard, which allows houses with no active heating system. Generally buildings in Europe are of high standard with the exception of Portugal and the new Eastern European member states [Figure 42].

55% of EU-15 households live in single-family houses with rates above 80% in Ireland and UK and around or below 40% in Spain, Germany and Italy. Germany also has the lowest owner occupancy rate with 44% compared to the average of 64%, although the rate for single-family houses is much higher with around 80% in average and 72% in Germany [Source: Eurostat 2004]. In Germany the average square meter living area is 140 for new houses built. Average price is 180.000 EUR. Most houses have a full basement, a pitched roof and a garage. Masonry account for 80% of the houses, timber construction is at 12,5%. Houses are heated using natural gas in 77% of the cases. Central heating is prevalent with 94% of the single-family houses. Alternative energies from wood, heat pumps and solar panels account for 5,7% [Statistisches Bundesamt Deutschland, 2002]. The European Foundation for the Improvement of Living and Working Conditions [2004] reports that citizen of the EU-15 countries average 1,9 rooms per person excluding kitchen and bathroom with the UK and Belgium standing out with 2,6 and 2,7 room per person and Finland being at the lower end. 9% of households are reporting at least 2 problems like leakage or rot in windows, where Portugal is peaking out with 24% and Sweden, Austria and Germany showing the lowest numbers with fewer than 5%. At least two problems with the environment were reported by 19%, with Italy, Greece and France scoring the highest with over 30% and Denmark, Sweden and the Netherlands scoring under 4%. Mean satisfaction with accommodation it at 7,7%, whereas Denmark and Austria score the highest and Portugal, Greece and France the lowest. The average lifetime of the houses are estimated to 76 years. In Germany real estate agent calculate with 100 years for traditionally built houses and 60 years for prefabricated houses.

### *Example companies*

The European prefabricated housing industry is not as well monitored as in the US or in Japan and data on a European level is not available. In average, companies range from 100-600 houses per year and 300-900 employees, which gives them an output of 0,5-2 houses per employee per year, which is much lower than in Japan where the companies have an output of 4-6 houses per employee per year and the US companies who reach up to 3 houses. Nevertheless, prefabrication is not just an issue of company size, since there are also companies with less than 10 employees offering prefabricated houses, sometimes building not more than 3 units a year. Indeed, every halfway modern equipped carpenter, who all work with CAM can reach a fairly high degree of prefabrication for a timber frame house. Actually most of the prefab companies derive from carpentries or cabinetmakers, which are more than hundred years old and started to produce houses in the 1950s and early 1960s. The boom years followed: In the early 1970s the German company OKAL claimed to be Europe's biggest house producer with more than 5.000 houses sold per year and six factories [Figure 42]. But the boom was over with the oil-crisis and many companies collapsed or merged. With the growing promotion of timber as a building material in central Europe, there is a growing incentive for the product. However, reservations against the 'factory-made' – or 'run-of-the-mill' house are high. Especially in Germany the descending housing market led to several company mergers in the prefabrication industries. The Austrian-Germany merger Elk-Bien-Zenker claims to be today's biggest prefabricated house producer in Europe with about 3.000 houses built in 2004 [Figure 43]. ELK-Fertighaus AG is the largest producer of prefabricated houses in Austria with 1.012 houses produced in 2003. The Austrian company holds a 57% majority interest in the German Bien-Haus AG, which cooperates with the Austrian Zenker AG. The Elk-Bien-Zenker group, with 3.000 houses sold in the year 2003 and a turnover of EUR 281 million, is furthermore the market leader in prefabricated houses in Europe, followed by the new Space4 from the United Kingdom and the German Kampa Group [Table 2].

In the UK, so far the biggest investment in setting up an off-site production has been done by speculative house builder Westbury Homes, who invested 22 million Euro and set up Space4 in 2001 [Ben Roskrow, 2003]. Westbury ranks ten under the UK house-builders with 3.812 units completed in 2002. Space4 produces in fairly modern factory panelized houses for Westbury and other house builders [Figure 44]. The factory is laid out to produce up to 5.500 units a year and is employing modern industry-leading technology [Figure 45]. Inspired by the automotive industry high-volume production lines are driven by CAD CAM software and just-in-time delivery is adopted. The factory works at a tolerance of 2.5 mm. The company had some 'teething problems' and in the year to March 2003 it made a 5 million Euro loss and only produced 30 units per week in July 2003. Currently they are at a production rate of 3.000 houses a year [Taylor, 2004].

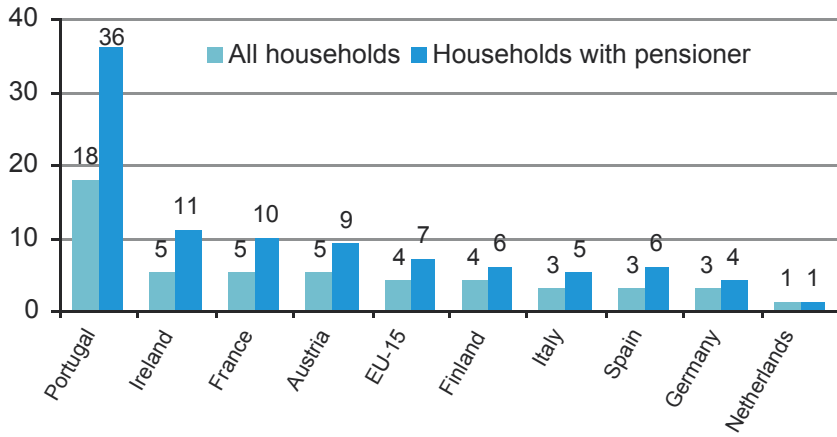


FIG. 42 Percentage of houses in Europe with low standards (at least one of the following basic elements missing: bath/shower, indoor WC, running water) in 1998. (source: Eurostat)

FIRM	NO. OF DWELLING UNITS (1999)	NO. OF DWELLING UNITS (2002)
<b>Traditional</b>		
Wimpey (UK)	6.157	13.480
Persimmon (UK)	6.483	12.352
Barratt (UK)	8.710	12.250
<b>Prefabrication</b>		
ELK-BIEN-Zenker	N/A	3.000*
Space4	N/A	2.000**
Kampa AG	N/A	1.200

TAB. 02 The largest 3 European house-builders in traditional and prefabricated sectors. (sources: Private Housebuilding Annual 2000 and 2003, \*Company Website, \*\*Roskrow, 2003)

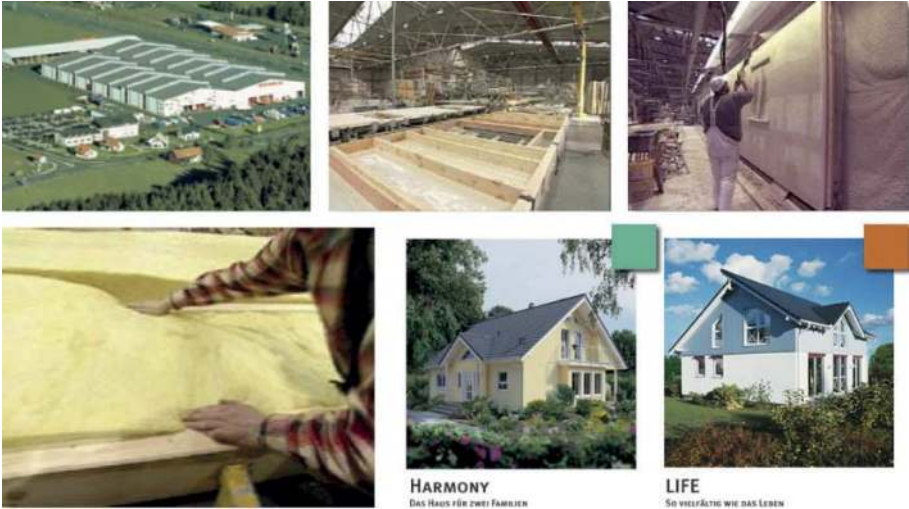


FIG. 43 The German-Austrian merger Bien-Zenker has 3 factories and claims that the one in Schüchtern (above) belongs to the most productive and modern on the world. Looking inside, though, there seems to be a lot of manual work involved. [source: [www.bien-zenker.de](http://www.bien-zenker.de)]



FIG. 44 Space4 factory in Castle Bromwich near Birmingham. [source: [www.space4.co.uk](http://www.space4.co.uk)]



FIG. 45 Inside the Space4 factory. [source: [www.space4.co.uk](http://www.space4.co.uk)]

The German Kampa group operates with several companies and brands like 'Kampa Haus' and 'ExNorm'. They recently acquired 'Hebel Haus', a company selling lightweight concrete houses and hold shares in companies in Hungary and Poland. With a turnover of 169 million Euros in 2004 they produced 1201 houses per year.

## *Conclusion*

Europe has a lively mixed housing market. Overall it is a growing to booming market with the exception of Germany, which has been shrinking the last years. Prefabrication industry differs strongly from country to country. Probably an average between 10-15% percent of prefabrication in houses is realistic for the main markets. Germany, which has long been the biggest single market in Europe, moves between 12-15%, even in a difficult market environment. There is no prefabrication company producing more than 3.000 units per year. Most of them are well under 1.000. Major prefabrication is timber based, facing a brick stone building tradition in Germany, UK, Netherlands and Austria. Most 'on-site' builders operate in concrete and brick stone with a timber roof. The production of the prefab companies is often claimed to be 'highly advanced' and 'using the latest technology', but in reality most companies use state of the art CAM supported carpenter machinery. In reality most factories are not much more than a building site under a roof with a more or less advanced workflow. Still a lot of work is done manual. On the company websites, this conflict becomes very obvious: on one hand they want to put forward the advanced industrial image, on the other hand they refer to craftsmen's skills and manual labor. The main target of the industry has been the lower market and recently the self-built market has been increasingly important. The quality of housing in Europe is generally very high and people are happy with their homes. People also expect a high quality. Homes have been generally good investments with a growing value. An average lifetime of 76 years is supporting that. To forecast the future of the prefab home industry is difficult. There are clearly underdeveloped regions like Spain and others, which stay on a fairly consistent level like Germany. What is interesting to learn is, that economically successful production of prefab houses is not necessarily a question of large production. There are several profitable companies in Europe, which produce less than 1.000 units a year. And the Swedish example shows, that even a substantial export is possible.

## Bibliography - Europe

Amt Für Amtliche Veröffentlichungen Der Europäischen Gemeinschaften. [2004]. Eurostat Jahrbuch 2004, Luxemburg.

Ball, M. [2005]. RICS European Housing Review 2005. London: Royal Institution Of Chartered Surveyors.

Birkbeck, D. [2000, August 17]. Design For Homes Newsletter No. 2., Design For Homes. Retrieved March 1, 2005, From <http://www.designforhomes.org/lettersview.html?id=8IS3F2SiTMS%3dbkpm%2bxmpfaq>

Carney, B. [2004, December 22]. What To Watch In Europe In 2005. Retrieved December 22, From [Http://www.businessweekonline.com](http://www.businessweekonline.com)

Clarke, L., & Wall, Ch. [2000, September]. Craft Versus Industry: The Division Of Labor In European Housing Construction. Construction Management & Economics, Vol. 18 Issue 6, 689-698.

Construction Task Force. [1998, July]. Rethinking Construction. DETR

Datamonitor PLC [2003a, January]. Homebuilding In Europe. Homebuilding Industry Profile: Europe. New York.

Datamonitor PLC [2003b, January]. Homebuilding In The United Kingdom. Homebuilding Industry Profile: United Kingdom. New York.

Eurostat [2004]. European Business - Facts And Figures [Data 1998-2002] Luxemburg: Office For Official Publications Of The European Communities.

Forintek Canada Corp. [2003]. Opportunities For Canadian Wood Products In Western Europe. Canadian Forest Service. Retrieved February 28, 2005, From [http://www2.nrcan.gc.ca/Cfs-Scf/Canada\\_Wood/English/View.Asp?X=14&All=True#38](http://www2.nrcan.gc.ca/Cfs-Scf/Canada_Wood/English/View.Asp?X=14&All=True#38)

Odd European Out. [2004, February 21]. Economist, Pp. 13-14.

Post, N., Welters, H., 1998, Wohnqualität - Kostenoptimiert. Cologne: Rudolf Müller.

Roskrow, B. [2003]. Prefab Progress. Retrieved March 1, 2005, From <http://www.house-builder.co.uk/articles/articleitem.php?id=995&keys=prefab>

Statistisches Bundesamt Deutschland. [2002]. Statistisches Jahrbuch 2002, Berlin.

Taylor, D. [2004, October 28]. The Prefab Sheds Its Social Stigma. Construction News, Pp. 28-29.

The European Foundation For The Improvement Of Living And Working Conditions. [2004]. Quality Of Life In Europe. Dublin: EU Publications Office.

United Nations Economic Commission For Europe. [2004]. Bulletin Of Housing Statistics For Europe And North America 2004. Retrieved February 22, 2005, [www.unece.org/env/hs/bulletin/bulletin\\_04.htm](http://www.unece.org/env/hs/bulletin/bulletin_04.htm)

#### Further sources:

Amt für amtliche Veröffentlichungen der Europäischen Gemeinschaften. [2004]. Eurostat Jahrbuch 2004 Luxemburg: Author.

European Committee for Standardization [CEN], [www.cenorm.be](http://www.cenorm.be)

European Union of Developers and House Builders / Union Européenne des Promoteurs Constructeurs [UEPC], [www.uepc.org](http://www.uepc.org)

#### On United Kingdom Houses:

House Builders Federation / New Homes Marketing Board [HBF/NHMB], [www.hbf.co.uk](http://www.hbf.co.uk)

The voice of the house-building industry in England and Wales. Its members range from large, multi-national companies to small, locally-based businesses. Together, they build over 70% of all new homes in England and Wales each year.

A comprehensive on-line database of new homes: [www.new-homes.co.uk](http://www.new-homes.co.uk)

Office of the Deputy Prime Minister: [www.odpm.gov.uk](http://www.odpm.gov.uk)

Royal Institution of Chartered Surveyors [RICS]: [www.rics.org.uk](http://www.rics.org.uk)

#### On German Prefab Houses:

Bundesverband Deutscher Fertigbau e.V. <http://www.bdf-ev.de>

The 30 companies organised under this association represent the main players of the Prefab market.

<http://www.fertighaus.org/>

#### Company Webpages:

[www.space4.co.uk](http://www.space4.co.uk)

[www.kampa-ag.de](http://www.kampa-ag.de)

[www.bien-zenker.de](http://www.bien-zenker.de)

[www.elk.at](http://www.elk.at)

## United States

The United States is the world biggest housing market with the biggest housing investment, which is more than double as much as even the second largest market, which is Japan [Figure 46]. And it is growing: The National Association of Home Builders [2005] reports that during the decade of the 1990s, the United States has seen dramatic changes in the production of single family homes [Figure 47]. The decade began with the housing industry approaching a cyclical trough that was reached in 1991 when single-family starts fell to a low of 840.00. As of 1996, stats had risen to 1.160.000 in a sustained period of recovery for the industry and strong growth throughout the economy. The growth went right into the new millennium and the total new single-family home sales for the year 2004 reached 1.183 million, an 8.9 percent increase from the previous annual record of 1.086 million set in 2003. Manufactured homes, as the majority of factory made homes in the US are called, had a strong increase during the 1990s, but dramatically decreased from 1999 after reaching a 40 year low in production. In an unparalleled housing boom in the United States, the amount of prefabricated units dropped from 439.000 in 1997 down to 262.000 in 2002 and it is not expected to recover until 2007 [U.S. Prefabricated Housing shipments, 2004].

Why are the numbers dropping in the United States, the country that brought modern mass fabrication in factories to the rest of the world?

### *Economic Situation*

The US economy is steadily growing and increasing in wealth and low interest rates have led to a never before seen investment into houses. People can build bigger and more expensive homes. The building sector is becoming more stable and powerful. A consolidation towards big public builders is taking place. Lahart [2003] reports in Fortune magazine, that over the past five years, homebuilding has become a safer investment. Smaller builders have gone out of business, allowing the top ten builders to double their market share to 15%. That trend has led to less volatility, says Smith Barney analyst Stephen Kim. In the past, small builders often drove the industry into manic ups and downs. In fat times they would overextend themselves; in the lean they'd rush for the exits. Big public builders – Toll, Pulte, Centex, KB Home, Lennar, and Beazer Homes – can weather the bad times better and, just as important, control themselves during a boom. That self-control is one reason the new-home market is in such good shape. The biggest danger to the housing market, aside from higher interest rates, according to Kass, is overbuilding. But, he says, "inventory has been contained – it's nowhere near the level where you need to be concerned." Other forecast are speaking of a 40% market share of the top 10 homebuilder by 2010 [Sichelman, 2004]. However, especially in the coastal areas there are severe signs of a bubble in the housing market. Spurred by historically low interest rates, house prices are continuously raising and many houses are over-valued [Tully & Ryan, 2004]. Manufactured houses – after a strong increase in 1994 – dramatically lost their market share since the summer of 1999 and reached the lowest figure of shipments since 1962 [Figure 48]. Although the manufacturers claimed to strongly work on customer value and change in image with the boom in the early 1990s, manufactured homes seem to loose rapidly in a highly speculative market, where houses are increasingly bought for investment instead of use. After stocking



up production facilities, now many producers of manufactured homes are struggling just to survive. Several factors can be made out for the decline of sales: A lower migration rate to the South and Midwest, where the bulk of mobile homes are sold; overexpansion by companies in the supply of manufactured housing; and the national prosperity, allowing more buyers to seek single-family homes. But probably the most important lies in the declining credit quality of the asset-backed securities, that manufactured-housing lenders issue after making the loans. This led to many better-quality borrowers fleeing the pools in the face of the lower rates in 1997 and 1998 [Julavits, 2000]. Sales of single-family houses increased and clearly shifted towards the luxury end of homes during the last few years. About 60% of American currently lives in a dwelling with more than 100 m<sup>2</sup> [U.S. Census Bureau, 2001].

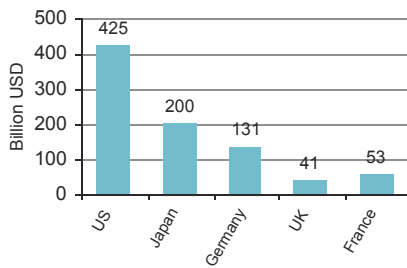


FIG. 46 Housing investment of major countries in billions of US Dollars in 2000. [source: OECD]

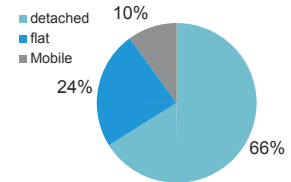


FIG. 47 Housing stock in USA 2000 [Source: US Census Bureau]

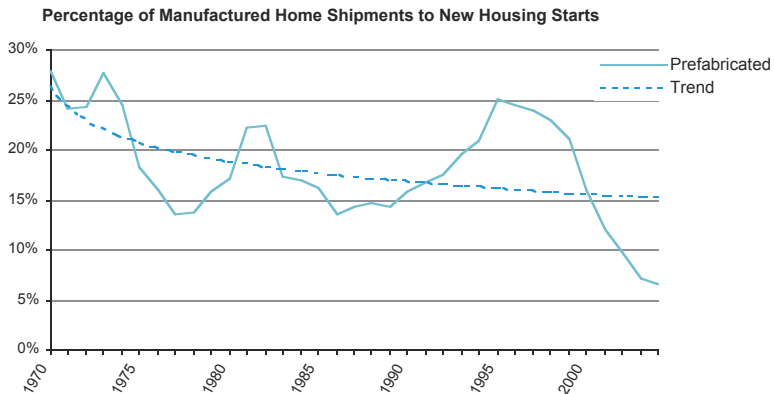


FIG. 48 Percentage share of manufactured home shipments to new housing starts. (USA, 1970--2004) with logarithmic trend line. The US manufactured housing industry shows a sharp decline on market share in the last years when the US housing market started to boom. [source: Office of Policy Development and Research, 2004]

## *Structure of the Housing Industry*

The United States have a long history in industrialization and the prefabrication of buildings and a substantial industrialized housing industry exists. Nevertheless most houses are still built in the traditional 2x4 (5,08 x 10,16 cm) balloon-frame or platform-frame method by small local builders. The 2x4s are the most common type of wall studs in both: conventional and manufactured homes. Their estimated market penetration is about 73% in conventional construction and 65 percent in manufactured homes. Statistical information is generally presented from a national perspective even though the competitive overlaps within and between these sectors occur in regional and local markets as well, and all the sectors face some degree of competition from sales of existing housing units.

The principal sectors of house building include site-built housing and factory-built. There is a difference between these two terms, although they are often confused, creating misunderstanding among homebuyers, city planners, developers, and even builders. In general, there are three methods to build homes: site built, modular, and manufactured [HUD-Code]. Often factory-built refers to modular homes, although manufactured homes are built in factories as well. One of the main differences between these homes is the building code that has jurisdiction over the design and construction of the home.

Site-built refers to homes fabricated primarily on the job site, and may include wall panels and components fabricated elsewhere. The design and construction of these homes must abide by the building code adapted by the local jurisdiction where the home is located. Local builders and regional divisions of national companies then construct site built homes.

Factory-built [or modular] refers to homes built in a factory in sections. These homes are built using the same materials as site-built homes, and are built on a permanent foundation. At the job site, the builder generally installs the foundation, and connects the utilities to the house. The builder may have to rent a crane to hoist the sections together for assembly. The design and construction of modular homes must meet the building code adapted by the local jurisdiction where the home is located. However, there are reciprocal agreements for design review and approval for a few states. The shipping radius for modular homes is approximately 300 miles. This allows the driver to deliver the home and return to the factory on the same day. These homes are indistinguishable from site-built homes.

A manufactured home refers to a house built off-site in a factory or construction yard on a permanent chassis with a HUD label (United States Department of Housing and Urban Development). These homes are built to the HUD code under the Federal Manufactured Housing Construction and Safety Standards [FMHCSS] established in 1976. Local building authorities do not inspect the construction of these homes; instead, third party in-plant inspectors inspect them. Manufacturers often sell their homes via local retail vendors who assist with transporting and placement of the home on the owner's property or lot site. Prior to 1976 people often referred these homes as "mobile homes" or "trailers." However, those monikers no longer reflect the true nature of these homes, as many designs can be

indistinguishable from site-built homes. HUD-code homes can be installed on permanent foundations. When a manufactured home is permanently attached to a foundation, the home is eligible for conventional mortgage financing [Toolbase Services, no date]. The NAHB Research Center [1998] gave a pretty clear image of these sectors during the 1990s, where the following descriptions draw from.

### *Site-Built*

The home building business has historically been dominated by the construction of new homes on site through sequential fabrication and assembly of products, materials and systems into finished homes by skilled tradesmen and general laborers. Still today it is the most dominant form of construction in the United States, accounting of over 90% of new single-family housing starts.

Activities are planned and coordinated by experts with regulatory oversight at the local or state level of government. The resulting "site-built" sector of the home building industry is large and very diffuse. It encompasses not only the construction of houses but ancillary activities including land development, infrastructure planning and sale of the finished product as a complete package. In 1996 the two largest conventional homebuilders, Pulte Home Corporation and Centex Corporation, each constructed more than 10,000 detached homes. For the same year the top 10 companies built almost 75,000 detached homes, which represented about 6,5% of national housing starts. Firm sizes drop rapidly from there; for example, the 100 largest companies built an estimated 162,000 single-family homes in 1994. Tremendous diversity and a concentrated, highly competitive economic structure are apparent when the site-built sector is viewed as a whole. Although recently consolidation took place, capital requirements are low and there are few barriers to entry or exit. For example, recent National Association of Home Builders membership information indicates that the site-building segment consists of some 50,000 active home building firms with average production of around 20 housing units a year. Typical firms are very small, with the majority building less than 10 units per year, and about 80% building less than 25 units per year. The broadest picture of all appears in the 1992 Census of Construction, which reported over 130,000 residential construction "establishments" with one or more employees, and another 210,000 residential construction establishments without employees. While these residential construction establishments also include firms exclusively involved in remodeling, they do not include the hundreds of thousands of special trade contractors used extensively by home builders as subcontractors performing carpentry, plumbing, electrical, mechanical and other work. The number of residential construction establishments in 1992 was not much changed from the number reported in the 1977 Census of Construction. The level of site construction activity is reported by the Bureau of the Census as housing "starts" (when ground is broken for construction) and housing "sales" (homes for which a sales contract has been signed). Both statistics customarily exclude HUD-Code housing units, which are reported separately. There are usually many more housing starts than housing sales because about one-quarter to

one-third of new site-built homes are started but not “sold.” Rather, they are built under contract between an owner and a builder serving as general contractor. While there is always some level of demand for new homes as population grows, new households are formed and economic activity shifts from one area to another, the housing business has been characterized by powerful cyclical trends as well. As the economy moves into recession, housing starts can drop abruptly, and as the economy recovers housing starts often rise very quickly. Since most houses are purchased with long-term loans, the demand for new homes is also very sensitive to interest rates and monetary policy. Site builders operating in this volatile environment have tended to protect themselves by minimizing fixed capital investment and making extensive use of subcontracting arrangements.

### *Manufactured Housing Sector*

New homes can be and often are built partly or almost entirely in factories rather than on site. Factory construction offers many opportunities for economizing and increasing efficiency in the production process modeled after experience gained in other industrialized sectors of the economy. For many years the most common type of factory-built housing was the “mobile home,” a narrow, lightweight technological descendant of the self-contained travel trailer that was designed to be towed from one location to another along public roads, and hooked up for temporary use. This sector first achieved prominence in the 1960s and early 1970s. By 1976 mobile homes had come under regulation in the form of the pre-emptive federal “Manufactured Home Construction and Safety Standards” or “HUD-Code,” and the era of modern “manufactured homes” began. Manufactured homes are required to be produced with a permanent chassis designed for over-the-road transportation. They are usually placed at the site on non-permanent foundations (e.g., block piers) and are almost invariably one-story units.

The manufactured housing sector has a profoundly different economic structure and way of doing business than the site-built sector of the industry. Production is much more concentrated in fewer firms than site-built home construction, and is exhibiting a trend towards consolidation. Producers of manufactured homes have historically been focused on the production process itself and left land development and retailing activities to others, but vertical integration into retailing and operation of manufactured home parks or rental communities is taking place. The level of economic activity in this sector is generally reported as units shipped from the factory (based on comprehensive production monitoring performed on behalf of HUD), or units placed for residential use (based on survey data). Production of manufactured homes, like site-built homes, is subject to cyclical trends and sensitivity to interest rates. Compared with the site-built sector, however, larger capital investment and the more concentrated industry structure of HUD-Code producers leads to less flexibility in responding to changes in the level of demand and more incentive to maintain production in slow markets. The two largest HUD-Code producers in 1996, Fleetwood Enterprises and Champion Enterprises, each built about 60,000 homes and together accounted for about 35% of total HUD-Code shipments for

the year. The top four firms accounted for over 50% of 1996 shipments, and the top ten firms accounted for over 70%. On a broader scale, numbers of firms and plants dropped steadily from 1977 to 1992, while output per plant and output per firm both rose by large amounts over the period.

### *Modular Housing Sector*

Modular housing is the largest of the other segments of the housing industry, each of which are for the most part very small compared to the site-built and HUD-Code sectors. Modular housing includes factory-built homes that are delivered to the building site in largely complete form as multiple modules and placed by crane on conventional basement or crawl space foundations. Unlike HUD-Code homes, however, the design and construction of modular homes is regulated entirely by state and local building codes similar or identical to those that apply to site-built homes. Many models are two-story houses, and modular producers often report that they compete directly with site-built homes in terms of design and amenities. Modular homes are usually sold through small builders responsible for preparing the site and foundation as well as required finish work. These builders often construct models on land owned by the purchaser. The modular sector represents an intermediate form of new home production and distribution that is of significant interest for the present study. Definitive information about the structure of production in the modular sector is lacking, but it is very clear that modular houses have never achieved the popularity of HUD-Code homes. A 1987 report estimated that about 152 firms produced modular homes, some operating multiple plants. Average production was estimated at between 300 and 400 units per firm, with the largest 25% of modular producers accounting for two-thirds of output. Most firms shipped to five or more states. To some degree modular production was found to be a regional phenomenon concentrated at that time in the northeastern and mid-Atlantic states, and to a lesser degree in the Midwestern and southeastern states. More recent estimates of annual modular production vary widely, from around 25,000 to 100,000 homes depending on the source. The Bureau of the Census has only published estimates of modular production since 1992, and reports that from 1992 through 1996 modular production has ranged from 32,000 to 37,000 homes per year. The largest modular producer in 1997 was All American Homes of Elkhart, Indiana (2,300 homes), and the second largest producer was Champion Enterprises (1,631 homes), a firm that is much better known as a producer of HUD-Code homes. An analysis of 1995-96 Census data on modular homes provides more information about how the modular compared to stick-built homes. For example, 26% of modulars were 2-story, compared to 48% of conventional stick-built homes; the median modular square footage was 1,560 compared to 1,950 for conventional homes. The modulars were more likely to have vinyl siding and less likely to have a fireplace or a garage than the conventional homes. Modular houses are disproportionately sited in the Midwest (45% of all modulars vs. 21 percent of stick-built) and uncommon in the West (6% of modulars vs. 25% of stick-built). Modulars were also more likely to be located outside of metropolitan areas (51% vs. 18% for stick-

built homes]. The report concluded that modular homes are geared more towards first-time and non-metropolitan purchasers than conventional homes.

### *Building Types*

There are several other, smaller sectors that constitute the remainder of the housing industry. These include log homes, pre-cut package homes and various types of panelized construction. Total production of all these types is currently estimated by the Bureau of the Census at less than 30,000 units per year. Producers are small and geographically dispersed.

### *Quality of the Single-Family House*

American Housing was revolutionized with the introduction of the balloon frame construction in the early 18<sup>th</sup> century. Very early whole pre-cut package homes were offered. The mail order house Sears, Roebuck & Co. of Chicago sold about 100,000 pre-cut kit houses from 1908 to 1940. Today, still over 95% of new houses are built by this method, mostly using standard 2x4s, no varieties, and built in factory or on-site.

One half of the single-family homes in the United States has one story, the other half two. Very rarely are there 3 story homes. 65% have a 2-car garage, only 12% account for having no garage or carport. Average square meters are 159 with a clear recent trend to 'bigger is better' with reaching 200 m<sup>2</sup> in average floor area for new houses built. 37% of the houses have a full or partial basement. This varies strongly with the climate zone. More houses have basements in the Northeast and Midwest, than in the South and the West. The majority of the houses have pitched roofs. The exterior wall material is dominated by Vinyl siding [39%], which strongly increased the last 10-year on cost of wood. Brick accounts for 21%. Houses are heated using natural gas or electricity as a main energy source, which is transferred into warm air furnaces, which can be found in 72% of the homes. Solar heating is virtually non-existent. 80% of all new houses have air-conditioners.

Over 99% of all houses have a telephone, television set and a refrigerator. Americans in majority are happy with their homes. If problems occur they are mostly related to plumbing and heating. Only 37% of conventional homes have double-glazed windows, manufactured homes even less. The average lifetime of the houses are estimated to 44 years.

### *Example companies*

The top 3 conventional homebuilders in the United States are DR Horton, Pulte Homes and Lennar Corp. [Table 3]. The main business of the big home building companies in the

United States is based on selling single-family homes including land. As the main market is the entry-level and move-up markets all of them praise themselves serving the luxury market as well. Their main business are conventionally site-built homes. The four biggest DR Horten, Pulte Homes, Lennar and Centex had a growth of 13 % to 22% in terms of units from 1993 to 2003. In terms of revenues it was well over 20%. DR Horten, which expects to sell about 50.000 homes in 2005, is the top ranking residential builder in the US. One of DR Horten's subsidiaries is Horten Homes, who is involved in the production of Manufactured Homes as well as Modular Homes, an industry with severe losses over the past years.

FIRM	NO. OF DWELLING UNITS (1993)	NO. OF DWELLING UNITS (2003)
Traditional		
DR Horten	N/A	37.600
Pulte Homes	N/A	32.700
Lennar	N/A	32.200
Centex Corp.	N/A	30.300
Prefabrication (HUD-Code)		
Champion	N/A	21.968
Fleetwood	N/A	19.982
Clayton	N/A	16.898

TAB. 03 The largest US house-builders in traditional and prefabricated sectors. (source: Builder Online)

Pulte Homes designs and builds entry-level, move-up, and semi-custom single-family detached houses [about 86% of total unit sales], duplexes, townhouses, and condominiums at prices that range from \$85.000 to almost \$1.4 million, and average \$284.000. They cover the whole range. Until recently the company was not involved in factory-built homes. After more than doubling their sale in the last five years and having a market share of 3-3,5%, Pulte Home has aspirations to get a market share of 20% within the next 20 years [King, 2004].

After production foundation in their Detroit plant since 2000, Pulte Homes started a whole new factory-produced housing program call Pulte Home Sciences homes or PHS homes. They focus on modern logistics and industrial processes of the automobile industries as well as others like the largest distributor in the US, Wal-Mart. PHS homes have so far been made in three subdivisions: Ridings at Blue Springs in Chantilly, Virginia, Laurel Hills in Lorton and White's Mill in Warrenton. This year, Pulte will start offering the PHS homes at the Mayfield Trace subdivision in Prince William County. So far, the builder has constructed some 125 houses in its Virginia factory. In the 10.700-square-meter factory where 60 machines and 50 employees complete sixteen separate automated processes. Pulte manufactures the whole range on the upper segment of the market: Houses up to 650 square meter - with varied floor plans - and priced at the high end of the builder's range, up to more than \$1 million homes have been delivered. Through the factory process Pulte is saving on labor costs and material. The main benefit is greater control over the processes.

Increasingly steel is replacing wood for structural parts as steel has more precision and long-term stability.

Pulte's growing sales, their good reputation and their eager management put them into a good position to be a pioneer in the US housing market. In the US environment, where factory-made houses have been serving traditionally, the cheap market segment has had a negative reputation. However, Pulte has the advantage as a housing developer they basically are able to sell the houses to themselves. On their test market in the Washington area, they have been offering their clients the choice between a traditional-built and a factory-built home without price incentives. First clients are very happy with their choice: one client, last name of Lopez said it was a "great decision" to go with the new building method. "There are no drafts in the home," she said, "no noticeable change of temperature from room to room." She called the house "airtight" and said the couple can't hear "any exterior noises." [Daniela, 2004]. This description is casting a light on the average building quality in the United States.

Lennar and Centex Homes act in the same markets. Centex Homes builds houses that range in price from \$57,000 to \$1.6 million; covering the whole range of home building. The company owns about 77,475 lots and has rights to purchase 115,366 more lots. They recently spun off their own involvement in manufactured homes forming Cavco Industries in 2003.

Champion Enterprises, Inc. is the largest manufactured homebuilder in the US, selling about 25,500 homes annually. Headquartered in Auburn Hills, Michigan, it is the parent corporation for a family of companies that manufacture and retail manufactured and modular housing. Founded in 1953, Champion has built and sold more than 1.5 million manufactured and modular homes – more than any other homebuilder. Champion has approximately 7,000 employees throughout the continental U.S. and western Canada. It manufactures homes at 29 plants in 14 states and in two Canadian provinces. Champion mainly produces single-section and multi-section homes that sell for \$15,000 to \$150,000 [averaging \$37,100] and range in size from 37 m<sup>2</sup> to 370 m<sup>2</sup>. It also builds one-and-a-half-story and two-story modular homes, Cape Cod-style homes, and town homes. The average new home retail sales price is \$89,500. Champion markets its homes through 77 Company-owned retail home centers in 17 states. 500 builders and developers also sell by more than 830 retail locations that have joined the Champion Home Center retail distribution network and its homes.

In 1950, Fleetwood began building recreational vehicles for American families who were enjoying their newfound post-war prosperity. The growing housing market at that time also let Fleetwood to enter the manufactured-housing market, which is basically building a house on a chassis with wheels, not so different from recreational vehicles. Fleetwood operates manufacturing facilities in the US in 21 states and in Canada; sales are made through both company-owned outlets and independent distributors. The company counts 13,800 employees.



Clayton Homes, a Berkshire Hathaway subsidiary, is the number 3 maker [by units] of manufactured homes in the US. Its one- and two-story homes range in price from \$20,000 to more than \$100,000 for luxury models. The homes range in size from 47 m<sup>2</sup> to 220 m<sup>2</sup>. Clayton Homes distributes its products in 49 states through a network of about 1,500 retailers [about 400 company-owned stores, 86 company-owned community sales offices, and 1,100 independent retailers]. The company operates 86 manufactured housing communities and owns financing, loan-servicing, and insurance subsidiaries. Clayton Homes acquired Oakwood Homes Corporation in 2004 and renamed it Reorganized Sale OKWD, Inc. Most of the production facilities of the manufactured home industry are not highly industrialized in terms of automation. A lot of manual work is seen (Figure 49). Like in Europe, processes are seen, which remind of a 'building-site under a roof'.



FIG. 49 Example images of manufactured home production, which still involves a lot of ergonomically unfavourable manual work [source: [www.skylinehomes.com](http://www.skylinehomes.com)]

### *Conclusion*

The United States experienced a very strong booming housing market with a clear trend to bigger and more luxury homes. The fear for a housing bubble has been around, but in fact the site-built building industry seems to consolidate and become more powerful. The manufactured home producers, who have been a solid industry since the 1960s, have suffered under the trend to more expensive homes. Traditionally they have served the low-income market. Their participation on the market has been sharply declining the last years. So the demand for more homes, does not necessarily translate to the factory-made home. The American manufactured home companies compared to Europe are big. In their better times, many companies have been producing well over 20,000 units a year. Manufactured homes are timber-based, as most of the American single-family houses are. A modern 2-unit manufactured home doesn't actually show much difference to a traditionally built home, except for the price. Although the US manufactured home industry managed to

operate under nation-wide identical regulations, their competition, similar to the European industry, has the multitude of local small builders and carpenters, who built the 2 x 4 based homes. Also the US prefabricated home industry is not very highly automated: under the factory roofs there is still a lot of manual labor as it would be seen on a normal building site.

The quality of the American houses is usually good, although lower than in Europe. Also expectations in the US are not as high and neither are environmental concerns. Usually no basement is required. In most regions houses have been a solid investment with a growing value. The average lifetime is estimated to be 46 years.

The current boom of the traditional builders and the decline of the manufactured home companies lead to a strong consolidation in both sectors, where the outcome is hard to predict. The investment of Pulte Home into a factory is an interesting development. But, although all the problems and inefficiencies of the on-site construction are well known, the United States prove the traditional on-site construction with a local small builder, as the most successful house building method of the 21<sup>st</sup> century.

## BIBLIOGRAPHY

A Few Facts About Manufactured Housing. Federal Reserve Bank of Richmond. Retrieved February 11, 2005, from <http://www.rich.frb.org/cao/reports/housing.html>

Allen, G. [1994, May/June]. The Manufactured Home Community Metamorphosis. *Journal of Property Management*, Vol. 59 Issue 3, 34.

Datamonitor PLC [2003]. Homebuilding in the United States.

Deane, D. [2004, December 11]. Home From the Factory. *washingtonpost.com*. Retrieved February 15, 2005, from <http://www.washingtonpost.com/wp-dyn/articles/A55765-2004Dec10.html>

Ehltng, D. [2001]. Vorfertigung Komplexer Ausbau-Bausysteme Für Offene Bauweisen [Doctoral Dissertation, Fakultät Bauwesen Der Universität Dortmund, 2001]. 462.

Flimsy Foundations. [2004, November 12]. *Economist*, pp. 71-72.

Julavits, R. [2000, July 9]. Economy's Streak Cited in Slump For Prefab Homes. *American Banker*, p. 9.

King, R. J. [2004, May 2]. Fast-Growing Pulte's Strategy: Dominate Home-Build Market. *The Detroit Business News*. Retrieved February 15, 2005, from <http://www.detnews.com/2004/business/0405/02/c01-139742.htm>

Lahart, J. [2003, June 16]. Housing Just Keeps Going Up. *Fortune*, pp. 100-103.

NAHB Research Center. [1998, October]. Factory and Site-built Housing - A Comparison for the 21<sup>st</sup> Century. Washington, D.C.: U.S. Department of Housing and Urban Development.

NAHB Research Center. [2002]. PATH Technology Roadmap: Whole House and Building Process Redesign. Washington, D.C.: U.S. Department of Housing and Urban Development - Office of Policy Development and Research.

NAHB. [2005]. New Single-Family Home Sales Top One Million Again In 2004. Retrieved February 10, 2005, from [http://www.nahb.org/news\\_details.aspx?newsID=1347](http://www.nahb.org/news_details.aspx?newsID=1347)

Office of Policy Development and Research. [2004]. U.S. Housing Market Conditions - 3<sup>rd</sup> Quarter 2004. Washington, DC: U.S. Department of Housing and Urban Development.

Pulte Homes, Inc. [2004] SWOT Analysis. Pulte Homes, Inc. SWOT Analysis, pp. 1-8.

Sichelman, L. [2004, March 8]. Forecast: Largest Builders Will Hold a 40% Market Share in 10 Years. National Mortgage News, p. 11.

Timmons, H. [08/05/98]. Despite Potholes, Some See Gold In Prefab Lending. [Cover story]. American Banker, Vol. 163 Issue 148, 1.

Toolbase Services. [no date]. The Difference Between "Factory-Built" and "Manufactured" Homes. Retrieved February 16, 2005, from <http://www.toolbase.org/tertiaryT.asp?TrackID=6&CategoryID=25&DocumentID=3829>

Tsao, A. [2003, Fr, 28. Jan 2005]. Are Homebuilders on Shaky Ground. Business Week Online,

Tully, S., & Ryan, O. [2004, September 20]. Is the Housing Boom Over. Fortune [Europe], pp. 38-47.

U.S. Census Bureau. [2001, May]. Current Construction Reports - New One-Family Houses Sold: 2001 [Report No. C25/01-3]. Washington, DC: U.S. Department of Commerce.

U.S. Congress - Office of Technology Assessment. [1986]. Trade, and the U.S. Residential Construction industry [Special Report OTA-TET-315]. Washington, DC: U.S. Government Printing Office.

U.S. Prefabricated Housing Shipments. [2004, January 3]. Plastics News, p. 3.

US Prefabricated Housing Shipments To Reach 285.000 Units In 2007. [2003, November 12]. Retrieved December 3, 2004, from [http://www.the-infoshop.com/press/fd16117\\_en.shtml](http://www.the-infoshop.com/press/fd16117_en.shtml)

Further sources:

[www.builderonline.com](http://www.builderonline.com)

Organisations:

National Association of Home Builders [NAHB]. [www.nahb.org](http://www.nahb.org)  
US Census Bureau, Washington. [www.census.gov](http://www.census.gov)

Company Web-pages:

[www.drhorton.com](http://www.drhorton.com)  
[www.pulte.com](http://www.pulte.com)  
[www.centex.com](http://www.centex.com)  
[www.championhomesoftennessee.com](http://www.championhomesoftennessee.com)  
[www.fleetwoodhomes.com](http://www.fleetwoodhomes.com)  
[www.clayton.net](http://www.clayton.net)  
Company details also from [www.hoovers.com](http://www.hoovers.com)

## Japan

Japan is the most advanced in the industrialized housing sector in the world and has the deepest understanding of the industrial process in construction, which includes ongoing research and a customer care program. In the 1960s Sekisui Chemical Company started Sekisui House to create new appliances for their products. Today Sekisui House is the world's largest house producer, producing up to 70.000 houses per year. Also Toyota transferred their Know-How in industrial production from the automobile to houses. In Japan, the big corporations regarded housing as an important growing market in the 1950s and 60s. By 1970, the number of dwellings produced had reached the level of new household formation. The market in terms of quantity had been satisfied, and emphasis shifted to quality: research and development activities shifted away from improving production processes aimed at raising the volume to the needs of improving the quality and higher demands for customization.

### *Economic Situation*

In Japan 1.2 - 1.6 million new houses are built annually of which some 50% are detached single-family houses. Thus, Japan is the second largest housing market in the world. Although the market and the circumstances are very favorable for industrial housing and the industries found in Japan are the most advanced in the world, they account only for about 15% of the market share for all new dwelling units built and about 20% of all new detached single family homes. The rest is custom-built by one of 83.000 local contractors. More than 90% of these firms manufacture or construct less than 10 dwellings annually as they are operating on a small scale [Iwashita, 2001].

This is astonishing, since labor and especially craftsmanship is not necessarily cheap in Japan. Different to the Western markets, the Japanese housing industries never really concentrated on the low price sector, but from the beginning on middle and luxury markets, prices were high. The Economist [Rebuilding, 1996] reports that prices before the recession in the 1990s were well above one third of comparable prices in the US. But they have been coming down continuously. A house in Tokyo now costs less than half what it did in 1991, after a now legendary property-price bubble in the late 1980s [A Boom Out of Step, 2003]. But the high prices and the shortage of wood in Japan allowed especially small companies on the American Pacific coast to enter the Japanese market with their products. Misawa Homes reacted to that situation in 2001 with their mass-produced industrialized housing model "Limited 25". The program planned to cut prices by half, from 500.000 Yen/tubo to 250.000 Yen/tubo [1 tubo = 3,3 m<sup>2</sup>].

However, since 1997 the economic recession in Japan has had a devastating impact on the Japanese housing industry, sending thousands of contractors out of business and reducing housing starts from 1.66 million units in 1996 to just 1.21 million units in 1999 [Figure 50]. Japan has suffered a nearly permanent deflation ever since. Interesting to note is that the amount of prefabricated dwelling units had a much weaker deflection and keeps a level around 200.000 units a year. In its percentage share of all newly built dwelling units, prefabricated dwellings even show an upward trend [Figure 51]. The big prefab companies invest into research and quality and can benefit from the generally low quality of Japanese housing. Datamonitor (2003) predicts an average growth between 2002 and 2007 of 0,4% in terms of market value and -0,1% in terms of units, which the strongest growth in 2007..

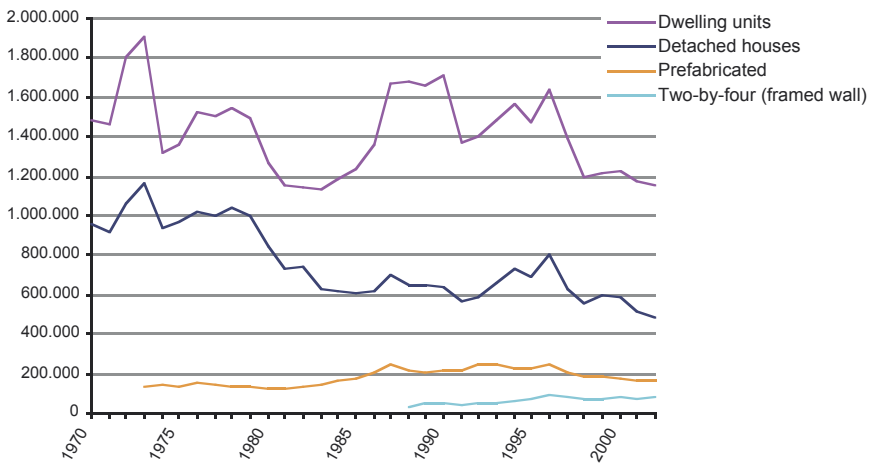


FIG. 50 New dwelling units of construction started by type of building and construction (Japan, 1970--2002) [source: Information and Research Department, Policy Bureau, Ministry of Land, Infrastructure and Transport.]

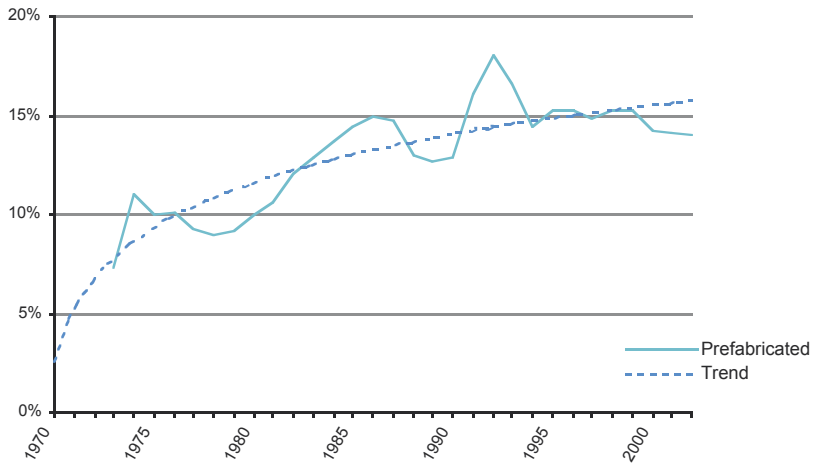


FIG. 51 Percentage share of newly built prefabricated dwelling units. (Japan, 1970--2002) with logarithmic trend line. [source: Information and Research Department, Policy Bureau, Ministry of Land, Infrastructure and Transport.]

The favorite form of living in Japan is the detached house, although condominiums are becoming more and more popular (Figure 52). The costs for housing are high in Japan. Over 7 average annual salaries are necessary to buy a single-family house (Figure 53). Having said that, the lifetime of the houses is very short and usually after 20-30 years a new house has to be built, not leaving any gains from the investment like in the Western world.

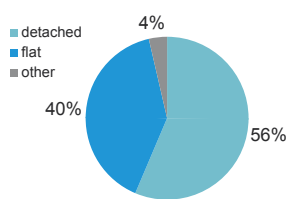


FIG. 52 Dwellings by type of building in Japan, 2003. [source: Statistical Handbook of Japan]

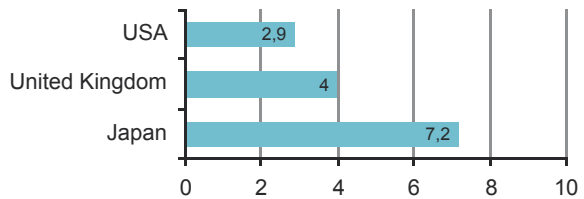


FIG. 53 Number of average annual salaries needed to finance a single-family home (ca. 2000). [source: Ishikawa, 2003]

## *Structure of the Housing Industry*

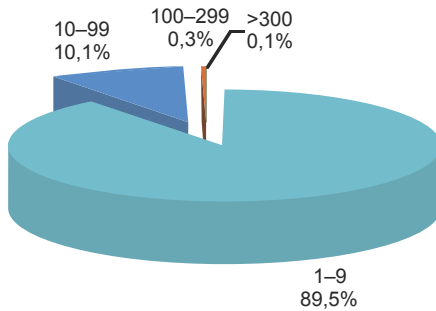
The principal sectors of the industry for detached houses include site-built and prefabricated, factory-built housing. In Japan, automatization on the building site is very high, except for the detached houses, where over 80% are still traditionally built homes. However, the largest and most advanced house factories of the world build the remaining 15-20%.

Although during the bubble economy between 1986-91 the construction firms went on a land-buying spree - and then had to cope with an 80% fall in land prices, traditionally the Japanese housing market is fairly detached from the land speculation. The attachment of Japanese households to the family plot of land is strong, with the result that the availability of large development sites is severely constrained. In most cases of single-dwelling housing production, customers own their land or make special purchases of land outside transactions for houses. Housing producers therefore cannot rely upon land speculation to ensure profitability; they must develop and use efficient production techniques [Gann, 1996].

Assembly of traditional carpenter-built houses takes around 120 days on site, conventional 50% prefabricated panel houses around 90 days, and modular unit houses as little as 40 days on site, including preparation of foundations, interior furnishings and inspection. The house itself is built up within 1-2 days.

### *Site-Built*

Traditionally, Japanese housing was and still is supplied by small, locally based builders using craft skills to build wooden post-and-beam homes. Today, these locally based suppliers use a combination of pre-cut timber and traditional craft skills to build timber-frame housing on-site. Iwashita [2001] impressively report how these traditional site-built homes make up the largest proportion of new housing constructed in Japan. In 1995, construction of traditional type of housing numbered 460,000; nearly 80% of all single-family custom-built houses. A small local contractor who is one of 83,000 small firms engaged in the manufacture and construction of custom-built single-family homes typically builds these houses. More than 90% of these firms manufacture or construct less than 10 dwellings annually. They are operating on a small scale. Large specialist house-building companies produce approximately 20% of single-family custom-built houses. Companies that produce more than 100 dwellings each, account for nearly 100,000 units annually.



Houses built per year/company	number of companies
1-9	74'000
10-99	8'368
100-299	277
>300	67

FIG. 54 The structure of the single-family custom-built housing industry in Japan. 90% of the companies build less than 10 homes per year!. [source: housing Loan Corporation, 1994, as cited in Iwashita, 2001]

### Factory-Built

Japan has a very long tradition of craft production, based on woodworking skills, which is still very present today, in contrast to the highly developed industrial production of houses [figure 54]. The first attempts in industrialized production started in the 1950s when overproductions on the supply side from materials and components industries [steel, plastics and plywood] were seeking for new markets. Matsumura [1994, as cited in Gann, 1996] states, that the main motive for industrialization by suppliers was conversion from armaments manufacture to housing [to find new markets for excess steel capacity], and not cost-reduction in housing production. This motive was supported by a large and stable market and pressures arising from shortages of skilled carpenters, depletion of indigenous supplies of timber; low quality housing; rapid economic growth and urbanization; the need for earthquake protection; oil-shock price rises; and the need for better fire protection in housing [Gann, 1996].

Early forms of industrialized housing adopted many techniques from the West and produced highly uniform houses from a small amount of components. These houses had difficulties to compete with the conventional timber methods, which offered greater variety of style. It was the search for new market opportunities, which led Sekisui Chemicals to invest into housing and surplus production of steel in the case of Daiwa. Both, Sekisui House and Daiwa House Industry are the world largest House producers, followed by Misawa Home [see Example Companies]. They have been able to sustain a continuous growth, by reacting on the market with continuous product improvement and variety. The market share for prefabricated houses doubled between 1980 and 1992 [Figure 51]. Sekisui House produced in its first 14 years of existence as many houses as in 1994 alone. The market growth was also related to the high-density housing markets in urban areas, where customers had positive attitudes towards factory-made products developed by manufacturers, who were increasing their efforts to satisfy consumer preferences.



The Japanese prefabrication industry has been able to build up a branding, which stands for quality. The companies consult their clients very well. In big showrooms materials and equipment can be valuated. The plan is done with the client on the computer and simulation can be watched. Once the plans are agreed, the data goes directly into the factory and the house is finished within 40 days, including preparation of foundations, interior furnishings and inspection.

The Japanese industry is strongly benefiting from the process of ongoing learning and improving, which is so inherent to Japanese culture. Like its people, Japan's enterprises are involved in an interactive, dynamic learning system in which they adapt and change in response to learning from past experiences, competitors, suppliers, other sectors and from overseas. What became common practice during the 1990s in the West – aka lean production - originated in Japan in the 1950s, when Toyota's President Eiji Toyoda started to initiate a process to simplify the production of cars. The low resistance of Japanese companies for cross-industrial learning, enabled the industrial housing companies to benefit very quickly from modern production technologies and pick-up computer-aided robot construction as early as 1990.

Steel-frames housing accounts for the largest market share of prefabricated units. In a highly industrialized process steel has many advantages like robot welding, cold forming, high precision and form consistency.

### *Building Types*

Japanese housing starts can be differentiated into wooden housing units and non-wood housing units. Residential housing was dominated by wooden housing well into the mid-1970s, accounting for almost two-thirds of all housing in 1976. However, the continued growth in multi-family housing and prefabricated single-family housing has contributed to the declining share of wooden housing and in 1999 wooden housing represented just 46.6% of all housing starts in Japan.

In terms of construction, wood-frame houses, including fire-resistant wood-frame houses, in the group of detached houses totaled 24,51 million, which accounted for 92,5% of the total detached houses. As for apartment flats, ferroconcrete or steel ferroconcrete structure amounted to 13,61 million units, accounting for 72,6% of the total apartment flats.

The factory-built housing sector has been able to catch up the decreasing market for detached houses are partially by apartment buildings (Figure 55).

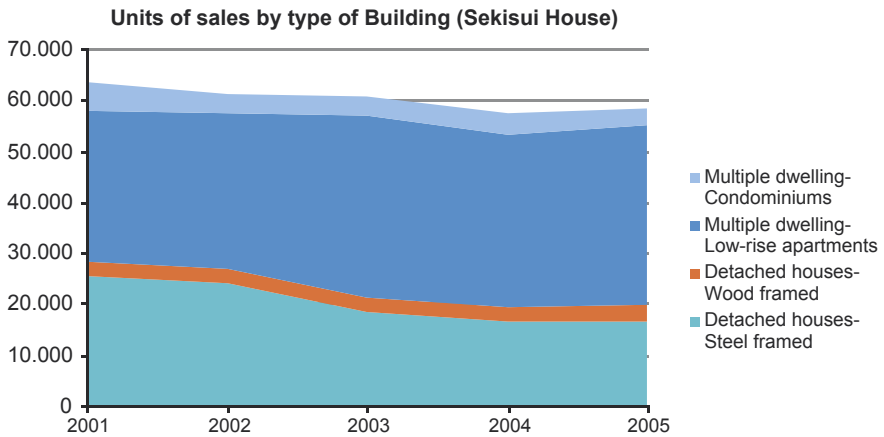


FIG. 55 The chart above shows how industrialized housing companies catching up the decreasing market for detached houses is partially by apartment buildings. It also shows the majority of steel-frame housing in the prefabrication industries. [Source: Sekisui House Ltd.]

The major prefabricated structural systems include timber-frame, steel-frame and reinforced concrete systems. Timber-frame houses come in pre-cut or 2 x 4 systems. Steel-frame systems include factory-made light-gauge welded panels or frames and modular systems. Reinforced concrete systems are mainly used for flats and apartments. The majority of factory-made detached houses are steel framed.

Figure 55 also shows that in the case of Sekisui House over 80% of the detached houses are made from steel-frame systems, which allow a very high level of customization.

#### *Quality of the Single-Family House*

Japan is not just known for its large house factories, but also for a very high level of industrialization, a high level of technology, high incomes and a high quality of living. However, when it comes to housing we have to challenge our preconceptions. Actually the housing standards in Japan compared to Western or even European standards are very poor. This is controversial. Although Japan ranks quite high when looking at the number of televisions per household or other electronic equipment, housing is typically poorly built, smaller than in the West, and lack what is considered as basic utilities in some Western countries, such as insulation, central heating or double-glazed windows. 1/3 of houses are built in non-fire-proof wood. What is more, recent scandals have revealed that at least 20% of houses in Japan use potentially life-threatening asbestos.

But more so, even basic structure seems to be under question. Recent market trends, including the adoption of the Housing Performance Indication System, revisions to the

Building Standards Law, crime prevention initiatives, and other social needs-driven measures, as well as heightened public concern regarding energy conservation, health, safety, and the environment have made customers' housing demands more challenging than ever. However, in a 1998 study by the Ministry of Land, Infrastructure and Transport, it was revealed that 32% of the housing of Japan's approximately 44 million households, or roughly 14 million housing units, does not meet new earthquake resistance standards. Roughly 12 million of the 14 million substandard units comprised detached housing, accounting for 51% of all detached housing, while the remaining approximately 2 million units were multiunit dwellings. PanaHome Corporation (2004) believes this relative deficiency in earthquake resistance in Japanese housing to be one potential source of future rebuilding demand.

The average floor space of new single-family houses built in 2000 is 107 m<sup>2</sup>. The average of all detached houses is 123 m<sup>2</sup>. The situation is much worse in apartments where the average floor area is only 45 m<sup>2</sup>. According to a survey performed in 1998 by the Ministry of Construction, 47,5% of Japanese families are not satisfied with their homes (Figure 56). The value is a little bit less with 43% for the owner occupied houses, but in no comparison to the 3% of dissatisfaction found with British owner-occupied homes.

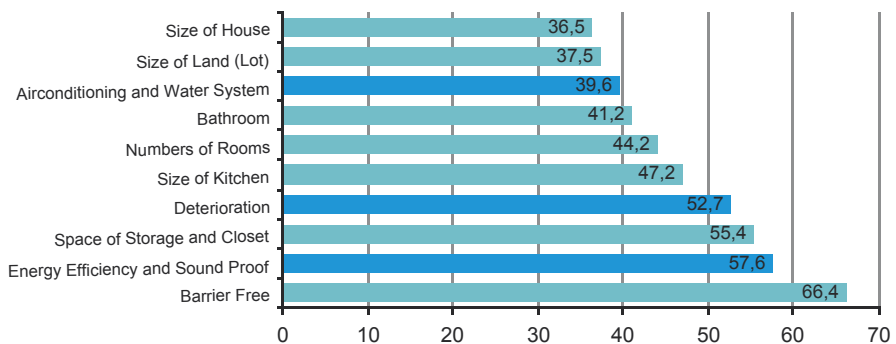


FIG. 56 Percentage of Japanese families, who are not happy with specific parts of their home. Basic technical systems highlighted by the author. (Source: Housing Demand Survey by Ministry of Construction[1998], as cited in Fumiaki, 2003).

Anderson reports in 2002 in the designcommunity.com Internet forum: "I live in a one-year old factory-built Misawa home. Under the skin and interior finish it is basically a traditional Japanese post and beam structure, on a 900mm grid. The structure was erected in a day. There is very little insulation or thermal breaks. This nearly new modern looking house has aluminum windows and doors and single pane glass. The owner wanted to save money, and the builder was happy to accommodate them. A better business practice would be to

refuse to sell windows that will damage the house. Moisture from condensation will get into the structure around the windows. People here are used to fogged up or frosted windows in the winter. Again no thermal breaks. The crawl space is heavily vented (basements are rare, except for architect designed custom houses) so the poorly insulated floors are cold in winter. These are “features”!

The high dissatisfaction rate is in stark contrast to the low moving frequency of people in Japan. Japanese move about 3-5 times less than English and Americans.

In the U.S, the ratio of annual investments for new house construction and house remodeling is about 2:1. Contrarily, in Japan, the ratio is about 7:1, which means that investment for house remodeling is very small. This reflects the condition that Japanese houses are generally demolished after a relatively short term (20 - 30 years) in order to build new ones. Nothing of the initial investment is left.

### *Example Companies*

The industrialized housing market is dominated by five major players, which share 80% of the market. These are Sekisui House, Daiwa House, Misawa Homes Sekisui Heim and National House, which are now called PanaHome (Table 4). Toyota Homes is actually a minor player in this field, although it is well known, as it has been the only car manufacturer entering the business.

FIRM	NO. OF DWELLING UNITS (1993)	NO. OF DWELLING UNITS (2003)
<b>Prefabrication</b>		
Sekisui House	70.000	61.000
Daiwa House	40.000	42.000
Misawa Homes	50.000	30.000
Sekisui Heim	34.000	16.100
National House	32.000	N/A (now PanaHome)
Toyota Homes	4.000	4.000*

**TAB. 04** The largest Japanese house builders are all fully industrialized. Numbers are approximate. (sources: 1993: Gann, 1996; 2003: Annual reports of companies; \*Inoue, 2004)

The history of these companies provides an important clue to how they have developed their manufacturing capabilities. None of these companies evolved from traditional craft house-building firms; with the exception of Misawa, large conglomerates, which were able to invest heavily in factory facilities and R&D, started them. In 1960, Sekisui Chemical Company established Sekisui House, hoping to exploit new markets for plastic products.

Sekisui Heim, a wholly owned subsidiary of Sekisui Chemicals, was formed in 1972 to compete in the markets for modular housing. Daiwa, a tubular steel fabricator, established Daiwa House in 1958. National House was established in 1963 as the housing division of Matsushita Group, the electrical components, consumer goods and heavy electrical products conglomerate, its major shareholders are Matsushita Electric Industries and Matsushita Electric Works. Its electronic products are also known as NationalPanasonic. In 2002 the group has been joined with its subsidiaries to the PanaHome group. Misawa Homes was established in 1967 as a company specializing in prefabricated housing [Gann 1996].

The general economic slowdown in the Japanese market and the harder competition under the homebuilders is forcing the companies to diversify the revenue stream. Many of them focus towards distributing only high-end housing units, especially around the Tokyo area, where demand is relatively stronger. Also more stringent environmental laws will challenge the industries in Japan, where traditionally houses have been relatively low insulated and equipped with individual air-conditioners against summer heat [Datamonitor PLC, 2003b]

### *Sekisui House*

Sekisui House based in Osaka, Japan is the largest homebuilder with business in the construction, sale, purchase and administration of residential properties; the design, execution, contracting and supervision of construction projects; real estate brokerage and landscaping. Sekisui House currently has 14,191 employees and in the fiscal year ending January 2002 reported sales of \$9.82 billion. Sekisui Chemical is the major shareholder of Sekisui House, with 21,90% of issued stock. Sales from construction contracts accounted for 75% of fiscal 2002 revenues; subdivision realty sales and other, 25%.

Sekisui House makes prefabricated steel or timber-framed housing panels in seven factories [Figure 57]. The company controls the whole process from design to final assembly on site, providing a high degree of customization to buyers, using the IT-based Sekisui's Flexible Planning System and HyperRips, a database supported system to quickly visualize a customized house in the sales offices. Its own expertise in software systems led them to extend business into computer software and information processing system areas. The company maintains sales offices and show rooms in prime metropolitan locations, which convey a high standard in customer care policy and product quality. A clear philosophy, based on trust, quality and comfort is contributing to a good brand image and reputation.

Through its focus on high customizability, Sekisui house has to deal with up to 2 million different kinds of parts. This is where its expertise in Logistics Software developed. Factory-produced elements of each house typically contain around 30,000 items, comprising 700 different component types. Components are stored in automated vertical warehouses,

which can be operated by a single person, controlling several cranes at once. Between 20 - 25% of the value of Sekisui Houses are produced in their factories, which make and assemble frames, wall panels, insulating materials, floors, partitions and doors, and make components kits of windows and roofs to be assembled on site. Today Sekisui House as a fully computerized production system. Steel frames are assembled by welding robots and continue to do electro-deposition coating, followed by baking-dryness without ever stopping. Also the integrated production of exterior wall panels is conducted on a single conveyor line all the way to a 3-step primer coating.

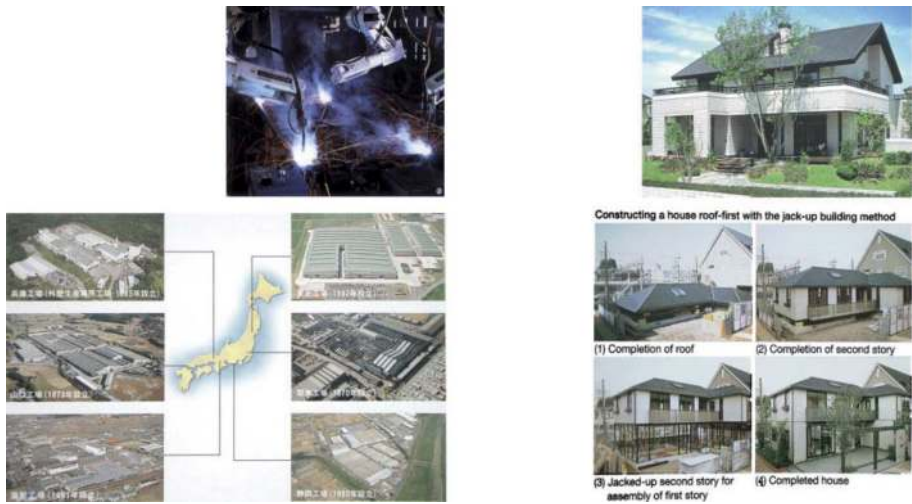


FIG. 57 Sekisui House is the world's largest house producer. It is highly industrialized, employing robot construction and a high degree of automation. [source: Sekisui House]

### *Sekisui Heim*

Sekisui Heim, produces about 20.000 homes, assembled from room-sized modules, which are produced in factory. The principle is to have a high degree on standardized module production, which result in a range of standard houses, which can be customized to a certain degree, which is naturally much less, than the panel system offered by Sekisui House. Sekisui Heim's U-shaped production and assembly line allows to finish one unit in 3 hours. Production start times can be staggered on the line such that all the units necessary for a complete houses can be finished in 3,5 hours. The on-site time is still 40 days, although this is the shortest compared to around 90 days of prefabricated panel systems and 120 days for traditional carpenter built houses [Gann 1996]. Nevertheless, the assembly of the house on site is only 1-3 days [Barlow 2003]. The rest includes site preparation (including the removal of the old house), interior fit-out and hooking up to

services, whereof on-site interior fit-out [kitchen and bath are pre-installed] includes mainly the floors and other exposed surfaces [Figure 57]. The modular approach the company set-off to differentiate itself from the competitor in terms of completion time and costs. Its focus ranges from the middle of the market upwards, although it is now concentrating on more expensive homes. Sekisui Heim's sales costs, excluding land and site preparations, are about 16% higher than conventional post-and-beam 'traditional' housing, but 18% below those of other modular housing suppliers. In mid-2000, average costs per m<sup>2</sup> were about ¥143.000 or 946€ at purchasing power parity. [Barlow, 2003]

### *Daiwa House*

Daiwa House Industry Co is a diversified construction company. It is a leading manufacturer of prefabricated housing in Japan and is also involved in the construction and redevelopment of residential and commercial properties. When the fiscal year ended on 31 March 2002, the company had generated revenues of \$9.03 billion [Daiwa House Industry Co. Ltd., 2004]. Daiwa, a tubular steel fabricator, established Daiwa House in 1958. Thus first houses were the shelter-like, fairly primitive "Pipe Houses" and the "Midget House" constructed from steel pipes. Today the company's product range extends to more comfortable dwellings such as barrier-free housing for the aged and disabled. Meanwhile Daiwa House is the 2<sup>nd</sup> largest house producer in Japan with 65% of its sales being housing, whereof 52% are single-family houses. The company also operates in the commercial building sector as well as managing 30 resort hotels. Daiwa House Industry also operates a chain of 36 Royal Home Center stores offering DIY products. The company still claims though single-family houses being their core business, where they offered the whole range from prefabricated steel frames house to 2 x 4 construction and even traditionally built timber houses. The decline in the house market makes them move more strongly into the renovation market. The company maintains 13 factories and is headquartered in Osaka.

### *PanaHome [formerly National House]*

PanaHome Corporation was established in 1963 as to support the Matsushita Group's housing business. On October 1, 2002, the 28 principal subsidiaries of the PanaHome Group merged to form PanaHome. The house-building segment was formerly known as National House. Originally sales had to be kept separate from the production system because many of Matsushita's existing customers for electrical components were small house builders, who might have been put out of business if the company were to sell houses directly. Today, next to the franchise system, where kit-houses are sold, PanaHome also follows a shop-display approach, where the company acts as land developer, putting up model homes to be sold and customized within one year. The company follows a 'Eco-Life' philosophy and offer houses with optional solar cells. Also they market the steel-frame dry-bolt construction has environmentally favorable, since houses can be disassembled and

recycled more easily. They maintain 4 plants in Japan. The integration of the Matsushita Electronics group allows potential in smart homes, which is not fully exploited yet. [PanaHome Corporation, 2004, March 31]

### *Misawa Homes*

Misawa Homes Co. Ltd., headquartered in Tokyo, Japan and established in 1967, specializes in creating and presenting computer-based architectural views of home designs and produce mainly in timber-post frame construction. In 2001, the company recorded revenues of \$4,2 billion. Consolidated subsidiaries operate manufacturing and sale of prefabricated housing materials, construction works, and golf course and resort facilities. Misawa focuses on the Urban clientele introducing early zero energy homes and home robot systems. Nevertheless the deflating economy and the decreasing new house sales forced them into a price war with competition.

Misawa developed its sales system having learnt from Toyota's car sales methods, which involved franchised agents in strong regional companies. Bridgestone, the car tire manufacturer, established Misawa's housing sales network in the early 1970s because they wanted to learn from their experience in new markets.

### *Toyota Home*

Toyota Automobile Industries enter the Housing Market in 1975. It is interesting to note the reasons for that, since although Toyota is much smaller than the other big producers, it is famous the automotive industry. They further developed the entire concept of lean production through the housing industry itself.

There is a tradition within the Toyoda family that a son from each generation must establish a new business. In the 1970s the third-generation son, Syohichiroh Toyoda, started the housing business because it was predicted to be a booming market, and Syohichiroh had wanted to be an architect in his boyhood. Nissan Motor Corporation, who developed a space rocket business had, already covered the other booming market of space exploration. [Gann, 1996].

Toyota Homes produce similar types of modular unit housing to those of Sekisui Heim. The target market is a slightly lower-priced housing, than the Sekisui Companies, nevertheless also Toyota still acts within the middle and high market segments. Toyota's housing group trades on the experience in automobile production in terms of quality, reliability and high levels of investment in advanced manufacturing techniques.



Toyota has three housing factories where Kasugai Housing Works is the largest and can produce an output of 2,000 houses per year. Its production capacity is 64 modules per day, averaging 5 houses per day. The factory processes around 4,000 component types for each house, amounting to around 120,000 components in total.

After an ongoing decrease in sales, Toyota established the Toyota Housing Corp. with 170 employees in Nagoya in 2003. The aim of the new company was to quickly and accurately understand customers' needs for a timely and appropriate response in terms of product planning and sales. Toyota increased housing unit sales by 12.8% to 4,036 in one year from March 2004 to 2004. Toyota's housing unit ranks eighth by unit sales of housing behind Sekisui House Ltd. and Daiwa House Industry Co., Japan's two biggest housing companies. Recently Toyota followed a call by the Japanese Government to help save the stumbling Misawa Homes Holding Inc., which may result in the acquisition of one third of Misawa by Toyota, which could extend Toyota's sales network. [Inoue, 2004]

### *Conclusion*

Given the steep downturn in Japan's economy, competition for business is tough between the principal players in the market. Sekisui House is Japan's largest homebuilder, both in revenue terms and the actual number of homes built. In Japan the large homebuilders are all fully industrialized producing in several factories. Astonishingly, their market share does not exceed the ones found in the Western industrial states. Although it has been steadily growing since the 1960s, it seems to have leveled at only ~15%. Very small traditional builders serve the rest of the house building market. It is interesting to note that the Japanese prefabrication companies managed to grow through the difficult time in the market they experienced by diversification and research into future markets, especially homes for the elderly population. The Japanese prefabrication industry runs an economy of scale with an output well above 30,000 units a year for the big ones. They are fully industrialized with a high degree of automation. Learning from the automotive industry the principle of lean production is fully employed. A continuous CAD workflow is established and robot welding and fully automated assembly and painting lines are standard as in the automotive industry.

General quality of Japan's housing is shockingly low. Even the factory-built homes would not fulfill the expectations of a German homebuyer. However, the research-based improvement of the product home, which is done by the big manufacturers, allows them to offer a better product with a higher degree of quality control, than the traditional onsite-builders. Japan's factory-made houses thus are not cheaper than traditional homes, but offer more value for the owner and a better warranty. The average lifetime of the houses is very short: 26 years. Usually the house is destroyed and a new one built after this time, which does not leave any return of investment for the Japanese homeowner.

The Japanese prefabrication industry has been able to built up large, solid companies, which sell a product, which has also a high reputation. Other than in Western house-building companies there is a solid investment into research to improve the product. Especially in earthquake resistance the factory-made steel-frame houses prove the stability. The industry is also exporting into the growing region of Asia-Pacific and is expected to grow further with the recovery of Japanese economics.

## BIBLIOGRAPHY

A Boom Out Of Step. [2003, May 31]. *Economist*, p. 5.

Anderson, G. [2002, July 18]. Message - Re: ArchWeek - Working Steel and the Tokyo Mini-House. [www.designcommunity.com](http://www.designcommunity.com). Retrieved November 21, 2005, from <http://www.designcommunity.com/discussion/20112.html>

Barlow, J. [2003]. Choice And Delivery In House Building: Lessons From Japan For UK Housebuilders. *Building Research & Information*, Vol. 31 Issue 2, 134-145.

Daiwa House Industry Co. Ltd. [2004]. Annual Report 2004. Osaka, Japan.

Datamonitor PLC [2003a]. Homebuilding in Japan [Reference Code: 0104-2074]. New York.

Datamonitor PLC [2003b]. Sekisui House, Ltd. Company Profile [Reference Code: 1497]. New York.

Fumiaki, K. [2003]. Opportunity and Challenge: Changing Housing Market in Japan [PowerPoint Presentation]. Retrieved November 8, 2004, from [http://www.ep.org/presentations/sem\\_japan\\_market.ppt](http://www.ep.org/presentations/sem_japan_market.ppt)

Gann, D. M. [1996]. Construction As A Manufacturing Process? Similarities And Differences Between Industrialized Housing And Car Production In Japan. *Construction Management & Economics*, Vol. 14 Issue 5, 437, 14p.

Inoue, K. [2004, December 28]. Toyota May Buy 10% of Misawa, Part of \$1.35 Bln Aid (Update2). Retrieved February 10, 2005, from <http://www.bloomberg.com/apps/news?pid=10000080&sid=ajoHcdf51Z8&refer=asia>

Ishikawa, T. [2003, February 3]. The Current Situation of Japan's Housing Market, and Policy Implications of the Projected Population Decrease. NLI Research, Economic Research Group. Retrieved November 8, 2005, from <http://www.nli-research.co.jp/eng/resea/econo/eco030203.pdf>

Iwashita, S. [2001]. Custom Made Housing In Japan And The Growth Of The Super Subcontractor. *Construction Management & Economics*, 19, 295-300.

PanaHome Corporation. [2004, March 31]. Annual Report 2004 Osaka, Japan.

Rebuilding. [1996, April 13]. *Economist*, p. 62.

Sekisui Heim. [2000]. Sekisui Chemical Co. Ltd. Retrieved February 4, 2005, from [http://www.sekisuiheim.com/english/top\\_eng.html](http://www.sekisuiheim.com/english/top_eng.html)

Sekisui House, L. [2000]. Sekisui House Corporate Profile. Osaka, Japan.

Sekisui House, L. [no date]. Six Factories. Japan.

Statistical Training Institute [Ed.]. [2004]. JAPAN STATISTICAL YEARBOOK 2005. Statistics Bureau / Ministry of Internal Affairs and Communications.

## Conclusion

The comparison of the world largest housing markets of Europe, the United States and Japan couldn't be more intriguing. Worldwide, the interest rates reached historic low values, which should be an easy explanation for the booming markets found in the US and some European countries, but Germany and Japan are not booming. In all economies the detached single-family house is the most wanted form for living, but also the most expensive. However, well over one half of the dwellings are houses, even two thirds in the US, where less than 3 years of average incomes are needed to buy a home, compared to nearly ten in Germany. This would make high-salary countries like Germany or Japan obvious candidates for factory-made houses. And indeed, Japan has the most advanced factories for houses. But in none of them the market share of prefabricated houses is reaching more than 15%. Even in the US, where manufactured homes have been up to 28% of new housing starts in the 1980s, a sharp decline during the booming housing market has brought them down to 6,6% in 2004, resulting in the trend line also reaching about 15%.

On the other hand, the trend in Japan for factory-made houses is increasing. In all regions the rest of the market is covered by small traditional contractors, although in Europe and the US, they are subcontracted mostly by large housing developers. The small traditional on-site builder can successfully compete with the mass-produced factory-made house. Obviously the industrialization of the house construction does not have a strong enough influence on the price and the quality of the product, to rule out the small contractors with their low entry and exit costs. In Japan, the house is the closest to a consumer product. After an average lifetime of 26 years, the building is usually destroyed and a new one built, the investment is consumed with no value left. Also the land is usually bought separately from the owner and there is not as much development in detached housing market as there is in the US

and Europe. But houses, even factory-made ones, are very expensive. Current endeavors of the Japanese companies to make the house cheaper or to make it longer lasting may increase their market share. Generally the factory-made house in Japan does not have such a negative image as in the US and Europe, but Japanese are very strongly attached to their tradition, especially if it comes to the house, which is a craft-made timber construction. Although many couldn't afford a real traditional Japanese house, the site-built wood-frame house makes them feel closer to it, than the factory-made steel-frame one, with all its advantages. In the US, the house is usually an investment product, where an increase in value, or at least a stable value is expected. Usually the house is bought together with the land, often from a developer. The situation is different with the manufactured or mobile homes, as they are also called. The land in the dedicated trailer parks is usually rented. However, even manufactured homes usually keep a value on the second hand market. This is also supported by the fact, that only 3% of all mobile homes are ever moved again after their first installation. The initial success of the manufactured home industry to provide affordable houses within as system of owned mobile houses and rented lots in trailer parks, seems to become its fate, since the industry seems not to be able to react on the increasing wealth of the people, looking for larger and more luxury homes, which offer an alternative investment in times of low interest rates. Also many producers ran into overproduction and loan problems. Since the Manufactured homes have been serving the low-income market and operated in dedicated trailer parks, they never lost the 'poor-man's' image. On the other hand, the big homebuilders, who used to work on a subcontracted traditional site-built basis like Pulte Homes, have been growing so much, that they started to invest into modern factories to produce panelized homes for their own use. In Europe, similar to within the US, a house is an investment product, with an even longer lifetime. Since the land value contributes most to the development of the value, location is a prime factor. In Europe the prefabricated home industry operates under the same conditions like the normal market. Although the quality of the prefabricated buildings is considerably high, the industry has been suffering under the 'run-of-the-mill' image, since the industry has not been able to build up their own character. In countries like Germany, people are also reluctant against the normally used lightweight timber-frame constructions, since they are used to solid brick-stone houses. The self-destroying price war in the German construction market and the increasing need for houses predicted in the UK and the Netherlands may offer new chances for industrialized housing. Table 5 is showing some key data in comparison of the largest house markets. Japan has most clearly understood the industrial production of houses as a ongoing process of research and improvement, although its effects on the building market are not different after all than in the other economies. The building sector shows impressively that industrialization is not necessarily a natural process with no point-of-return.

CA 2001	EUROPE [EU-25]	UNITED STATES	JAPAN
Population	437 mio	281 mio	127 mio
Existing Housing Stock	201 mio [est.]	119 mio	44 mio
Housing Starts	1,7	1,7 mio	1,2 mio
Housing market	Booming to shrinking	Booming	Shrinking
Value of Housing Market EUR	320 mio [est.]	360 mio	165 mio
Percentage of detached houses	55% [EU-15]	66%	56%
Traditional Construction	Brick-Stone	Timber-Frame	Timber-frame
Life-time	75	44	26
Average sqm [existing]	100 [est.]	162	123
Average sqm [new]	120 [est.]	211	107
Median Price	130.000 EUR [UK]	120.000 EUR	240.000 EUR
Average House Quality	High	Medium	Poor
<b>PREFAB</b>			
Market share	15% [est.]	15% [average trend downwards]	15% [average trend upwards]
Target Market	Lower-medium	Low end	Medium-luxury
Output of largest companies	3.000 units/year	20.000 units/year	30-60.000 units/year
Main construction	Timber-frame	Timber-frame	Steel-frame
Automation	Medium-Low	Low	High
General Character	"Advanced building site under a roof"	"Building site under a roof"	Fully industrialized
Production Character	Serialised Variety Production	Serial Standard/ modular Production	Mass-customisation

**TAB. 05** Differences and similarities in the main housing markets Data for owner-occupied (mostly single-family houses) [sources: different sources and estimates by the author]



# 02 THE INDUSTRIAL PRODUCT

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Products are traded on markets to satisfy the needs of people (Figure 58). The relation of the industrial process to the market and needs.]. Next to its basic functions all products have further attributes like features and design, which may have an influence on the buyer's decision. The industrial product is the result of the industrial process. At the beginning of the industrial revolution, this process was mainly based on mechanization made possible by science and engineering and cheap labor and land costs. The prime concern was the costs of raw material. Today, the cost of raw material is still a concern, but with increasing labor and land costs the development of the process has become the prime concern. The ongoing fine-tuning of that process allowed the development of factories with less and less people working, but producing more products, considerably cheaper. The modern industrial process is an ongoing cycle starting with research, design, production, quality control, marketing and distribution. This process requires continuous attention and improvement to stay competitive and ensure profits.

The globalization not only opened new markets, but also created a much higher competition, which deeply restructured our industries and the understanding of the industrial process in the last decades. Today's companies face an increasing speed in the product development, having to offer new products continuously. The car industry is offering new models every other year, whereas the consumer electronics are down to a few months. This speed has in a first step been achieved by a more efficient logistical understanding of workflow and recently by interlocking most processes digitally. Traditional producer markets have turned into consumer markets, where marketing and marketing research has become increasingly important.

The results of this 'third' industrial revolution are products, which are on a very high level and relatively cheap.

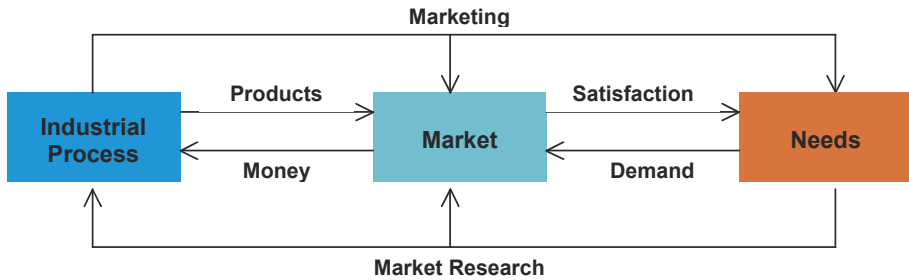


FIG. 58 The relation of the industrial process to the market and needs.

## 02.01 THE PRODUCT

A product can be considered from many sides: The need, the function, the use, its production, the branding and marketing. Products need not only be hardware, but can also be services. Nevertheless, we will consider the hardware product, which is manufactured under industrial conditions. The way we look at products fundamentally changed in the last decades. In the 1950s a good product still was a product that worked. Today, where global competition and legal consumer protection is much higher developed, the levels of value of a product are much more complex. Products are expected to work today and are protected by warranties and producer liabilities. Through this development design has taken an increasingly important role to distinguish products and target them to the consumer. A product has certain attributes and is usually responding to needs. It is offered on the market, where attributes and needs meet at a certain price.

### Attributes

On an individual level, each product has its own specific attributes and technical requirements. A product fulfills a certain core function, like it is expected an airplane to fly. On a higher level all products offer additional benefits, which are communicated and delivered by tangible product attributes like quality, features, style and design. But also branding and the price are important attributes of a product [Figure 59].



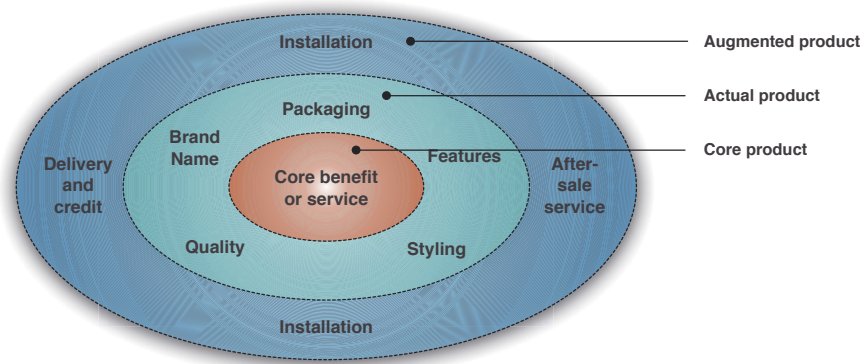


FIG. 59 Modern marketing identifies 3 level of a product. The levels beyond the actual core product have become increasingly important in the recent years. [source: Kotler, 2004]

### Quality

Quality is defining how well a product performs its function, thus it is a major attribute and closely linked to customer value and satisfaction as well as production and industrial design. In the narrowest sense quality can be define as 'freedom from defects'. But, there is more to it. The product performance over its lifetime is as important and especially with longevity products as vehicles and houses aspects like maintenance and flexibility are quality attributes. Kotler [2004, p 546] defines product quality with the ability of a product to perform its functions; it includes the product's overall durability, reliability, precision, ease of operation and repair, and other valued attributes. Although some of these attributes can be measured objectively, from a marketing point of view, quality should be measured from in terms of buyer's perception. Many of today's companies are not product-centered anymore, but customer-centered. They define quality in a much wider approach with customer satisfaction [Kotler, 2004]. Siemens defines quality this way: "Quality is when our customers come back and our products don't." However, the "Total Quality Management" TQM has become an inherent and successful tool to improve a company's performance during the last two decades. TQM derives as the whole modern production from the Toyota production systems, where 'quality circles' were introduced and the Japanese concept of 'kaizen' as a continuous improvement process was introduced. Product quality has two dimensions - level and consistency. Not each product can be of the highest objective quality without compromising affordability. But the level of quality needs to be right for the product offered and its market segment. Not everybody wants or can afford a Rolex watch to check the time. Beyond quality level, high quality can also mean high levels of quality consistency. Here, product quality means conformance quality - freedom from defects and consistency in delivering a targeted level of performance.

## Features

Features are additional functions and values offered to the core product. A 'stripped-down' model without any extras is the starting point. Often extra features do not add to the costs for the company, but are a competitive tool for differentiating their product from other competitors. Apple's success of the iPod is not only based on its own product features and design, but the feature, that it is integrated in an easy flawless software for administration of one's music library and the shopping of music. One of the best sources for identifying new competitive features is the user themselves. The features should be assessed on the basis of its customer value versus its company costs.



FIG. 60 The Fiat Multiplo and Doble MPV [right] often have been dubbed as the worlds ugliest cars and didn't help Fiat to prevent dramatic losses on market share.

## Style and Design

Further customer value is added through product style and design. Style has got a big attention since the beginnings of industrial design, but especially with the 'streamlining' in the 1930s, which made designers like Raymond Loewy and Norman Bel Geddes celebrities. But style simply describes the appearance of the product. Design is a much broader concept. Style may attract a lot of attention, but it doesn't necessarily make a product perform better. Design does. Design goes to the very heart of the product. Good design contributes to a product's usefulness as well as to its looks. It can attract attention, improve product performance, cut production costs and give the product a strong competitive advantage in the target market [Lorenz, 1990]. Some companies have integrated design with their corporate culture. Many of these belong to the most famous brands like Apple Computers, Braun, and BMW etc. Although Kotler [2004, p. 546] states that still many companies lack 'design touch'. Their product designs function poorly or are dull or common looking. Some companies like Fiat have learnt the hard way, that design

and style matters. The Italian car company's European market share had collapsed from 10% in 1990 to 6% in 2003. Part of the problem is that they have alienated drivers by succeeding in making some rather ugly-looking cars: Britain's Car magazine has described Fiat's Multipla (Figure 60) people carrier as having 'bozz-eyed swamp-hog looks' and that its Doblo MPV is a 'Toytown-styled utilo-box' that is 'very big if you're desperate for space. But you'd have to be'. [James MacKintosh, Fiat Facelift Ditches Ugly Cars, Financial Times [29 May 2003], p. 12, as cited in Kotler 2004]

### *Branding*

A brand is a name, term, sign, symbol, design or a combination of these, that identifies the maker or seller of the product or service. Brands are the tools with which companies seek to build and retain customer loyalty. Because that often requires expensive advertising and good marketing, a strong brand can raise both prices and barriers to entry. But not to insuperable levels: brands fade as tastes change [Nescafé has fallen, while Starbucks has risen]; the vagaries of fashion can rebuild a brand that once seemed moribund [think of cars like the Mini or Beetle]; and quality of service still counts [hence the rise of Amazon]. Many brands have been around for more than a century, but the past two decades have seen many more displaced by new global names, such as Microsoft and Nokia. The Economist reports [The case for brands, 2001] that a change is taking place in the role of brands. Increasingly, customers pay more for a brand because it seems to represent a way of life or a set of ideas. Companies exploit people's emotional needs as well as their desires to consume. Hence Nike's "just-do-it" attempts to persuade runners that it is selling personal achievement, or Coca-Cola's relentless effort to associate its fizzy drink with carefree fun. Companies deliberately concoct a story around their service or product, trying to turn a run-of-the-mill purchase [like Häagen-Dazs ice cream] into something more thrilling. This peddling of superior lifestyles is something that irritates many consumers. They disapprove of the vapid notion that spending more on a soft drink or ice cream can bring happiness or social cachet. Fair enough: and yet people in every age and culture have always hunted for ways to acquire social cachet. For medieval European grandees, it was the details of dress, and sumptuary laws sought to stamp out imitations by the lower orders; now the poorest African country has its clothing markets where second-hand designer labels command a premium over pre-worn No Logo. But brands have to be nurtured, they fall from grace and newer, nimbler ones replace them. Of the 74 brands that appear in the top 100 rankings in both of the past two years, 41 declined in value between 2000 and 2001, while the combined value of the 74 fell by \$49 billion – to an estimated \$852 billion, a drop of more than 5%. Brands of the future will have to stand not only for product quality and a desirable image. They will also have to signal something wholesome about the company behind the brand. Brands will communicate social responsibility [Who's Wearing the Trousers?, 2001]

## Needs

The most basic concept underlying a product is that of needs. Needs are basic parts of the human make-up and are states of sensed deprivation. The American psychologist Abraham Harold Maslow (1908-1970) has been describing a Hierarchy of Human Needs, which is often presented as a pyramid. The base of the pyramid is the physiological needs, which are necessary for survival. Once these are taken care of, an individual can concentrate on the second layer, the need for safety and security. The third layer is the need for love and belonging, followed by the need for self-esteem. Finally, self-actualization forms the apex of the pyramid. In this scheme, the first four layers are what Maslow called deficiency needs or D-needs. If they are not filled, you feel anxiety and attempt to fill them. If they are filled, you feel nothing; you feel only the lack. Each layer also takes precedence over the layer above it; you do not feel the lack of safety and security until your physiological needs are taken care of, for example. In Maslow's terminology, a need does not become salient until the needs below it are met. Needs beyond the D-needs are "growth needs", "being values" or B-needs. When fulfilled, they do not go away, rather, they motivate further [Table 6].

Truth	- rather than dishonesty
Goodness	- rather than evil
Beauty	- not ugliness or vulgarity
Unity, wholeness, and	- not arbitrariness or forced transcendence of opposites choices
Aliveness	- not deadness or the mechanization of life
Uniqueness	- not bland uniformity
Perfection and necessity	- not sloppiness, inconsistency, or accident
Completion	- rather than incompleteness
Justice and order	- not injustice and lawlessness
Simplicity	- not unnecessary complexity
Richness	- not environmental impoverishment
Effortlessness	- not strain
Playfulness	- not grim, humorless, drudgery
Self-sufficiency	- not dependency
Meaningfulness	- rather than senselessness

**TAB. 06** B-needs as being needs listed by Maslow. Note that the negative descriptions are as important to define the needs.

If a need is not satisfied, a person will either look for an object or service that will satisfy it or try to reduce the need. Wants are the form a human needs take as they are shaped by culture and individual personality. A hungry person in Hong Kong may want a noodle soup, whereas a hungry person in Denmark may favor a hot dog. People usually have narrow, basic needs [e.g. for food or shelter] but unlimited 'almost wants'. But, they have limited resources." Kotler (2004) describes Human wants that are backed by buying power as Demands. Consumers view products as bundles of benefits and choose products that give them best bundle for their money. Marketing research has become increasingly important, even for small companies. It explores the needs, wants and potential demands of different

target groups. Marketing research is the function linking consumer, customer and public to the marketer through information that is used to identify and define marketing opportunities and problems, to generate, refine and evaluate marketing actions, to monitor marketing performance, and to improve understanding of the marketing process. It is employing scientific research methods to get valid data, which is often very valuable for companies. Often new products are not the result of a direct want of people. Pre-Paid mobile phones derived from Italian market research. People did not say they wanted 'pre-paid' mobile phones but expressed anxiety about overspending on calls. Having developed the prepaid mobile phone system, it was tested using research to gauge consumers' reaction to the concept and their willingness to pay by testing various pricing options.

## Markets

The market brings the product to the people. A market is the set of actual and potential buyers of a product. These buyers share a particular need or want that can be satisfied through exchanges and relationships. Thus the size of a market depends on the number of people who exhibit the need, have resources to engage in exchange, and are willing to offer these resources in exchange for what they want. On the other hand the market consists of the supplier of seller, who offers the product to the people. With the increasing wealth of the societies, markets have been developing from producer's markets to consumer's markets, which are not any longer dominated by what's available, but by what the people buy. Kotler [2004] identifies five different concepts, which also reflect the historical development.

- 1 **Production Concept:** The philosophy that consumers will favor products that are available and highly affordable, and that management should therefore focus on improving production and distribution efficiency.
- 2 **Product Concept:** The idea that consumers will favor products that offer the most quality, performance and features, and that the organization should therefore devote its energy to making continuous product improvements.
- 3 **Selling Concept:** The idea that consumers will not buy enough of the organization's products unless the organization undertakes a large-scale selling and promotion effort.
- 4 **Marketing Concept:** The marketing management philosophy which holds that achieving organizational goals depends on determining the needs and wants of target markets and delivering the desired satisfaction more effectively and efficiently than competitors do.
- 5 **Social Marketing Concept:** The idea that the organization should determine the needs, wants and interest of target markets and deliver the desired satisfactions more effectively and efficiently than competitors in a way that maintains or improves both the consumer's and society's well-being.

The communication between the market and industries [Figure 61] is not always straight forward as many failures in product development show. Anthony Ulwick [2002] argues that many industries are just fulfilling the needs of people as they are communicated. But by asking people in the 1980s e.g. the mobile phone would not have been casted as a

successful product. Although buyers are looking on a market for solutions for their needs, they should not be asked what solutions they need, but what outcome they wish to achieve.

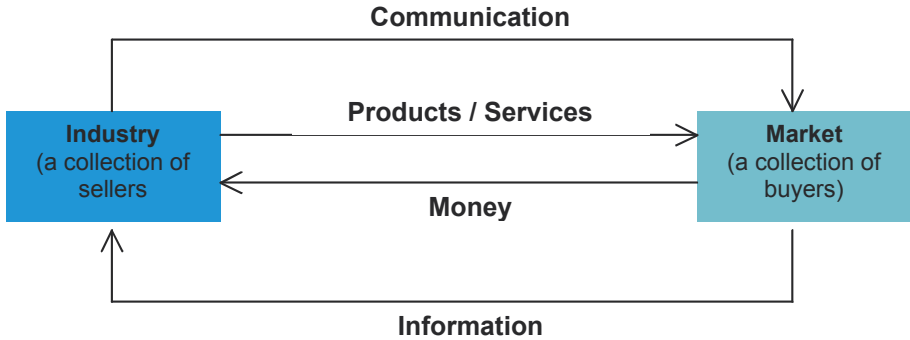


FIG. 61 Model of the relationship between industry and markets. [source: Kotler, 2004]

Modern marketing has a very wide approach to the product and identifies everything, which contributes to a successful product. It has also to be considered, that markets are increasingly dynamic and can quickly change. With better means of communication many markets have been accelerating in speed and quantity. Especially business-to-business markets are moving towards real-time markets [Figure 62].

Dynamic Trading Characteristics			
The changing demands of manufacturing show a move toward real-time, customizable transactions.			
Characteristic	Traditional Model	Current Internet Model	Bid Trading Model
Value proposition	Product	Information	Service
Speed	Weeks	Days	Real Time
Scope	Local	National	Global
Attribute	Seller-selected	Seller-selected	Buyer-selected
Pricing	List	List	Transactional
Production	Pre-sale	Pre-sale	Post-sale
Service	9AM-5PM weekdays	24X7X365	24X7X365
Consumer interactions	100s	10,000s	1,000,000s
Marketing focus	Product positioning	Consumer acquisition	Customer retention
Consumer relationship	Standard	Targeted	Customized
Strategic asset	Location	Visibility	Customer database

(Source: Forrester Research Inc.)

FIG. 62 Markets have shown a dramatic acceleration in the last decade, developing to real-time markets, where also price-building is real-time. [Source: Autofieldguide.org]

The industrial process of is the prevalent system of manufacture in today's 'industrial societies'. Manufacture of products went through three basic historical steps, which also exist in parallel today. These steps were craft production, mechanization and automation. Historically the main focus of the industrial process was on production. Today there is a more holistic view on productivity and competitiveness. Competitiveness is requiring the companies to invest into research to be able to stay on the leading edge with their products. Marketing has become a general approach to guarantee the success of the product and is working closely together with design, which translates a product idea into an actual product for fabrication through production. Today's production technologies don't allow for tolerances and quality control is an integrative part of the industrial process. Logistics has always been important, but has become a major issue with the emergence of lean production.

In markets with low competition a product could be successful by just focusing on its production and its distribution. Now these times are gone, if they ever existed. Today the industrial process and the successful survival of a product have more aspects to it, which are equally important. The industrial process consists of research, marketing, design, production, quality control, distribution and recycling.

### Research

It is widely recognized that research is the main driver for innovation and increased productivity. In today's competitive markets no company can survive without constant improvement and innovation of their products, their production and their marketing. This can only happen by continuous research. The average spending of European companies in Research and Development is about 4% of their total turnover. Health care and pharmaceuticals are at the upper end with 12% and building construction at the lower end with less than 1%.

Research is best described as a "self-correcting" process; it is the foundation of the scientific method. Generally, one can distinguish between basic research and applied research. Naturally industries have a special interest on applied research, but much of the applied research is based on findings of basic research. This is always an issue, when it comes to funding of research. Often the effect of research is not immediate, but can take a long time to be implemented.

### Marketing

Marketing has become increasingly important in our consumer markets. Marketing is not advertisement, it is about an integrative understanding of markets and understanding and satisfying customer needs. Marketing communicates values rather than prices. It communicates these values to the customers but also inside the organization and thus

creates meaning and corporate identity. Today's successful companies have a strong customer focus and heavy commitment to marketing. These companies share an absolute dedication to sensing, serving and satisfying the needs of customers in well-defined target markets. They motivate everyone in the organization to deliver high quality and superior value for their customers, leading to high levels of customer satisfaction. These organizations know that if they take care of their customers, market share and profits will follow. Thus a sound marketing study often stands at the beginning of a new product development and the marketing department is involved at all stages of the process.

The last decade was full of examples how sometimes very old products have been successfully launched or reinvented by marketing. One example would be Starbucks introducing quick Italian espresso coffee worldwide and in turn, bringing Nescafé into financial trouble; the Smart Car, after the small car concept was abandoned by most manufacturers; or Puma and Adidas, who made wearing sneakers a fashion after it was completely out of fashion.

Because this new product development process typically requires both engineering and marketing expertise, cross-functional teams are a common way of organizing a development project. The team is responsible for all aspects of the project, from initial idea generation to final commercialization, and they usually report directly to senior management.

## Design

Like marketing the term design is not very clear for most people. There may be as many definitions as people. But, design is easy to define: Basically it is a process. The process from the idea to the product [Busse 1998, p. 16]. Good design provides a solution for a good product, which is based on safe technology, economical production, self-explaining ergonomics and appropriate aesthetics. But like marketing, design is more than a single act, it is a philosophy and can communicate much more than the above points. Design is a key element of the industrial process. Only with an existing design the whole calculations and estimates for the production process can be done.

Design gives the product its final looks and functionality. It immediately relates to the user and communicates its functionality. Consequent clarity in product design has an eminent influence on branding and the perception of the quality of a product. Some industrial designs are viewed as classic pieces that can be regarded as much as works of art as works of engineering.

Industrial design is an applied art whereby the aesthetics and usability of products may be improved. Design aspects specified by the industrial designer may include the overall shape of the object, the location of details with respect to one another, colors, texture, sounds, and aspects concerning the use of the product ergonomics. Additionally the industrial designer may specify aspects concerning the production process, choice of materials and the way the product is presented to the consumer at the point of sale. It is becoming



increasingly common to consider producibility in the initial stages of product design, a process referred to as design for manufacturability. It is much cheaper to consider these changes during the initial stages of design rather than redesign products after their initial design is complete.

Product design is focused on products only, while industrial design has a broader focus on concepts, products and processes. In addition to considering aesthetics, usability, and ergonomics, it can also encompass the engineering of objects, usefulness as well as usability, market placement, and other concerns.

## Production

Industrial production has been always a central focus in the industrial process. At the beginning of the industrial revolution the amount of production was rarely a problem, the more the better. The manufacturing industry has been very much producer-led. Even the supporting techniques – work-study, stock control, and so on – were designed to reduce costs and help the manufacturer. The range of products available in the marketplace was such that such an approach worked – the customer had to wait to get what he/she was offered. This changed by the increasing globalization of the markets. Next to product innovation the reorganization and improvement of the production process has become one of the main competitive factors of a modern enterprise [Jung, 2001, p. 517].

Production has different interpretations in literature. In terms of fabrication it means the machining of raw materials to semi-finished or finished products. According to classical economy the three factors of production are land, labor and capital goods. Production itself comprises the acquisition of these factors and the necessary raw materials, transport, stock keeping and fabrication.

Two basic principles of production can be distinguished: Craft production and flow production. In craft production the product comes to the means of production, which are the machines and workers, whereas in flow production they come to the product. In flow production the spatial and temporal organization of the production is in line-production to minimize distances, interim storage and tooling. Today necessary craft production is often integrated into the flow production in so-called 'production-islands'. These then feed the assembly line.

If the organization of production is looked at how many products are produced at a time, we can distinguish fabrication types. Bestmann [2001, p. 219-220] distinguishes one-time production, batch production, type production and mass production. One-time production comprises usually built-on-order products, which strongly differ. Usually craft production is employed and the final product is too big to be transported as a whole, with examples being building industries, bridges, ship construction and large machines. Batch production means that small series are run and require a certain tooling time to change to the next product. The process has to be optimized regarding tooling costs, storage and market requirements. This is mainly craft production. Type production can already be based on flow production,

where different variants of the same type can be produced on the same production equipment. An example is the clothing industry, where a dress is made in different sizes and fabrics. Mass production means that the same product is produced over a longer period of time. This production employs assembly belt and automatic assembly.

The basic underlying problem of these fabrication types is to combine flexibility and efficiency. Craft production is highly flexible, but has a low efficiency and mass production is the other way round. Only in the last three decades have computers been around to slowly revolutionize production.

The main resistance of high investment costs is slowly breaking up, as systems become cheaper, more elaborate and more flexible. In the last decade Computer Aided Manufacturing [CAM] made it in some way into most craft-based shops. The main advantages are increased efficiency and utilization of capacity, high quality levels and decreased pass-through times, storage and tooling costs.

The increasing flexibility of production – also called agile production – allows to react on the market. But, also the market reacts on the production capabilities and mass-customization is on the way to break-up another problem between individual craft production and mass production: the gap between design-to-order and the low-cost consumer product.

### *Craft Production*

In craft production, the craftsman must bustle about a shop, getting parts and assembling them. He must locate and use many tools many times, perhaps hundreds of times to assemble a complex product such as a clock. The quality of work is highly dependent on the individual and its qualification.

### *Mechanisation or Mass Production*

In mechanization or mass production, each worker repeats one or a few related tasks that use the same tool to perform identical or almost identical operations on a stream of products. The exact tool and parts are always at hand. The worker spends no time going and getting them. Thus a constant supply chain has to be maintained. Another important scale benefit is that the factory can purchase very large amounts of materials. This reduces the overhead costs (shipping, purchasing negotiations, paperwork, etc.) associated with purchasing the parts. Machines need power, which was originally delivered by streaming water. With the introduction of steam power and later electricity, the factory became independent from its location, as being near a river was no longer necessary. Today energy and transport logistics are available nearly anywhere.

The so-called American system of manufacturing, developed by Eli Whitney in 1799, involves semi-skilled labor using machine tools and templates [or jigs] to make standardized, identical, interchangeable parts, manufactured to a tolerance. Since parts are interchangeable, it is also possible to separate manufacture from assembly, and assembly may be carried out by semi-skilled labor on an assembly line - an example of the division of labor. In order to eliminate hand tools, Whitney invented new machines to eliminate all skilled operations - introducing a kind of router to replace the chisel, for example. The next revolution in mass production was the introduction of the conveyor belt or moving assembly and production line by Henry Ford, constantly keeping the process of assembly in motion. The economies of mass production come from several sources. The primary cause is a reduction of non-productive effort of all types. Another important scale benefit is that the factory can purchase very large amounts of materials. This reduces the overhead costs [shipping, purchasing negotiations, paperwork, etc.] associated with purchasing the parts.

#### *Just-in-Time or 'Lean' Production*

The Ford mass production influences all other industries and was quickly adopted. But mass production still produced a lot of waste. It needed vast storage spaces and inventories and was inflexible for the change of models, since times to change tooling were long. The next revolution in production was the introduction of the 'Just-in-time' or JIT system by Toyota. JIT causes dramatic improvements in a manufacturing organization's return on investment, quality, and efficiency. By careful analysis of the production process Toyota engineers reduced waste and downtime of production. The Kanban, a system that utilizes a series of signals and cards, tells production processes to make the next part. So each production process has a direct feedback and feed forward to the next process in line. Toyota engineers then determined that the remaining critical bottleneck in the retooling process was the time required to change the stamping dies used for body parts. It sometimes took as long as several days to install a large [multi-ton] die set and adjust it for acceptable quality. Procedural changes [such as moving the new die in place with the line in operation] and dedicated tool-racks reduced the die-change times to as little as 40 seconds.

Some of the results were unexpected. A huge amount of cash appeared, apparently from nowhere, as in-process inventory was built out and sold. This by itself generated tremendous enthusiasm in upper management. Another surprising effect was that the response time of the factory fell to about a day. This improved customer satisfaction by providing vehicles usually within a day or two of the minimum economic shipping delay. Also, many vehicles began to be built to order, completely eliminating any risk that they would not be sold. This dramatically improved the company's return on equity by eliminating a major source of risk.

Since assemblers no longer had a choice of which part to use, every part had to fit perfectly. The result was a severe quality assurance crisis, and a dramatic improvement in

product quality. Eventually, Toyota redesigned every part of its vehicles to eliminate or widen tolerances, while simultaneously implementing careful statistical controls. Toyota had to test and train suppliers of parts in order to assure quality and delivery. In some cases, the company eliminated multiple suppliers.

When a process problem or bad parts surfaced on the production line, the entire production line had to be slowed or even stopped. No inventory meant that a line could not operate from in-process inventory while a production problem was fixed. Many people in Toyota confidently predicted that the initiative would be abandoned for this reason. In the first week, line stops occurred almost hourly. But by the end of the first month, the rate had fallen to a few line stops per day. After six months, line stops had so little economic effect that Toyota installed an overhead pull-line, similar to a bus bell-pull, that permitted any worker on the production line to order a line stop for a process or quality problem. Even with this, line stops fell to a few per week.

The result was a factory that became the envy of the industrialized world, and has since been widely emulated.

The Just-in-Time philosophy was also applied other segments of the supply chain in several types of industries. In the commercial sector, it meant eliminating one or all of the warehouses in the link between a factory and a retail establishment.

### *Automation*

A step beyond mechanization, where human operators are provided with machinery to help them in their jobs is industrial automation, where the use of computers to control industrial machinery and processes are replacing human operators. This is turning into a new quality as since the 1980s, robots were introduced which were even more flexible than normal machines which were usually designed only for a one process step. The more universal robots can be operated by computers, and thusly, have become more flexible in their production potential.

### *Digitalisation or Mass-customization*

The continuous development of CAM starts to open new potential for manufacturing called mass customization. This is the latest development and may further revolutionize the consumer goods production. For a computer driven cutting machine as an example, it does not matter if one meter or two meters are cut; the process is as fast, just the data set needs to change. With the combination with robots and automated logistics the whole tooling process and machine set-up can be automated. This would allow that individual data, i.e.: the shoe size of a customer, go from shop directly to the factory, where one-off shoes can be produced at the same costs as thousand and without stopping the production process.

## Quality Control

Quality control is a set of measures taken to ensure that defective products or services are not produced, and that the design meets performance requirements. Quality Assurance covers all activities from design, development, production, installation, servicing and documentation. This field introduced the rules “fit for purpose” and “do it right the first time”. Quality has become so important in modern products, that it goes as a matter of course. Products today are expected to work and powerful warranty laws put the consumer on the stronger side.

It is a truism that “quality is free.” Very often, it costs no more to produce a product that always works, every time it comes off the assembly line. While this requires a conscious effort during engineering, it can considerably reduce the cost of waste and rework. Commercial quality efforts have two foci. First, to reduce the mechanical precision needed to obtain good performance. The second, to control all manufacturing operations to ensure that every part and assembly is within a specified tolerance.

A valuable process to perform on a whole consumer product is called the “shake and bake.” Every so often, a whole product is mounted on a shake table in an environmental oven, and operated under increasing vibration, temperatures and humidity until it fails. This finds many unanticipated weaknesses in a product. Another related technique is to operate samples of products until they fail. Generally the data is used to drive engineering and manufacturing process improvements. Often quite simple changes can dramatically improve product service, such as changing to mold-resistant paint, or adding lock-washed placement to the training for new assembly personnel.

Many organizations use statistical process control to bring the organization to Six Sigma levels of quality. In a six sigma organization, every item that creates customer value or dissatisfaction is controlled to assure that the total number of failures are beyond the sixth sigma of likelihood in a normal distribution of customers - setting a standard for failure of fewer than four parts in one million. Items controlled often include clerical tasks such as order-entry, as well as conventional manufacturing processes (Industrial and Manufacturing Engineering, no date).

The quality revolution of the last ten years arose because the marketplace has become increasingly global. The big players cut across national and even international boundaries in ways, which has opened up customer choice. The growth of service industries where the customer often plays a direct role in the service delivery process has led to an increasingly sophisticated and aware customer base. Manufacturing can no longer assume that it can put products out to customers to its own schedule and quality levels.

Of course, most manufacturing industries have realized this – at least those parts of the industry that have survived. They have spent the last ten years searching for change – change that will allow them to identify, and respond to, customer desires, and that will allow them to get their products to market quickly (Agile Manufacturing, no date).

## Logistics

Logistics is the art and science of managing and controlling the flow of goods, energy, information and other resources. In business economy integrative logistics comprise procurement, transportation, handling, stock keeping, distribution and disposal [recycling] of goods, services and energies.

Procurement can comprise all what is needed to run a company, which are land, labor and capital goods. In a narrow sense it comprises the procurements of raw materials for production. Distribution is comprising in the broadest sense to bring the product to the market and last not least to the client, both physically and virtually. Physically means transport and logistics and virtually is object to marketing and promotion [Jung, 2001].

The full computerization of logistics, which took place over the last few years, increased the speed of transportation and the reliability of system tremendously. The system led to a sharp reduction of storage, since the aim of modern logistic is, that no part ever has to be stored. It is either in the production process or transported. The well-known bar code is likely to be replaced by RFID-chips, which can send the information wireless.

The potential for the construction industry, which is operating with million of parts is tremendous.

02.03

## EXAMPLE INDUSTRIES

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All major industries have fully adopted the industrial process, except the building industry. As comparable industries to building construction automotive, aerospace and shipbuilding have been suggested several times. It is also fact that many architects have played with this parallel, but rarely the building industry. It is a fact, that the comparison is not so straightforward as architects do postulate in their specific manner [“Why can’t we build buildings like cars?”]. The first very obvious difference is the immobility of the end product, the house. Automotive, Aerospace and shipbuilding hand over a finished product, which is ready to use, whereas building always involved a certain amount of site work and site adjustments. The US Department of Commerce employs this characteristic of immobility as a criterion in defining construction. For example, 1982 Census of the Construction Industry claims that even though ships are heavy, durable, complex and costly goods, shipbuilding is not classified as construction since ships are movable. For the same reason, data regarding mobile homes and travel-trailers are included in the manufacturing census rather than that of construction. Historically, construction refers to all types of activities associated with the erection and repair of immobile structures and facilities. However, the scale of aerospace and shipbuilding components are as large and complex in geometry as any building parts and transportation has never been a problem in history and has never been as cheap as today.

The reason why there is such few technology and process diffusion into the building industry is because neither in the US nor in Europe, is there a culture of cross-industry learning. Especially in Europe the culture of building is still strongly influenced by its historical heritage, originating in the craft guilds, which try to protect themselves against competitive influences. Even the US and European factory-made houses industry, does not really do it. The only ones who really incorporated this are the Japanese house prefabricators. The Japanese do not see a difference in industrially produced car or houses. Japanese house producers like Sekisui House and Misawa Homes have strongly learned and adopted systems and methodologies from the automotive industries, ranging from production, to logistic and even to marketing. To do justice to small European prefabricators, behind Japanese companies, there are usually big industrial conglomerates, seeing the housing market just as another market to earn money with an industrial product.

The following overview shall give an idea about how other industries work compared to the building industry. Unfortunately, the other industries are pretty much self-contained. The openness to learn from each other and the ability to see parallels, where they are not necessarily obvious, needs to be trained in our culture more. It could be that also the building industry might have qualities that could be contributed to others.

### Automotive Industries

As much as construction industries, automotive industries are under pressure of salary costs. This caused, in contrast to the construction industry, a high degree of automation all during its history. Today a German midsize car is assembled in 30 hours. The Smart car is put together out of finished modules in 8 hours. The tendency goes to a unified platform design, which contains engine and chassis. On top of this different models and designs can be build up. This saves development and production costs.

#### *Product*

The big resources in production facilities and technical and managerial skills created a consistent and strong incentive to extend into related products and sometimes even less related products. The Ford Motor Company, for example, also produced Tractors and airplanes in the 1920s and 30s. GM manufactured refrigerators and diesel-powered railway locomotives. In Europe, Rolls-Royces is not only known as a luxury car producer, but also a major jet-turbine manufacturer. Probably one of the widest diverse conglomerates was build up by Daimler, who became major players in aerospace and telecommunication. Still visible in the company names until recently, the trend towards more international consolidation in the late 1990s, has formed more independent companies and many auto companies were forced to divorce from their non-automotive companies and concentrate on the core business. The same happened to the Japanese companies, who have been traditionally been big conglomerates like Mitsubishi, who produced not only cars, but also electronics, household supplies, ships. Only recently did Mitsubishi sell its

automotive branch to DaimlerChrysler. Noteworthy is the investment of Toyota into the production of houses in 1976.

A car is very strongly sold by design. Every little detail is important [Figure 63]. After selling cars by horsepower during the 1960s and 1970s, today's car marketing has a strong emphasis on lifestyle [Figure 64]. The product has been from the beginning been connected to personal freedom and independence. The car industry has been leading in marketing and branding. Today, marketing and brand identification are going well beyond the actual product.



FIG. 63 The beauty of each detail is highly emphasised to sell a car as a quality product. [source: BMW]



FIG. 64 Lifestyle and design are conveyed by commercials, rather than the technical specification of the product. [source: BMW]

### *Production*

The automobile industry, more than any other industry, has exceptional influence on modern production methods and thus is often used as the icon of modern mass production. Although the automobile originated in Europe in the late 19<sup>th</sup> century, the United States completely dominated the world industry for the first half of the 20<sup>th</sup> century through the invention of mass production techniques. In the second half of the century the situation altered sharply as western European countries and Japan became major producers and exporters. Especially the introduction of 'lean-production' and 'Just-in-time' production by Toyota had a major impact on our whole economic system, which is still revolution with the automobile industry on its forefront.



## *Mass production*

The outstanding contribution of the automotive industry to technological advance was the introduction of full-scale mass production, a process combining precision, standardization, interchangeability, synchronization, and continuity. The United States, with its large population, high standard of living, and long distances, was the natural birthplace of the technique in the early 19<sup>th</sup> century. The kind of interchangeability achieved by the “American system” was dramatically demonstrated in 1908 at the British Royal Automobile Club in London: three Cadillac cars were disassembled, the parts were mixed together, 89 parts were removed at random and replaced from dealer’s stock, and the cars were reassembled and driven 800 km without trouble. So apparently new trends in modular car construction don’t seem that new, although, given the high amount of electronics, self-repair of a car has become increasingly difficult.

The mass-produced automobile is generally and correctly attributed to Henry Ford, following his dream of “a car for the great multitude.” The car was the so-called Model T, the best-known motor vehicle in history. Given the rough American country roads of that period, the car was designed first to meet the requirements for durability and easy repair, and then the problem of how to produce it cheaply was considered. The solution was found in the moving assembly line. The technique consisted of two basic elements: a conveyor system and the limitation of each worker to a single repetitive task. Despite its deceptive simplicity, the technique required elaborate planning and synchronization. This system was often referred to as ‘the American production system’. The Model T was first put on the market in 1908, and more than 15 million were built before it was discontinued in 1927. The price of the Model T touring car dropped from \$950 in 1909 to \$360 in 1916 and still lower to an incredible \$290 in 1926. By that time Ford was producing half of all the motor vehicles in the world. Still today the bulk of the world’s new cars are coming from moving assembly lines, but the process is much more refined and elaborated today. Also the conditions for the workers have been improved towards less monotony.

Mass production also led to a consolidation of the industries into a small number of big companies. It requires a heavy investment in equipment and tooling and is therefore only feasible for a large organizations. Once the technique is instituted, the resulting economies of scale give the large firm a commanding advantage, provided of course that the market can absorb the number of vehicles that must be built to justify the investment. Although the precise numbers required are difficult to determine, the best calculations, considering both the assembly operation and the stamping of body panels, place the optimum output at between 200.000 and 400.000 cars per year for a single plant.

## *Lean production*

Although the origins of lean production are in the 1950s, when Toyota's President, Eiji Toyoda, carefully analyzed the American mass-production techniques, it was not until the 1980s when it shook the Western car manufacturers and continued to 're-engineer' most producing industries up to today. Although the American system had a impressive output, Toyoda found it to wasteful and did not like the combination of unskilled worker and expensive, single-purpose machines. He combined some advantages of craftwork with those of mass production, but avoiding high costs of craft and rigidities of factory systems. The result was the evolution of Toyota's lean production system, which employed teams of multi-skilled workers at all levels of the organization and highly flexible, automated machines to produce volumes of products in enormous variety [Gann, 1996].

Three developments were crucial in the evolution of lean production. First, simple dies had to be made so that they could be changed easily and quickly, enabling the same press line to make many parts, and avoiding the build up of huge inventories. Second, the introduction of the just-in-time system allowed to streamline the workflow, without the need of surplus production for just-in-case anything goes wrong, as it was done in the American system. The system carefully leveled production to avoid wild fluctuations and overproduction. Third, the worker was not reduced to a monotonous repetitive task, but the attainment of good labor relations and team working was fostered. The Japanese worker was seen as an integral part of the process of continuous improvement, a term known as 'kaizen'. Improvement reporting systems were introduced and resulted in 'quality circles', where teams formed to improve their production.

With the introduction of computers in the production process, the system has been highly refined and optimized. The modern robot and computer-aided-manufacturing technologies allow fast change of production and open the way for mass-customization. The worldwide networking of computers allows theoretically a production response from the local car dealer through the production down to the steel foundry.

Modern car brands have strongly outsourced whole production units, which mostly are just assembly in the main factory [Möser, 2000].

## *Organisation*

It is interesting to see how the industry started from small shops and developed to big manufacturers quickly. Most early automobile companies were small shops, hundreds of which each produced a few handmade cars, and nearly all of which abandoned the business soon after going into it. The handful that survived into the era of large-scale production had certain characteristics in common. First, they fell into one of three well-defined categories: they were makers of bicycles, such as Opel in Germany and Morris in Great Britain; builders of horse-drawn vehicles, such as Durant and Studebaker in the United States; or, most

frequently, machinery manufacturers. The kinds of machinery included stationary gas engines [Daimler of Germany, Lanchester of Britain, Olds of the United States], marine engines [Vauxhall of Britain], machine tools [Leland of the United States], sheep-shearing machinery [Wolseley of Britain], washing machines [Peerless of the United States], sewing machines [White of the United States], and woodworking and milling machinery [Panhard and Levassor of France]. One American company, Pierce, made birdcages, and another, Buick made plumbing fixtures, including the first enameled cast-iron bathtub. Two notable exceptions to the general pattern were Rolls Royce in Britain and Ford in the United States, both of which were founded as carmakers by partners who combined engineering talent and business skill.

In the United States almost all of the producers were assemblers who put together components and parts that were manufactured by separate firms. The assembly technique also lent itself to an advantageous method of financing. It was possible to begin building motor vehicles with a minimal investment of capital by buying parts on credit and selling the finished cars for cash; the cash sale from manufacturer to dealer has been integral in the marketing of motor vehicles in the United States ever since. European automotive firms of this period tended to be more self-sufficient.

Although the appearance of mass production in the automotive industry coincided with the emergence of large-scale business organization, the two had originated independently. They were related, however, and influenced each other as the industry expanded. Only a large firm can make the heavy investment in plant and tooling that the assembly line required. When Ford introduced mass production, it was already the largest single American producer. Also the Japanese car industry starting in the 1950s and the Korean starting in the 1970s had big industry conglomerates behind them, much like the Japanese prefabricated housing producers.

The mass producer in turn enjoyed a cost advantage that tended to make it increasingly difficult for smaller competitors to survive. There have been exceptions, but the trend has been consistent. It was General Motors, who introduced in the 1920s a staff-in-line organization with autonomous manufacturing divisions, which facilitated management of large corporate structures and became the model for other major automotive combinations, but also other industries. A central organization with an executive committee is responsible for overall policy and planning. The operating divisions are semiautonomous, each reporting directly to the central authority but responsible for its own internal management. In some situations the operating divisions even compete with each other. This is known today as so-called 'Profit Centers' in many industries. In addition, the largest producers decentralize their manufacturing operations by means of regional assembly plants. These permit the central factory to ship frames and components rather than complete automobiles to the areas served by the assembly plants, effecting substantial savings in transportation costs. This system was developed for the Ford Company as early as 1911.

Some alteration of that principle took place in the 1980s and '90s as Japanese firms built new plants around the world and American and European manufacturers adopted, to varying degrees, the Japanese "just-in-time" inventory method. Rather than stockpiling a large number of parts at the assembly plant or shipping all the parts from central locations, automakers have yielded the manufacture of many non-critical components [such as seats and wheel assemblies] to independent suppliers to make the pieces at small facilities close to the assembly plants. The components are often assembled into larger groups of parts or modules [a complete instrument panel, for example] and sent to the assembly plant in the exact sequence and at the exact time needed.

This development led to a very close relationship and interdependency of the car manufacturer and the suppliers. Suppliers, often not known by name by the general public, are a major part of the industry. There is a tendency of the car-manufacturers to become pure 'car-assemblers', having out-sources most of its production.

### *Design Process*

The process of putting a new car on the market has become largely standardized. If a completely new model is contemplated, the first step is a market survey. Conferences then follow for engineers, stylists, and executives to agree on the basic design. The role of the design and the aesthetics has been an important part of the product car from early on. Design and styling became increasingly important in automotive design as a marketing device. The general trend in styling became established late in the 1920s when cars began to lose their square, boxlike lines and to develop flowing curves. In time the new design encompassed both body and chassis, integrating such formerly separate features as mudguards, running boards, and bumpers. A combination of pressures made American cars of the 1950s high-powered and ornate, with extravagant use of chrome and exaggerated tail fins; these features were abandoned when the public found the simpler lines of imported cars more attractive. During the 1970s and 1980 especially the European cars became fairly mundane and emotionless in design, following straight lines and optimizing aerodynamics, safety and technical performance, where especially German cars got their high reputation from. In the 1990s a trend to more individualism and fun was started, which resulted in many new models and a wider variety beyond the normal 4 door limousine spanning from the small car, roadster, off-road and luxury limousine.

The next stage in the design process is a mock-up of the car, on which revisions and refinements can be worked out. With the high computerization of the design process this 'Zero-Model' has got an even higher importance. All subcontractors must make sure their parts fit into this zero-model, before their files go into production. Often the component maker is given full responsibility for the design and engineering of a part as well as for its manufacture.

Since earlier the time-to-market from the market research has been up to five years, there was always a certain element of risk, as illustrated by the Ford Motor Company's Edsel of

the late 1950s, where market research had indicated a demand for a car in a relatively high price range, but, by the time the Edsel appeared, both public taste and economic conditions had changed.

Because of the increasingly competitive and international nature of the industry, manufacturers have employed various means to shorten the time from conception to production to less than two years in many cases. This has been done by concurrent design, where vehicle engineers, designers, manufacturing engineers, and marketing managers form a single team responsible for the design, engineering, and marketing launch of the new model. Automakers also involve component manufacturers in the design process to eliminate costly time-consuming reengineering later. This process of concurrent design and concurrent engineering has been and is still adopted by many other industries meanwhile. The institution of the annual model was adopted in the United States during the 1920s to promote new-car sales in the face of used-car competition. The new model must have enough changes in styling or engineering to persuade prospective buyers that it is indeed an improvement. At the same time, it must not be so radically different from its predecessors as to give the buyer doubts about its resale potential.

### *Manufacturing Process*

The bulk of the world's new cars come from the moving assembly line introduced by Ford, but the process is much more refined and elaborated today [Figure 65]. The first requisite of this process is an accurately controlled flow of materials into the assembly plants. No company can afford either the money or the space to stockpile the parts and components needed for any extended period of production. Interruption or confusion in the flow of materials quickly stops production. Ford envisioned an organization in which no item was ever at rest from the time the raw material was extracted until the vehicle was completed—a dream that has not yet been realized.

The need for careful control over the flow of materials is an incentive for automobile firms to manufacture their own components, sometimes directly but more often through subsidiaries. Yet complete integration does not exist, nor is it desirable. Tires, batteries, and dashboard instruments are generally procured from outside sources. In addition, and for the same reasons, the largest companies support outside suppliers even for items of in-house manufacture. First, it may be more economical to buy externally than to provide additional internal facilities for the purpose. Second, the supplier firm may have special equipment and capability. Third, the outside supplier provides a check on the costs of the in-house operation. American companies rely more than others on independent suppliers. Production of a new model also calls for elaborate tooling, and the larger the output, the more highly specialized the tools in which the manufacturer is willing to invest. For example, it is expensive to install a stamping press exclusively to make a single body panel for a single model, but, if the model run reaches several hundred thousand, the cost is amply justified.

The assembly process itself has a quite uniform pattern throughout the world. As a rule, there are two main assembly lines, body and chassis. On the first the body panels are welded together, the doors and windows are installed, and the body is painted and trimmed [with upholstery, interior hardware, and wiring] (Figure 66). On the second line the frame has the springs, wheels, steering gear, and power train [engine, transmission, drive shaft, and differential] installed, plus the brakes and exhaust system. The two lines merge at the point at which the car is finished except for minor items and necessary testing and inspection. A variation on this process is “unitized” construction, whereby the body and frame are assembled as a unit. In this system the undercarriage still goes down the chassis line for the power train, front suspension, and rear axle, to be supported on pedestals until they are joined to the unitized body structure. Most passenger vehicles today are manufactured by the unitized method, and most trucks and commercial vehicles still employ a separate frame. The moment of putting body and chassis together is called a ‘marriage’ in car industries.

Assembly lines have been elaborately refined by automatic control systems, transfer machines, computer-guided welding robots, and other automated equipment, which have replaced many manual operations when volume is high. Austin Motors in Britain pioneered with its automatic transfer machines in 1950. A universal form of automatic control has used computers to schedule assembly operations so that a variety of styles can be programmed along the same assembly line. Customers can be offered wide choices in body styles, wheel patterns, and color combinations.



FIG. 65 The production of cars is highly advanced and automated. [source: Mercedes]



FIG. 66 Labourers enjoy a friendly, clean and ergonomic work environment. [source: BMW]

The trend in manufacturing is going towards much higher integrated modules, which are often subcontracted. The amount of electronics in modern cars made the cable harness, similar like in aerospace, the single most expensive and complex part of a car. The need for ever new designs and different models is leading the industries to a platform design, where more models share the same parts and potentially all non-design critical elements like engine, chassis, gearbox and tank are integrated in one platform, onto which different model variations can be built up. In turn, this will save development time and costs.

### *Sales and Service*

Mass production implies mass consumption, which in turn requires an elaborate distributive organization to sell the cars and to develop confidence among customers that adequate service will be available. In the early days of the industry, cars were sold directly from the factory or through independent dealers, who might handle several different makes. When sales in large quantities became the objective, however, more elaborate and better-organized techniques of distribution became essential. In the United States the restricted franchise dealership became the uniform and almost exclusive method of selling new cars. In this system, dealers may sell only the particular make of new car specified in their franchise, must accept a quota of cars specified by the manufacturer, and must pay cash on delivery. In return the dealers receive some guarantee of sales territory and may be assisted in various ways by the manufacturer—financing or aid in advertising, for example. Contracts also specify that dealers must maintain service facilities according to standards approved by the manufacturer. Seemingly weighted in favor of the manufacturer, the system has been subjected to periodic dealer complaints, producing state legislation and a federal statute in 1956 to protect dealers from arbitrary actions by manufacturers. Yet dealers have never been united in these attitudes, and no effective substitute for the restricted franchise has yet been found. On the contrary, it is becoming the general practice in other parts of the world where large-scale markets for motor vehicles have developed.

Attempts by automakers in the 1990s to move away from the traditional franchised dealer network to direct selling via the Internet met strong resistance in the United States. American dealers enlisted the help of state governments in enacting prohibitions of this practice (and in blocking attempts by automakers to own dealers through subsidiary corporations). In markets outside the United States, principally in Europe and South America, manufacturers sold directly to consumers via the Internet in limited quantities. The market in used cars is an important part of the distribution system for motor vehicles in all countries with a substantial motor vehicle industry because it affects the sale and styling of new cars.

Like all machinery, motor vehicles wear out. Some become scrap metal to feed steel furnaces; some go to wrecking yards where usable parts are salvaged. Throughout the world, however, the disposal of discarded motor vehicles has become a problem without a completely satisfactory solution. In many areas, abandoned wrecks or unsightly automobile graveyards disfigure landscapes. Spurred by European legislation requiring automakers to

take back all of their end-of-life-cycle vehicles beginning in 2007, manufacturers worldwide have begun engineering new products with the complete recycling of components in mind. At the same time, they have used more and different recycled material in new vehicles. For example, old bumper covers have been recycled into fender liners or battery trays for new cars.

### *Economic Significance*

The automotive industry has become a vital element in the economy of the industrialized countries—motor vehicle production and sales are one of the major indexes of the state of the economy in those countries. For such countries as the United Kingdom, Japan, France, Italy, Sweden, Germany, and South Korea, motor vehicle exports are essential to the maintenance of healthy international trade balances.

The effect of motor vehicle manufacturing in other industries is extremely good. Almost one fifth of American steel production and nearly three-fifths of its rubber output go to the automotive industry, which is also the largest single consumer of machine tools. Moreover, the special requirements of automotive mass production have had a profound influence on the design and development of highly specialized machine tools and have stimulated technological advances in petroleum refining, steelmaking, paint and plate-glass manufacturing, and other industrial processes. The indirect effects are also considerable through the many auto-related businesses, such as motor freight operators and highway construction firms. In addition, truck transportation has grown steadily throughout the world.

### *Ship Building Industries*

The ship building industries for modern luxury liners bears many interesting analogies to housing construction. A cruise ship is assembled out of 18–20 blocks of the size of a 5-storied apartment building. The building material is only steel. 3 x 12m plates in different thicknesses and a selection of shipbuilding profiles are used. These are precision cut by water-jets and joined by automatic welding machines. The individual cabins are delivered fully equipped, including furniture by subcontractors.

### *Product*

The output of the ship building industry is ranging from small one-person boats to big ocean liners. The products could be divided into the typologies pleasure, transport and military. Military would comprise submarines, destroyers up to large aircraft carriers. Transport ships are either cargo or people. People transport ships, or ferries, range from small boats to big ferries, which can take up not only people, but also cars, trucks and



entire trains. Cargo ships range from huge oil tankers, which are the largest ships built to small river transporters. In overseas trade the container ship has taken over an important role in the global distribution of goods. Transportation of goods by ships is still in many cases the most economic way, if time is not a critical issue. There is a growing sector in pleasure boats, from small yachts to huge luxury cruisers. Luxury cruises had a revival in the last decade, after changing the image from rich old people's holiday to a family friendly relaxed way of holiday in a controlled environment with an expedition component (Figure 67). They are like giant swimming holiday resorts, offering all kind of amenities (Figure 68).



FIG. 67 The Brilliance of the Seas was built in 2001. It has a tonnage of 90'090 and 1691 cabins with a total passenger capacity of 2'400 and additional a crew of 859 people.



FIG. 68 The multi-storey atrium of the Brilliance of the Seas. [source: [www.cruiseweb.com](http://www.cruiseweb.com)]

### *Production*

The shipyard is the main production facility of ships and bears similarities to on-site construction, but has permanent shops and assembly lines. The wooden ship was constructed on a building berth, around which timbers and planking were cut and shaped and then fitted together on the berth to form the hull. A similar practice was followed with iron vessels and, later, with the earlier steel ships, as these tended to be replicas of wooden hulls. Gradually iron came to be used more effectively in its own right, rather than as a substitute for timber. The berth or slipway from which the vessel is launched is a final assembly area, rather than the ship construction site, which is next to it. In many shipyards the number of launching berths has been reduced to increase the ground area available for prefabrication sheds. Greater ease of [pre-]fabrication means that, despite the reduction in the number of berths, more ships can be built and construction costs lowered.

In general, a shipyard has few building berths and uses extensive areas around them for the construction of large components of the steel hull. Building berths slope downward toward the waterway, to facilitate launching. Building basins, or dry docks, are sometimes used for the construction of very large vessels, because it is convenient to lower, rather than to lift, large assemblies, and this method also eliminates problems associated with launching.

Extensive water frontage for the building berths is unnecessary. The main requirement is a site of considerable depth, rather than width, with a large area extending inland from the berths. Steel plates and sections are delivered to the shipyard at the end of the area farthest from the berths. There they are stored in a stockyard and removed, as needed, for cleaning, straightening, shaping, and cutting. Separate streams of plates and rolled sections converge toward the prefabrication shop, where they are used to build structural components or subassemblies. The subassemblies are transported to an area nearer the berths, where they are welded together to form large prefabricated units, which are then carried by cranes to the berth, to be welded into position on the ship.

### *Organization*

A shipbuilder undertakes to deliver to the client by a certain date and for a stated sum a vessel with specific dimensions, capabilities, and qualities, a vessel that has been tested on trial and is ready for service. The function of a shipyard is the production of completed ships in accordance with the shipbuilder's undertakings. The raw materials for construction and finished items to be installed on board are delivered there. The labor force in the yard consists of various workmen—steelworkers, welders, shipwrights, blacksmiths, joiners, plumbers, turners, engine fitters, electricians, riggers, and painters. Management is headed by a chairman and a board of directors, consisting usually of about 6 to 12 members from the technical, commercial, and secretarial departments, with one or more representing outside interests. The chief departments are the design, drawing, and estimating offices, planning and production control, the shipyard department—responsible for construction up to launching—and the outside finishing department, which is responsible for all work on board after launching. Other departments are responsible for buying and storekeeping and the yard maintenance. The construction of the hull is only one of a shipbuilder's responsibilities. As soon as a contract is placed, he must negotiate with subcontractors for the supply of items that shipyards do not produce—the electric power plant, propulsion machinery, shafting and propellers, engine-room auxiliaries, deck machinery, anchors, cables, and furniture and furnishings. Production planning and control is therefore a complex undertaking, covering subcontracts, assembly, and installation, in which costs must be kept as low as possible.

## *Design Process*

Delivery of a completed ship by a specified date requires careful planning. Following the introduction in the United States of the critical path method of planning and control by the E.I. du Pont de Nemours and Company about 1959, new techniques were adopted in many shipyards. The critical path method is the basis of network analysis, which is used in planning complex production projects. The network, and information derived from it, is used for overall planning of a project and also for detailed planning with production progress control. The network gives a logical, graphical representation of the project, showing the individual elements of work and their interrelation in the planned order of execution. An arrow, the tail of which is the starting point of activity and its head the completion, represents each element of work. The arrows are drawn to any suitable scale and may be straight or curved. An event, which represents the completion of one activity and the beginning of another, is usually indicated by a circle and described further by a number within the circle. But each activity need not be completed before the next activity is begun. The logical order of steelwork in a hull, for example, is: [1] detailed drawings of steelwork; [2] ordering of steel; [3] manufacture and delivery of steel; [4] storing of steel material in stockyard; [5] shot blasting, cleaning, and forming operations; [6] subassembly work; and [7] erection of structure on berth. These operations can be represented on a ladder type of diagram. Many such diagrams—ladder and other types—go toward making up the complete aggregate operation of building a ship. When the proper sequence of operations is decided upon, times must be allocated to each operation to ensure that the workers in charge understand their obligations. Planning, based on realistic estimates of times and costs, must begin at the pre-contract stage, so that, throughout the building program, a clear plan, with scheduled dates for each major section, is available. Detailed networks must be prepared for each of the major sections, showing dates for completion. The earliest and latest permissible starting and finishing times are indicated for each activity.

The critical path of a project is a series of activities whose duration cannot be increased without delaying the completion of the project as a whole. In large networks there may be more than one critical path. Up to about 100 activities can be dealt with manually but, for more complex cases, a computer does the numerical work. The spare time available for a series of activities—i.e., the maximum time these activities can be delayed without retarding the total project—is aggregated into a “total float.” This is regarded as a factor of safety to cover breakdowns, mishaps, and labor troubles. Intelligent and experienced use of critical path methods can provide information of great value. Savings in production costs depend upon the use that management makes of this information.

## *From Contract to Working Plans*

Before an order is placed, the main technical qualities of the ship are decided upon and a general-arrangement drawing of the vessel, showing the disposition of cargo, fuel, and ballast, and crew and passenger accommodation is prepared. This plan provides a

complete picture of the finished vessel. It is accompanied by detailed specifications of hull and machinery. This general-arrangement plan and the specifications form the basis of the contract between ship-owner and shipbuilder. As soon as an order is confirmed, drawing offices and planning departments produce working plans and instructions. Since ships are usually constructed according to the rules of a classification society, the stipulated structural plans are normally submitted to the society for approval. The appropriate authority, for example, must approve the spacing of bulkheads in passenger ships. For all ships, passenger and cargo, the approval of the maximum permissible draft must be sought from the classification society. Necessary working drawings include the lines plan and detailed plans of the steel structure—shell plating, decks, erections, bulkheads, and framing—as well as accommodation spaces, plumbing, piping, and electrical installations, and main and auxiliary machinery layout. The planning and production department prepares a detailed progress schedule, fixing dates for the completion of various stages in the construction. A berth in the yard is allocated for the ship, arrangements for the requisite materials, labor, personnel, and machines are made, and precautions are taken to ensure that the many interrelated operations will progress according to the timetable.

#### *The Lines Plan; Fairing*

A 'lines plan' is a 1/48 scale drawing of a ship, and is used by designers to calculate the required hydrostatic, stability, and capacity conditions. Full-scale drawings formerly were obtained from the lines plan by redrawing it to full size and preparing a platform of boards called a 'scribe board' showing the length and shape of all frames and beams. Wood templates were then prepared from the scribe board and steel plates marked off and cut to size. An alternative to the full-scale scribe board is a photographic method of marking off, introduced about 1950 and widely adopted. The lines plan is drawn and faired [mathematically delineated to produce a smooth hull free from bumps or discontinuities] to a scale of one-tenth full-size by draftsmen using special equipment and magnifying spectacles. The formerly used wood templates are thus replaced by specially prepared drawings, generally on one-tenth scale. Photographic transparencies of these drawings are then projected full size from a point overhead onto the actual steel plate. The plate is then marked off to show the details of construction, such as position of stiffening members, brackets, and so on. This optical marking-off system is much more economical in terms of space and skilled labor than the older method.

By the 1960s, digital computers were being used to fair the preliminary lines plan by a numerical method. Faired surfaces can be produced to a specified degree of accuracy and the lines can be drawn by a numerically controlled drawing machine, bringing the process under continuous scrutiny. Tapes can be produced for use in numerically controlled plate burning machines, which cut plates to shape, and for the automatic cold bending of frames and curved girders. Fairing calculations produce data that can be fed back into a computer, and programmed to generate hydrostatic and stability data and other information.

## *Manufacturing Process*

### Fabrication and Assembly

Since 1930, riveting has been progressively supplanted by welding. This has proved more than a mere alteration in the method of connecting structural components because welding facilitates prefabrication of large component parts of the main hull structure. Before welding came into wide-scale use every ship was constructed on the building berth. The keel was laid, floors laid in place, frames or ribs erected, beams hung from the frames, and this skeleton, framed structure was held together by long pieces of wood called rib bands. Plating was then added and all the parts of the structure were riveted together. In other words, the ship was built from the keel upward.

The modern method is to construct large parts of the hull, for example, the complete bow and stern. Each of these parts is built up from subassemblies or component parts, which are then welded together to form the complete bow or stern (Figure 69). These sections of the ship are manufactured under cover in large sheds, generally at some distance from the building berth, before being transported to the berth and there fitted into place and welded to the adjacent section. The advantages of this procedure are that work can proceed under cover, unhampered by bad weather, and the units or component parts can be built up in sequences to suit the welding operations – not always possible at the building berth itself (Figure 70).

The industry is reducing the raw material on a few types of steel sheets and profiles. Individual pieces are cut computer-controlled and then welded together with profiles to form decks and walls (Figure 71 and 72). The steel structure then is equipped from third party supplier, delivering fully equipped bathrooms and cabin interiors.

A number of techniques can be used to weld together two pieces of the same metallic material. The ideal weld is a continuity of homogeneous material, with the same composition and the same physical properties as the parts being joined. In steel shipbuilding, metal arc welding is produced by an electric arc formed between the parts to be joined; a coated electrode supplies the fusion material. The welding electrode consists of a core rod that is deposited as weld metal; it is flux-coated to protect the molten metal from the atmosphere during deposition and to supply certain metallurgical properties to the weld. A great deal of research has gone into the production of the best possible coated electrodes for specific duties. The main advantages of welding over riveting are: [1] a lighter structure (because overlaps are eliminated), [2] improved water tightness and oil tightness, [3] smoother surfaces, and [4] reduced hull upkeep. Certain precautions, however, are necessary. The design of the structure must be adapted for welding because structural details that can be riveted are seldom suitable for welding. The joints must be carefully prepared beforehand for welding. Incomplete penetration, lack of fusion, porosity, and cracking are typical weld defects that must be avoided. Hard spots must be avoided and gradual tapering off of stiffness is necessary if defects in service are to be minimized.



FIG. 69 A 6-storey high prefabricated part of the ship is craned to the main hull. [source: www.meyerwerft.de]



FIG. 70 The whole final assembly of the ship takes place in the main building berth. [source: www.meyerwerft.de]



FIG. 71 The reduction to some standard steel sheets and profiles allow in combination with computer controlled plasma-cutters a high customisation. [source: www.meyerwerft.de]



FIG. 72 Computer based technology for the design, construction and building of ships are integrated into all areas of the modern yard. [source: www.meyerwerft.de]

### *Sales and Service*

The globalization of the markets, especially for low-technology freight ships has started a strong competition in the shipbuilding industry, which is facing an open and free market. Price is everything, except in market niches such as inland waterway cruise ships and other passenger vessels. Competition in these segments is based on quality and expertise, not pricing. Nevertheless, the tough market is forcing shipbuilders to focus more on a good

product mix, quality and customer relations. Within the industry, market experts defined the following trends: package solutions, product-related services, and tailor-made service concepts. Demand for sophisticated ferries and passenger boats increases steadily.

Next to keeping a good relation to existing customers, trade fairs are a very important instrument for new client contacts and keeping up-to-date with the market. Exhibiting at a fair is, in fact, one of the least expensive ways to test market receptivity and to assess the strength and scope of the competition. Such exposure also helps to establish contact with others 'in the trade'. The leading international fair within the shipbuilding industry is the Shipbuilding, Machinery and Marine technology international trade fair [SMM], which takes place in Hamburg every two years.

2004 saw an unexpected boom in shipbuilding which led to a new quality in customer relations: Whereas only a short time ago, owners used to bitterly discuss technical specifications, prices and payment terms, nowadays they are more pragmatic, accepting terms and conditions imposed by shipyards, provided that they allow them to place new orders.

### *Economic Significance*

In 2001, Japan was the world's largest shipbuilding country with 33% market share in new orders, Korea was second with 30% and China had 11%. The EU accounted for 13% dropping from 24% in 1998. In 2002, Korea had around 45% of the world market after having tripled its shipbuilding capability in the 1990s. The largest European shipbuilding group is Norwegian Aker Yards Group, the world's no. 4 with more than 10 shipyards [European Parliament Fact Sheets, 2004]. The industry in Europe covers the highest technological segment of world production - advanced container vessels, ferries and Roll on/Roll Off ships; multipurpose and shuttle tankers, offshore platforms and FPSO, chemical and gas carriers, high standard fishing vessels and the manufacture of small and specialized ships. Other than in Aerospace and automotive industries the contribution of the Americas to international shipbuilding is marginal. Whereas the European shipbuilding industries went through a tough shrinking and specialization process, the Asian production is booming. The high volume of these Japan, South Korea and China comes from commercial, not naval, construction. Commercial shipbuilding has, however, always been considered a strategic industry, and not only because its infrastructure can also support warship construction. England at the dawn of the industrial revolution, and Japan as it strove to catch up with the West in the 19<sup>th</sup> century, both used shipbuilding as a catalyst for wider economic development. The shipbuilding industry has for some time been facing major problems due to an imbalance of supply and demand. Past expansion of shipyards, mainly in Korea but now increasingly in China too, has resulted in prices decreasing rapidly. In the 1990s, South Korean shipyards tripled their shipbuilding capacities, while ignoring demand levels in order to achieve market leadership, which they achieved in 1999. This led to overcapacity and destructive prices for the international shipbuilding market. Thanks to a historically high level of ordering in 2000, prices recovered to some extent, but the

significant drop in orders in 2001 led to a new reduction in prices [total orders were 21% lower in 2001 than in 2000 based on Compensated Gross Tonnage CGT]. While the decline in world economy in 2001 mainly affected the liquid bulk and the container segments, the events of 11 September had a strong impact on the cruise industry, which saw three bankruptcies and a significant drop in bookings. This lack of incoming orders is likely to become a great threat to European shipbuilders, since there is an increasing uneasiness about the situation after 2003, when most of the previous orders will have been completed. The shipbuilding industry is an important client of the domestic steel production and an important local employer.

### Aerospace Industries

The Aerospace industry is the most advanced, when it comes to modern construction. Building materials are mostly light metals [Aluminum-Titan-alloys], ceramics and composites. With the Airbus 380 carbon fiber plays an increasing role. The materials are used in lightweight monocoque construction methods. An aircraft has to withstand environmental conditions unsurpassed by any terrestrial conditions. The hull construction is very durable at a minimum weight.

### *Product*

The product line of the aerospace industry is, by necessity, broad because its primary products – flight vehicles – require up to millions of individual parts. In addition, many support systems are needed to operate and maintain the vehicles. In terms of sales, military aircraft have the largest market share, followed by space systems and civil aircraft, with missiles still a modest grouping. The industry's customers range from private individuals to large corporations and commercial airlines, telecommunications companies, and military and other government agencies. Aerospace vehicles can be categorized into 'lighter-than-air', which would include balloons and airships and 'heavier-than-air'. The latter include aircraft, helicopters, Space Launchers, Spacecraft and unmanned aerial vehicles. From an industrial sector viewpoint, aircraft are generally divided into civil aircraft and military aircraft. Builders of civil aircraft comprise two categories: producers of general aviation aircraft and producers of heavy aircraft. General aviation is defined as all aircraft activities not related to military, major airline, or air-cargo flying. It includes light planes and helicopters used for private pleasure flying, personal transportation, corporate travel, and short-haul commercial transportation, such as air taxis and commuter airliners, with low takeoff weights. Also encompassed are specialized aircraft such as agricultural sprayers, acrobatic craft, sailplanes, motor gliders, air ambulances, fire-control aircraft, pipeline-patrol aircraft, and others with a broad variety of civil applications. The category of heavy aircraft comprises commercial transports and cargo planes. From the viewpoint of architecture, commercial heavy aircrafts are especially interesting. They have to provide space for up to 800 passengers [Airbus A380] for a limited period of time, including all the necessary provisions for food supply and hygiene [Figure 73]. The new Airbus 380 even includes a shop and a bar. Further the design plays an eminent role for customer



relation, branding, comfort and safety [Figure 74]. Commercial heavy aircraft involve the prefabrication and shipment of large parts as wings or sections of the hull to the final assembly line.



FIG. 73 The new Airbus A 380 is a new generation of commercial heavy aircraft. It seats up to 800 people. [source: www.airbus.com]



A joy to wake up to

FIG. 74 Marketing and Design goes very closely together for civil airlines [source: www.airbus.com]

### *Production*

At its outset the aircraft-manufacturing industry was virtually self-contained in the producer's plant, with the exception of a few key products such as engines and tires, which were delivered by the automotive industry. The majority of labor was associated with woodworking and sewing of fabric for the fuselage, wings, and empennage—skilled labor used limited tooling. The few machined parts and specialized groups within factories fabricated even components such as seats—devised by the airplane designers.

In the 1930s, as aircraft became more sophisticated, the demand increased for machined parts, castings, forgings, and extrusions, which all required different machinery and different skills. The result was a major vertical expansion of aircraft businesses—i.e., the move to incorporate or control all levels of component manufacture and assembly within one organization. This took the form of either expanded internal plant capabilities or the development of a group of suppliers from whom specialized components such as instruments, radios, and passenger equipment were procured. The latter group became an intrinsic part of the industry, much as engine manufacturers had earlier.

With the beginning of World War Two, the German aircraft industry was the most advanced in the world. Like others, the United States had to achieve a before unknown level of production: facilities of existing plants were expanded, new facilities erected, non-aircraft producers (mainly automobile manufacturers) brought in, qualified personnel recruited and trained, and new production processes developed. Non-aircraft producers obtained licenses to build entire products developed by the aircraft industry or acted

as subcontractors for aircraft manufacturers. As a result, a revolutionary change in the technology of airframe production occurred, shifting from “job shops” with craft labor to assembly lines with workers of lesser skills. This necessitated greater standardization of parts and job processes because of the complexity of the product. For example, the 5.5-metre nose section of the Boeing B-29 bomber had more than 50,000 rivets and 8,000 different parts procured from over 1,500 suppliers. On the other hand, automobile-engine manufacturers were able to use existing skills to build aircraft engines along mass-production lines in already established factories.

By the end of the war, airplane production in the United States and Britain had assumed the character largely maintained to the present day. Design, major assembly, and integration of systems in the maker’s factories rather than the complete manufacture of an entire vehicle became the emphasis. Development departments performed most of the engineering, and supplier specialists and vendors complemented and supplemented the aircraft producers’ manufacturing departments and equipment requirements.

Modern aircraft manufacture has been described as “a craft process with a mass production mentality.” With the exception of experimental and very specialized airplanes, this has generally been true. Large aircraft consist of the assembly of one million to five million separate parts, and complex spacecraft of several hundred thousand parts. Each different type demands unique skills and manufacturing methods.

Because of the extensive range of skills and facilities required, no single company builds an entire flight vehicle. Manufacturing in the aerospace industry crosses nearly all construction boundaries—for example, conventional machine shops for mechanical components, clean rooms for electronic parts, and unusually large final-assembly facilities for multi-hundred-ton aircraft, space vehicles, and missiles. In every developed country of the world, major aerospace production programs incorporate a complete range of hardware and software from suppliers that operate as subcontractors to the prime contractor or systems integrator. Subcontracting covers not only the onboard equipment but also, in most large projects, major elements of the airframe itself. In Europe, where large developments occur in multinational cooperative efforts, the distribution of the production is especially broad.

### *Organization*

Because of enormous financial and technological demands, the number of manufacturers in the industry has become increasingly limited, while the average size of aerospace firms has grown through acquisition or merger. In 2000 the world’s largest aerospace companies [ranked in terms of total revenues] were Boeing, Lockheed Martin, EADS, United Technologies, Honeywell, Raytheon, Textron, and BAE Systems. Russia’s major producers included Ilyushin and Tupolev for civil aircraft, MiG and Sukhoi for military aircraft, and Energia for space launch vehicles.

By the start of the 21<sup>st</sup> century initial plant investment for modern airliners had reached as high as \$2 billion, even with more than 50% of the work being done by suppliers to the prime contractor. Thus, a community of structural subassembly contractors building wings, sections of fuselages, and horizontal surfaces now relieve some of the space and tooling needs of prime contractors such as Boeing in the United States and Airbus Industry in Europe.

### *Design Process*

Initiation of the product development process differs between the military and commercial sectors. In the United States the defense services normally provide detailed mission specifications for desired products, against which contractors submit proposals as part of a competitive process. Proposals are reviewed, and one or more development contractors are selected. In some cases contracts are awarded solely for the development of competitive prototypes. The company or team of companies that develops the winning design then may receive a full-scale development and production contract.

In the civil aircraft sector, manufacturers conduct detailed market studies to determine the need for new vehicle designs, then define specifications, announce to potential customers their intention to develop the new product, and solicit orders. When sufficient firm orders are obtained—from the so-called launching customers—the program is officially initiated. The customers' engineers generally work together with the manufacturers to influence the final design to fit specific needs.

The design cycle of a new flight vehicle has changed radically since the 1980s because of new methods, tools, and guidelines. Traditionally, the cycle begins with a conceptual design of the overall product followed by the preliminary design, where many subsystems take shape. In most, if not all, cases, several iterations must be made before a final design is achieved. Since design engineers generally don't anticipate all production issues, substantial design rework is common. Despite the apparent simplicity of the initial conceptual design phase, 70–80% of the aerospace product's cost is determined in this stage.

Because reducing costs has become increasingly important, a new design method, concurrent engineering (CE), has been replacing the traditional cycle. CE simultaneously organizes many aspects of the design effort under the aegis of special teams of designers, engineers, and representatives of other relevant activities and processes. The method allows supporting activities such as stress analysis, aerodynamics, and materials analysis, which ordinarily would be done sequentially, to be carried out together. A step beyond CE, incorporating production, quality assurance, procurement, and marketing within the teams, is a method called integrated product and process development (IPPD). IPPD ensures that the needs of the users and those who bring the product to the customer through manufacturing and outside procurement are considered at the beginning of the design/build cycle. In cases in which maintenance plays a major role in the life cycle of a product, relevant personnel from that segment are also brought into the teams.

CE and IPPD have resulted in numerous improvements for the industry. They have shortened the total time required to bring products to market, simplified product structures by reducing parts counts, lowered product and life-cycle costs, reduced defect rates, increased reliability, and shortened development cycles. For example, in the development of the 777, Boeing formed 238 design and build teams, which helped to reduce the number of changes necessary after release of initial designs to less than half of that for earlier models done conventionally.

The computer has also fundamentally changed the development process by permitting digital modeling and simulation as well as computer-aided design in conjunction with computer-aided manufacturing. In the early design stage of a flight vehicle, digital computer modeling of prospective designs enables rapid examination of several candidate configurations and thus replaces a portion of costly wind tunnel testing. Modern systems create a three-dimensional model – a virtual flight vehicle – based on the data sets entered. All details, from the airframe to the electric subsystem, are stored in the computer. This eliminates the requirement for full-size physical models, known as mock-ups, on which the engineers verify design layouts. Widely used CAD/CAM software packages in the aerospace industry include CATIA from Dassault Systèmes/IBM, Unigraphics from Unigraphics Solutions, and CADD5 and Pro/ENGINEER from Parametric Technology Corporation. Boeing used the CATIA package to develop the 777, the first aircraft to have been designed completely with computers without a mock-up.

Nevertheless, prototyping and wind tunnels testing remains an important part of the development process in the aerospace industry. In the prototype construction phase, emphasis shifts to testing. A customary procedure is to build several test airplanes solely to verify the design. The structural integrity of the aircraft is determined in static and dynamic tests. Ground testing requires an array of facilities, including ovens for applying high temperatures to materials, acoustic chambers to permit study of the effect of high-frequency engine noise on structures, rigs for measuring landing impacts, and variable-frequency vibrators for investigations of vibration and flutter characteristics of structures. Test fixtures verify that the ultimate load factor called for in the design has been met or exceeded; for example, the wings may be loaded until they break. In dynamic or fatigue tests, the life of the aircraft is simulated in time-lapse fashion. Thus an airplane may go through more than 100,000 equivalent “flight hours” before it is taken apart and examined completely in every detail.

Engines are tested extensively as well and must operate for more than 1,000 hours continuously, many at maximum thrust. Several flight tests need to be done over sparsely populated areas or over water because of the possibility of an accident and to allow freedom for maneuvers.

Once a civil aircraft has demonstrated its airworthiness in the flight certification program, it can enter regular service.

## Manufacturing Process

From originally self-contained production plants, the aerospace industry increasingly became an assembly industry with a widespread and highly specified subcontractor system. Although the airframe manufacturers remain the major integrators and sellers of aircraft, costs of production have shifted increasingly toward the key subsystems of propulsion and avionics and auxiliary equipment such as landing gear and interior equipment. Typically, for civil transports the costs average 50% for structure and integration, 20% for engines, and 30% for avionics.

Assembly of aerospace vehicles at the prime contractor or systems integrator begins with the accumulation of subassemblies [Figure 75]. An example of a typical subassembly for a transport aircraft is the rear fuselage section, which is of itself composed of several segments. [Subcontractors, who in turn deal with their own suppliers of the segments' constituent elements often, build these segments.] The segments are taken to the subassembly area, where teams of workers fit them into support jigs or fixtures and join them into a unit, within which the interior equipment is then installed. In similar manner, teams put together other subassemblies such as the remaining fuselage sections, wing sections, tail sections, and engine nacelles. The various subassemblies then are taken to the main assembly line, where final integration takes place [Figure 76].



FIG. 75 A piece of the hull of the Airbus A 380 is shipped from Hamburg to Dresden. [source: www.airbus.com]



FIG. 76 Final assembly of the Airbus A 380 takes place in Toulouse. [source: www.airbus.com]

The performance of subassemblies as units is verified prior to their integration into final assemblies. In the case of structural subassemblies, verification usually is confined to load testing, alignment and assurance of dimensions and tolerances, and electrical conformity checks for installed cabling. For subassemblies with electrical and electronic, hydraulic, and mechanically actuated components, extensive tests are usually performed in simulated flight environments incorporating vacuum, temperature, and vibration excursions. The required time, test equipment, and related computer software represent a significant portion of the cost of these elements of about 10–25%.

## *Lean Manufacturing*

Consistent with improving the economics of aerospace vehicles is the transition to a new paradigm for the entire industry, from concept development to operations. This approach involves all processes pertaining to the acquisition, design, development, and manufacturing of a product or system and has been variously called “lean,” “agile,” or “synchronous” manufacturing. It strives to eliminate non-value-added or wasteful resources, including material, space, tooling, and labor. It applies such principles as waste minimization, flexibility, and responsiveness to change; these are supported by efforts to optimize the flow of material and information and to achieve superior quality in order to eliminate scrap and rework.

Lean manufacturing was derived from studies of the automobile industry, which showed that the best Japanese carmakers had achieved competitive advantages by using practices rooted in the principles noted. For the aerospace industry, its implementation involves major cultural changes emphasizing integrated teams of workers having decision-making responsibility at levels closest to where work is performed, in contrast to the conventional system in which responsibility is transferred upward through multiple layers of management. It is estimated that full implementation of this paradigm can reduce costs and product cycle times by 50%.

In 1992 the U.S. Air Force funded a study to evaluate the applicability of lean manufacturing to aerospace products. From that effort was established the Lean Aerospace Initiative, a consortium of 20 companies and several government agencies. With federal funding, the participating firms undertook pilot programs, some of which led to the incorporation of commercial lean manufacturing practices in the manufacture of defense products. Although these changes have produced major benefits in local stages of production, their translation to entire product enterprises has been slow. Part of the reason is that a complete enterprise comprises not only of design and production but also the overhead functions of administration and support as well as customers and suppliers. Nevertheless, progress was being made with the expansion of lean initiative programs to these elements.

## *Final assembly*

The final assembly of complete aircraft usually requires a facility furnished with a network of overhead rails on which ride heavy-lift cranes capable of moving large portions of vehicles. Vehicle dimensions govern facility size; for example, Boeing’s plant in Everett, Washington, is the world’s largest building by volume, containing some 13.4 million cubic meters and covering an area of 405,000 square meters. Airbus Industry’s Final Assembly Complex Clément Ader, near Toulouse, France, although smaller with 5.3 million cubic meters, is Europe’s largest industrial building.

Aircraft assembly normally starts with the joining, or mating, of fuselage subassemblies that have been craned into a supporting jig or fixture. As the vehicle is assembled, it is moved through a succession of workstations, acquiring additional subassemblies and accumulating its onboard systems, ducts, control cables, and other interior plumbing. Light- and medium-weight aircraft may be moved on wheeled fixtures; heavier aircraft are craned. Modern large planes and spacecraft often are moved via an adaptation of the air-cushion technique. Highly compressed air is pumped into the assembly fixture supports and escapes downward through holes. The powerful thrust of the escaping air lifts the entire fixture and vehicle assembly several millimeters off the floor, enough to permit movement by tractor or human power. Major assembly steps include the additions of nose and tail sections, wings, engines, and landing gear. On completion of work at the last station, the airplane is rolled out of the assembly plant to the flight line for its production flight test, a process that involves a thorough checkout of specified performance.

### *Sales and Service*

After the merger with McDonnell Douglas in 1997, Boeing became the world largest aerospace company. Positively for the market in the civil aircraft sector the increasing success of Airbus Industries, left these two main competitors on the market. The manufacturers and the customers, which are mainly the civil airlines, are in a very close relation. Given the high costs of an aircraft, the aerospace industry is a built-to-order industry with mass production elements. After a initial design, a new aircraft design is only built, when enough buying option from the airlines have been collected. The aircrafts are then built and outfitted to the demands of the airlines. The final painting and especially the interior design are strongly affected by the corporate identity and branding of the airlines. Also economic calculations as the number of seats are important customizable elements. The customers' engineers generally work together with the manufacturers to influence the final design to fit specific needs.

### *Maintenance*

The operator normally carries out routine maintenance of aircraft. It includes frequent inspections, either after every flight or a designated series of flights or after a time interval, and minor maintenance such as replacement of a part or repair of a faulty item of equipment. This type of maintenance can be handled at most airline terminals. Major maintenance work involves complete rework of an airplane or engine that has had considerable service time. Larger airlines have their own extensive technical facilities for major overhaul. Usually these facilities specialize in servicing specific models to achieve a high degree of proficiency and efficiency. Despite their competition in the air, smaller airlines often cooperate on the ground and contract for the technical services of other carriers to do their maintenance work. Some manufacturers offer maintenance

service through subsidiaries that specialize in this business. The costs involved in the maintenance of aerospace systems are substantial. For example, over the lifetime of a normal jet engine, an operator will spend about two to three times its original acquisition cost on maintenance.

The role of the actual manufacturer in the maintenance of its products is principally that of a supplier of parts, documentation, and advice. Provision of spare parts is a particularly important source of revenue for the original equipment manufacturers. Boeing, for example, sends out some 650,000 spare parts per year to about 400 airlines. The firm's key spare-parts center holds 410,000 different parts – 50,000,000 items altogether – and operates 24 hours a day. The supplying of documentation in electronic form is now a routine feature. Documentation for the Airbus A320 jetliner, which originally involved 60,000 text pages, 16,000 figures, and legions of microfilms and which weighed 100 kg (220 pounds), has been replaced by several CD-ROMs, which include the maintenance manual, an illustrated spare-parts catalogue, a troubleshooting manual, and a product management database.

### *Economic Significance*

Technological progress is the basis for competitiveness and advancement in the aerospace industry. The industry is, as a result, a world leader in advancing science and technology. Aerospace systems have a very high value per unit weight and are among the most complex, as measured by the number of components in finished products. Consequently, it is economically and politically prestigious for a country to possess an aerospace industry. Among the world's largest manufacturing industries in terms of monetary value of product output and employment, the aerospace industry is characterized by a relatively small number of large firms and numerous international partnerships at every level.

For the major aerospace countries, their own military establishments and, in some cases, foreign militaries constitute the largest customers. The next most important buyers are the world's commercial airlines, primarily American, European, and Asian-Pacific Rim carriers. Most general aviation (primarily private, business, and non-airline commercial) aircraft are sold in the United States, with Europe becoming a growing marketplace and special-use markets developing in the Middle East and Latin America. Of the nearly 50 countries that have one or more aerospace companies, the United States possesses the world's largest aerospace industrial complex (while some companies are dedicated solely to aerospace, others are more diversified.) Although their own government is the major procurer of military systems, American firms are also the dominant supplier of both military and civil aerospace hardware to the rest of the world. Today, non-American companies seek a larger portion of the global market and challenge American dominance. Russia retains the second largest aerospace industry in the world. After the break-up of the Soviet Union in 1991, Russia acquired most of the highly competent Soviet design bureaus. Partnerships with American and European firms were initiated, and Russia entered Western markets for the first time. Western Europe's aerospace industry has become a strong global player,



with France, the United Kingdom, and Germany particularly active. Through the success of cooperative programs such as the Airbus line of commercial transports and the Ariane family of space launch vehicles, the European industry has gained considerable experience in the development and manufacture of almost the entire range of aerospace systems. Sweden's industry is smaller than that of the other major European aerospace countries, but through its national policy of selective specialization it, too, has developed a high degree of competence. In the Asia-Pacific Rim region, Japan has the leading aerospace industry, but – compared with the United States, Western Europe, and Russia – its capabilities are still limited. Japanese companies also perform as key subcontractors to firms in the United States and Europe. China has built aircraft of Soviet design since the early 1950s, with indigenous design efforts generally confined to adapting Soviet technology. It is in the process of forging partnerships with a number of foreign ventures in both aircraft and spacecraft systems. The country also has developed space launchers, small satellites, and craft intended for manned spaceflight. Other countries with small but advanced aerospace industries are Argentina, Australia, Brazil, Canada, the Czech Republic, Greece, India, Indonesia, Israel, Italy, The Netherlands, Poland, Spain, Switzerland, Taiwan, and Ukraine. Emerging industries exist in Austria, Belgium, Chile, Colombia, Egypt, Finland, Hungary, Iraq, Lithuania, Malaysia, New Zealand, Nigeria, Norway, Pakistan, the Philippines, Portugal, Romania, Singapore, South Africa, South Korea, Turkey, Uzbekistan, and Yugoslavia. The worldwide reduction in acquisitions of aerospace defense systems after the end of the Cold War in the early 1990s has prompted many manufacturers in the United States, Europe, and Russia to shift toward a more balanced mix of military and civil products. Some firms have adapted military aerospace hardware for civilian use or have sought non-aerospace markets for their expertise. To remain profitable, many companies have engaged in an almost continuous process of consolidations, mergers, divestitures, and international joint ventures and partnerships. Nevertheless, they all have been affected to some degree by the following developments: the ever-increasing costs of producing complex new aircraft and spacecraft, the globalization of the economy, the volatile level of government spending on defense-related projects, the state of commercial air travel and its needs, and the commercialization of space and the prospect of its low-cost access. These are the factors determining the size and scope of the aerospace industry today.

### Construction Industries

The construction industry is experiencing a severe competition, which is resulting – especially in Germany – in an increase in bankruptcies of small and mid-size companies. But also the largest contractors like Philipp Holzmann AG and Walter Bau have collapsed in 2002 and 2005. More and more subcontracting to low-salary countries of Eastern Europe is taking place, often under a loss of quality management. Still there are too many variables and unforeseen events in the process of building, which can cost a lot of money. The insecurities of the production process and the risk of price changes make building an adventure. This is especially true for the average, single-family house consumer.

## *Product*

Building construction stems from ancient humans need for shelter. It began with the purely functional need for a controlled environment to moderate the effects of climate. Constructed shelters were one way by which humans were able to adapt to a wide variety of climates and help to become a global species. The increasing wealth of urban settlements quickly led to more representative buildings (Figure 77) like temples and palaces, but also public buildings like theatres and libraries (Figure 78). The complexity and aesthetic control of these buildings required a systematic design approach and control of the building process, which the architect as the 'master builder' controlled. Thus, the product is often referred to as 'architecture', which always referred to aesthetic considerations as well. Buildings usually have several layers of classification. The most obvious is the functional one, which is immediately represented in their names: 'single-family house', 'train station', 'social housing', 'airports' etc. Usually function is divided on a top-level in public or private buildings. Public buildings comprise of government buildings, cultural buildings such as theatres, cinemas, transportation, education, health and social housing. Private buildings encompass of housing, offices buildings and industrial buildings. Another often-used classification is materials: timber building, steel frame, concrete etc. Each material has a certain logic and limitations in construction, which become apparent in the appearance of the architecture as well as in its costs. As for spatial planning and the integration into the environment, architects often refer to the shape of a building and its morphological aspects: solitaire, cube, L-shape, U-shape, courtyard building, block, slab, towers and so on are terms describing buildings, which have the specific logic in organization and definition of interior and exterior spaces. The architect is often referring to 'typologies' of buildings, which can be functional, morphological or regarding construction. These allow a certain classification over several layers of meaning. Whereas up to hundred years ago, there was a very strong convention, how buildings of certain functions had to look (e.g. Classic Roman Temple entrance for bank buildings), this has been radically questioned by the modern movement of the 1920s. Today, although the majority of buildings are rather conventional, some public and highly representative buildings have become a playfield of creativity and new building technologies. The Roman architect Vitruvius, one of the first architectural theorists, described that the product of architecture has to satisfy three basic functions: *firmitas*, *utilitas* and *venustas*. This translates into structural stability, functional usability and aesthetics. The core product of architecture is thus to provide a shelter against the changing impacts of the unprotected environment, to provide a platform for human activities and satisfy the human needs for beauty and comfort.



FIG. 77 The SwissRe high-rise building in London is a new landmark of London's skyline.



FIG. 78 The Sydney Opera House has become a symbol of the culture of Australia.

### *Production*

The production of buildings has, like shipbuilding, a very old history and tradition. Early materials have been made of timber and clay, which turned into prefabricated brick stones, which allowed fast and fireproof construction. Although material properties and building technologies were improved considerably the last hundred years, the principle of the construction with these materials is still the same as it was 2000 years ago. Stone was always very expensive to build with and was used for temples, palaces or cladding only. New materials like iron, steel and reinforced concrete strongly impacted the way we build, although there is still a considerable volume of timber buildings and masonry buildings, using some of the oldest building materials. Building, despite the use of slavery in Egyptian and Roman constructions, has always been very craft based and up to recently builders have been and some still are organized in craft guilds. The need for completely new building types and volumes introduced a higher degree of prefabrication and efficiency on the building site. Many of the building components now are produced in factories and delivered to the site. However, the integration of the components mostly does not happen in the factory, but on site, with different contractors involved at the same time in a limited space. This leads to a lot of inefficiency and irritation. Everybody involved in building construction is familiar with this difficulty. There are several research programs that are studying on how to use modern information technology to make the on-site assembly more productive. The main difficulty is to reach the small subcontractors, who are not able to invest into technology, but are highly interested in keeping their fixed costs as low as possible. Some considerable progress has been done in the prefabrication of concrete elements and elevations. Nevertheless compared to other industries this is still considerably low. Prefabrication is reaching a worldwide average of about 15%. Building has stayed by its nature, an on-site activity.

## *Organization*

Because of its relatively low level of technology, wide geographic distribution, highly variable demand, and wide variety of building products, the building industry in industrialized countries is subdivided into many small enterprises. This lack of centralization tends to discourage research and keeps building components sturdy and simple, following well-tried formulas. The classic role of the architect was not only to design the building for the client, but also to organize the building to completion. This has become increasingly difficult for smaller architect's offices with the increasing complexity of building and building technology. Specialized project management offices tend to take that role from the architect. This complexity and the amount of people and skills involved in building create a lot of interface problems, where information gets lost or changed without feedback. When the final design is done together with the involved consultants and engineers, the architect tenders all the different building parts to an open market of subcontractors, often running business near bankruptcy. Recently a trend has shown using general contractors who offer the whole construction package. General contractors then themselves employ subcontractors, whose quality and performance is difficult to control. In several occasions there has been an increasing loss of quality control, since the architect or client does not have an influence on the selection of these subcontractors. On the other end of the scale are the building materials manufacturers. These are mostly big companies, who rarely suffer under the fluctuating building market. But, they are not interested in the building process as such. The long duration of building, high costs and fluctuating quality in building has been identified as the main problems of the industries. Improved support by the computer to prevent information loss may help to improve the organization. But the real challenge would be to organize an 'open' factory, which is run by individuals, working independently and on different places.

## *Design Process*

The design of a building begins with its future user or owner who might have in mind a perceived need for the structure, as well as a specific site and a general idea of its projected cost. The user, or client, brings these facts to a team of design professionals composed of architects and engineers, who can develop from these a set of construction documents that define the proposed building exactly and from which it can be constructed.

Building design professionals include those licensed by the state—such as architects and structural, mechanical, and electrical engineers—who must formally certify that the building they design will conform to all governmental codes and regulations. Architects are the primary design professionals; they orchestrate and direct the work of engineers, as well as many other consultants in such specialized areas as lighting, acoustics, and vertical transportation. Architects have been described as one of the last generalist professions, knowing much of everything, but little about something in detail whereas engineers might be known as the vice versa.

The design professionals draw upon a number of sources in preparing their design. The most fundamental of these is a building science, which has been gradually built up over the past 300 years. This includes the parts of physical theory that relate to building, such as the elastic theory of structures and theories of light, electricity, and fluid flow. There is a large compendium of information on the specific properties of building materials that can be applied in mathematical models to reliably project building performance. There is also a large body of data on criteria for human comfort in such matters as thermal environment, lighting levels, and sound levels that influence building design.

In addition to general knowledge of building science, the design team collects specific data related to the proposed building site. These include topographic and boundary surveys, investigations of subsoil conditions for foundation and water-exclusion design, and climate data and other local elements.

Concurrently with the collection of the site data, the design team works with the client to better define the often-vague notions of building functions into more precise and concrete terms. These definitions are summarized in a building space program, which gives a detailed written description of each required space in terms of floor area, equipment, and functional performance criteria. This document forms an agreement between the client and the design team as to expected building size and performance.

The process by which building science, site data, and the building space program are used by the design team is the art of building design. It is a complex process involving the selection of standard building systems, and their adaptation and integration, to produce a building that meets the client's needs within the limitations of government regulations and market standards. The building type for which they are intended has divided these systems into a number of clear sectors. The design process involves the selection of systems for foundations, structure, atmosphere, enclosure, space division, electrical distribution, water supply and drainage, and other building functions. These systems are made from a limited range of manufactured components but permit a wide range of variation in the final product. Once the systems and components have been selected, the design team prepares a set of contract documents, consisting of a written text and conventionalized drawings, to describe completely the desired building configuration in terms of the specified building systems and their expected performance. When the contract documents have been completed, the final costs of the building can usually be accurately estimated and the construction process can begin.

### *Manufacturing Process*

A specialized construction team usually executes construction of a building; it is normally separate from the design team, although some large organizations may combine both functions. The construction team is headed by a coordinating organization, often called a general contractor, which takes the primary responsibility for executing the building and signs a contract to do so with the building user. The cost of the contract is usually

an agreed lump sum, although cost-plus-fee contracts are sometimes used on large projects for which construction begins before the contract documents are complete and the building scope is not fully defined. The general contractor may do some of the actual work on the building in addition to its coordinating role; the remainder of the work is done by a group of specialty subcontractors who are under contract to the general contractor. Each subcontractor provides and installs one or more of the building systems e.g., the structural or electrical system. The subcontractors in turn buy the system components from the manufacturers. Often there are conflicts of systems, which are only discovered on the building site (Figure 79), or conflicts with schedules of different subcontractors, who have to work in the same space and have to follow a critical path (Figure 80). During the construction process the design team continues to act as the owner's representative, making sure that the executed building conforms to the contract documents and that the systems and components meet the specified standards of quality and performance.



FIG. 79 The individuality of most building-sites makes them difficult to plan and often conflicts and inefficiency can be observed.



FIG. 80 The building assembly is often accompanied by in-situ adjustment work and schedule conflicts by the subcontractors working in the same space at the same time.

### *Sales and Services*

Building construction is a design- and built-to-order industry. The differences in available sites and the ever changing needs make it difficult to establish mass produced office buildings. This is rather possible in the single-family house, but due to historical reasons, the mass produced house still has a negative image. Buildings are either owned by the client or rented. Clients approach an architect either by direct appointment for small buildings or a competition for larger buildings. If the client is happy with the design and has a cost estimate, the building is ordered. Architects rely on their good reputation and customer care, since as a liberal profession they are not allowed to make advertisements other than through their work. Larger developments like office parks or housing scheme would not be possible with individual clients, therefore developers play an important role

in the provision of buildings. Developers collect the money for a larger investment, buy the site appointed by the architect and rent or sell the buildings with profit. Except for an up to 10-year warranty on planning mistakes and faulty construction, the relation to a client stops after the construction and final payment of the building. Maintenance is usually appointed later again, often to different companies. Recently, especially for owners of office buildings and larger housing schemes grew an understanding that the lifetime costs of a building are much higher than the initial construction cost. Together with a improved interlocking of CAD and building databases a new specialty developed: facility management. Facility management is the management of buildings and services. These services are sometimes considered to be divided into hard services and 'soft services'; hard services includes such things as ensuring that a building's air conditioning is operating efficiently, reliably, safely and legally; soft services includes such things as ensuring that the building is cleaned properly and regularly or monitoring the performance of contractors. Facility management has recently established as a management discipline in its own right. It is the role of facility management to ensure that everything is available for the other staff in an organization to do their work.

### *Economic Significance*

Buildings, like all economic products, command a range of unit prices based on their cost of production and their value to the consumer. Cumulatively, the total annual value of building construction in the various national economies is substantial. In 1987 in the United States, for example, it was about 10% of the gross domestic product, a proportion that is roughly applicable for the world economy as a whole. In spite of these large aggregate values, the unit cost of buildings is quite low when compared to other products. In the United States in 1987, new building cost ranged from about \$0,50 to \$2,50 [approximately €0,46 to €2,32] per pound [0,45 kg] [building construction, n.d.]. The lowest costs are for simple pre-engineered metal buildings, and the highest represent functionally complex buildings with many mechanical and electrical services, such as hospitals and laboratories. These unit costs are at the low end of the scale of manufactures, ranking with inexpensive foodstuffs, and are lower than those of most other familiar consumer products. This scale of cost is a rough index of the value or utility of the commodity to society. Food, although essential, is relatively easy to produce; aircraft, at the high end of the scale, perform a desirable function but do so with complex and expensive mechanisms that command much higher unit prices which reflect not only the materials and labor required to produce them but also substantial capital and research investments. Buildings fall nearer to food in value; they are ubiquitous and essential, yet the services consumers expect them to provide can be supplied with relatively unsophisticated technology and inexpensive materials. Thus there has been a tendency for building construction to remain in the realm of low technology, for there has been relatively little incentive to invest in research given consumer expectations.

Nevertheless, buildings represent a big part of a nation's asset and wealth. Construction industries are also big employers and are thus economically important as well.

## Prefabricated Houses Industry

As we have seen in Chapter 2.2: Today's Situation in the Housing Markets Japanese factories are the most advanced and adopted the best of modern industrial processes. Nevertheless they face the competition by the small traditional house builders. In the following chapter we will focus mainly on the European Industry and especially on the German Prefab industry, which operates in the largest market in Europe.

### *Product*

The product line of the prefabricated house industry ranges from the turnkey house to different stages of finish. This is mostly due to meet the customer's preferences. Some like to equip the kitchen and bathroom themselves, or bring along appliances from their old house or apartment. Especially the sector of the self-equipped houses increased during the recent years. Customers buy a house, which is finished to the degree to be weather-tight and then they finish painting, kitchen installations and so on themselves, thus saving money. The industry is offering different types of houses, which can be customized to a certain degree. By offering a widespread individuality the industry tries to counteract their 'run-of-the-mill' image. Unfortunately they rarely achieve it, since they rarely manage to give much character to the houses. House sizes range from 100 – 180 m<sup>2</sup> and are 2 stories high. In Germany, even price conscious buyers spend a lot of money for a basement, since they are not used to any other solution. Furthermore, for the factory-made house, companies are offering several services around house buying, ranging from financing and land-acquisition to getting building permission. The companies sometimes do have in-house architects, but are also collaborating with local architects on a provision basis to help the client to deal with the specific site-conditions, local building regulations and personal customization of the product. Often the local architect and the company's salespersons are the main contacts for the client.

### *Quality*

The quality of today's prefab houses is usually of a very high standard, and in the best case it should be better than site-built houses of the same kind, since there can be more quality control. However, the prefabrication industry has to suffer equally from mistakes done in the past and bad press that is often exaggerated and not necessarily true anymore, such as how some prefab houses from the 1960s had high values of formaldehyde used in the chipboards or as prefab-houses were usually faster built compared to on-site construction, the problem of mildew occurred more often. However, the prefab industry learned from their mistakes and the BDF's member companies founded a quality control association in 1989. Its statutes continuously impose new and more stringent quality standards in excess of legislative requirements to form a basis for intelligent and progressive construction methods.



### *Features*

Often the prices for a prefab house are not considerably cheaper than traditionally built houses. The main benefit for the client is that he only has to interact with a total contractor, who offers everything within one office. This can give the client many benefits, but also cause the loss of independent expertise control, as it would be with an architect-designed house. Prefab industries have a widespread catalogue of features they offer. This is mainly to counteract their negative 'industrial' image, but also to be able to have an adjustable price-mix. Common features, for example are bay windows, skylights, and balconies, but also features such as solar heating and sauna are offered.

### *Style and Design*

Automotive industries, Aerospace and shipbuilding employ top designers for their product, since they know that design sells. In the house building industry high quality professional design rarely sells.

Architects in Germany design less than five percent of 30.000 newly fabricated houses [Hoffmann, 2003]. Rather than leading the industry by design, prefab companies serve stereotypical ideas by offering typical designed houses and give them identifiable names such as 'Finca', 'Swedenhouse', or 'Blackforest House'. These types are then offered with a wide range of individual options for the client to choose from, with or without professional guidance. Thus, most of the houses are not just dull and boring in design, they are often architecturally unacceptable. This is one of the reasons, architects don't want to have anything to do with the prefabrication industry. The industry thinks as long as they sell their product, there is no need for change. Thus an important market development potential is given away as a less traditional clientele such as late baby-boomers, already exists.

### *Branding*

According to a survey by Stern Trendprofile [2003], Kampa is the most known Prefab brand in Germany, followed by WeberHaus. However, compared to the advanced and market leading marketing and branding concepts of the automotive industry, branding is far behind in the prefab industry. If there is a logo, it is often made with the graphic element of a gable roof, but the majority is just using the name, which is often the family name of the founder, or an abbreviation of it [Figure 81]. Most brands do not communicate any elegance, modernity or life-style.



FIG. 81 Typical graphical logo for housing

### *Production*

House production is performed in factories with a main hall for assembly and additional buildings for the subcomponents. Since storage is difficult given the size of the houses or components, usually houses are built-by-order. There are 3 principles of prefabrication: First, ready made large-scale wall and roof elements, which are assembled on site usually within a day. Second: fully installed modules, which are assembled on-site. Third, fully finished turnkey houses, which are usually set up and operational within one day. In Europe, most manufactures work with wall-elements and a fewer number with modules. Full houses are rarely transported, due to restrictions of the existing street network. In principle the degree of prefabrication is dependent on the transportation. European street regulation allow permit-less transportation up to 2,55m width. Any above 3m, requires a permit and police escort. The element method allows best use of the transportation volume and is thus preferred. The wall elements are usually fully equipped with doors, windows, plumbing and electrics in the factory. Generally, the degree of automation found in European house-building factories is pretty low as a lot of work-procedures are done as they would be if on a normal building-site. Advantages of the factory are the independence of weather and the more regulated distribution of work processes.

### *Organization*

The prefab housing industry has been historically independent and competitive. With the invention of the chipboard, or pressed wood, in the 1950s, many carpentries entered the housing market. The 'Bundesverband Deutscher Fertigbau e.V.' (BDF) was established in 1961 as an association of manufacturers of pre-fabricated timber buildings and currently has 42 members. It is a non-profit organization with the main objective of providing information on intelligent construction for potential customers of its member companies and for the media. BDF aims to support customers and improve product quality. In the 1980s permanent house exhibition (Musterhaussiedlungen) were established, which are

distributed over Germany. This allows potential clients to visit the houses by the main companies all year round, and helped keeping sales relatively consistent. The industry goes through a period of consolidation with mergers and collaboration agreements. However, the majority of the factories are not producing more than 1000 houses a year and there are many carpentry businesses that only produce between 3 and 10 prefabricated houses a year. Indeed, each modern carpentry can easily produce a prefabricated houses based on timber frame construction. The pre-fabrication industry has a very low level of sub-contractors. Usually they buy the materials and components like doors and windows on the same market as traditional builders do.

### *Design Process*

The design of prefabricated houses is usually based on type designs, which are calculated for building structural design and energy efficiency. Thus they can be offered for a fixed price. The companies usually base their designs on market expectation, whereas a main market might be young and just starting a family. Once the base design is calculated, companies allow a high degree of alteration, if the main building structure is not changed, usually at an additional price for the extras like skylight or bay windows. Mostly it is within the responsibility of the client to check for building permits and site conditions. The prefab industries benefits from the fact that each type design can be repeated and does not require major recalculations by the building experts. Many prefab companies are also offering the production of houses with individual architecture plans brought by the client. In most cases a first contract is made with the clients including a basic equipment of the house. The detailed outfitting of the houses is then specified later together with the client. The companies have sample centers where the client can select radiators, electric outlets, doors, floor finish, etc. Higher quality outfitting can be selected at the correspondent surcharge.

### *Manufacturing Process*

Manufacturing of the house elements takes place in the controlled environment of the factory, where production usually starts with the machining of the timber beams. The CAD data from the construction drawings is directly fed into the CAM machines and the computer aided machining of the timber allows a quick and precise assembly of the wall, roof and floor frames while on a flat surface. After the frame is finished, the wood or plasterboard siding is moved onto one side. The wall is turned over and the insulation material and installation is fitted in. After the second siding is mounted, the wall elements are turned into vertical position, where windows and doors are fitted in. After painting, the elements are packed weatherproof for transportation by the truck. For a standard size house, about 4 large trucks are needed. The assembly of the elements takes place on the site, where the basement and the floor slab have been cast in concrete previously. A mobile crane is rented and used for assembly. The house is usually weatherproof within 1-3 days, and after about one week, the final touches are made.

### *Sales and Services*

The industry mostly prefers to sell directly from the company or from their house exhibitions. Sometimes, local builders and architects are contacted and offered provisions for their expertise, as they can be much closer to potential clients. Some may even go into contracts with builders or architect's offices as local representatives of their system. Services may include financing and land acquisition support, although, after completion further services are rarely offered.

### *Economic Significance*

The prefab housing industry has to be considered part of the building and construction sector even though, compared to the traditional building industry, the prefab housing industry has a much lower economic significance even though they do provide local employment in their factories.

Something to note is that while slightly more cost-effective, prefab houses still lose value faster than traditional-built masonry houses and even if two houses were identical, the prefab house would usually sell for less.

02.04

## DISCUSSION

The development of all example industries, except the building and prefab industry, experienced over the last century a strong consolidation and globalization. The strongest acceleration of this tendency was during the last decade, which has experienced the biggest industrial mergers ever. Small companies only exist in very special niche markets. However, through a strong outsourcing of component parts to specialized subcontractors there is an abundance of medium-size and small subcontractors around the big companies, which more and more become the assembly centers of the final components.

### *Product*

The prefabricated house can best be compared to the products of the automotive, aerospace and ship building industry, leaving aside, its site-related adjustments. The non-building industry's movements to diversification and consolidation have been different. The prefab industry has never gone through these phases to the same extent. Since the production investment is in comparison relatively low, there was never a strong incentive in diversification. Different than the Aerospace and ship building industry, the automotive and prefab industry offers an end user product, which means that there are very diverse

target markets. The automotive industry offers a range of models with different prices and sizes to accommodate those markets. Most big brands, which make their main turnover by average mid-size cars, invest into sports cars, concept cars, formula one and other races to convey the image of being a leader in design and technology. Some prefab house producers have only adopted this approach recently, however, a designed house by a famous name does not translate into an average product.

### *Quality*

A persistent quality level and quality control stays a big issue in building construction. Since building structure usually has a high redundancy, the quality control and certification process are less demanding than in the vehicle industry. The prefab industry usually follows state-of-the-art quality management, since control within a factory is easier than on the building site.

### *Features*

Especially in end consumer product like cars or computers, features are an integrative part of the marketing. Usually in these industries features quickly become standard and new items become features. An example might be the electric window for cars, which was originally a surcharge feature and has become standard in most cars today. In the building industry, technological development is often not that fast as comparison to price and features of custom-designed houses is not given. Prefab companies usually offer core houses with balconies, a roof over the entrance or terrace, winter gardens or solar heating as possible surcharge features. The integration of a special feature for brand identification is rarely seen. The German company Baufritz is offering such an example with the 'Cabrio House'. The parallel to the convertible car is seen and the hydraulic roof offers a balcony space, which can be used all year round [Figure 82].



1



2



3

FIG. 82 The 'Cabrio-Haus' offers a glazed roof section, which can be opened like in a convertible car. (source: [www.baufritz.com](http://www.baufritz.com))

## Style and Design

Style and design is a major element in product identity and branding within many industries such as automotive, aircraft and cruise liners. In all of these industries, top designers are utilized at the highest price, as mediocre design would have devastating results. However, this is not the case in the building industry. The majority of the building and prefab industry seems to be pretty indifferent about the quality of the design, especially prefab house producers can symbols of the mediocre design mentality in the house building sectors be found. One of the few exceptions is the German 'Huf-Haus', which has a clear and puristic architectural style [Figure 83]. The half timbered house was been designed in 1972 by architect Manfred Adams and the family run company has been keeping with the design ever since and even offer a white and a black color option alongside the white and brown. Huf houses have been sold to the UK and is preparing for sales within China. Huf-Haus has successfully been operating in a market niche in the medium und upper markets, selling approximately 120-130 houses per year.



FIG. 83 The Huf-Haus is an architect designed product with a clear style and the clear lines and the openness of the house convey a classic modern architecture. [source: [www.huf-haus.de](http://www.huf-haus.de)]

## Branding

Nearly all car names rank under the Top 100 Brands [2005] listed by BusinessWeek. Boeing and Airbus are well known as well as the national airlines. Shipping and house brands are known on a much lesser extent. With the housing brand, this is astonishing and an indicator that the 'house as a product' has never been adopted. Even prefab house builders do not design their houses for distinguishable design items like the BMW that has a rear side

window detail [Figure 84]. As many other products are clearly marked with logos and names of the producer (BMW, Mercedes-Benz etc.) houses are not. Apparently it is not something people like to show, although, if one looks into some gardens of single-family houses, there is no shyness in the pride the homeowner might have. The prefab industry still does not have the courage to make their product look different than the average home [Figure 85] as they seem to be too afraid to change their “run-of-the-mill” image. Instead, they might attempt to use some form of individualization and craftsmanship instead without understanding the role design and branding might have in the modern consumer world.

Architecture history on the other hand is full of design examples, where architects designed houses for potential production in factories with very specific design details and branding ideas.

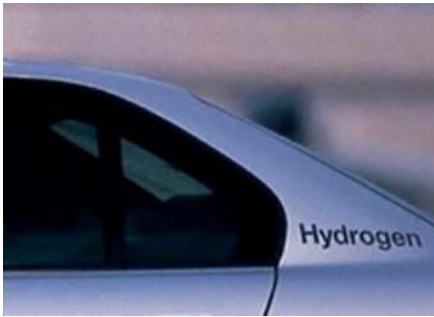


FIG. 84 The rear side window of this BMW car is a highly specific design feature of this brand with a high value of recognition. [source: BMW]



FIG. 85 Kampa House is known by one third of the German population, but one could not distinguish a Kampa house from any other along the road. [source: Kampa]

### *Production*

The automotive industry has been leading all other industries in production innovation and most of them adopted principles developed in that industry. Unlike European prefab houses, cars are an economy of scale and are truly mass-produced. The aerospace industry benefits from high security standards, but has cut costs through stringent introduction of CAD design and lean production. The ship building industry also adopted a closed chain of computer-aided design to manufacturing. The ship building industry is especially efficient in making parts out of a few standard steel products and using automatic laser cutting and plasma welding to produce quickly every customized building fragment needed. As all other industries, the shipbuilding relies strongly on subcontractors, who deliver ready-made interiors for their steel hull.

The building industry works with subcontractors, though relations are not close and rarely finished products are delivered. The prefab industry also limits itself timber as the main building material, which allows fast and easy fabrication with relatively cheap machinery. The amount of subcontracting and outsourcing is low. Since skills and production facilities needed to prefabricate houses are not highly specialized, location is less important, as it would be to perhaps aerospace or shipbuilding industries.

### *Organization*

As all industries went through a strong consolidation and globalization in the last decade, the prefab housing industry has not. Although Japanese companies are active in Asia-Pacific and Canadian and American companies have entered the Japanese market, European companies work regionally. The relation of the effort of being present on a market, compared to the expected sales, seems not to be beneficial. Potential market opportunities are thus often overseen. Recently Huf-Haus was successful in selling some houses to the United Kingdom. The quality of building in the UK is much lower than in Germany and prices were very high in the housing boom of the last decade. Some people in the UK started to realize that they get a higher quality at a cheaper price if they buy a prefabricated home from Germany. The majority of the industry had ignored this market potential and Huf-Haus has been successful in recognizing it.

The industry is usually organized on a national level, separately from the traditional building industry. In Europe there is no pan-European organization and markets are still strongly segregated by the different building laws.

### *Design Process*

In all vehicle industries a fully computerized design process and a seamless link to manufacture has been established in the last decade. Catia is the most widely used program for CAD design. To avoid geometrical conflicts, which can also happen by the use of CAD data, the car manufactures worked with a so-called zero-prototype, which is the only applicable reference for production. Each subcontractor has to prove that his component fits correctly on the zero-prototype. This avoids costly mistakes once the production lines are running.

The building industry has also been computerized in the last ten years, although it is in many cases an electronic form of drawing and is not exploiting the full potential for manufacturing. Even often data loss occurs by non-standard interfaces. The implementation of a closed chain computerization through the building process is an envisaged goal, but still difficult to realize. The many different parties and small-scale companies with a low profit margin do not allow the introduction of a complex computer system.



Many problems on the building-site could be avoided by the introduction of a virtual 'zero-prototype', where the building process and its components can be tested beforehand.

### *Manufacturing Process*

All vehicles industries have adopted the principles of lean production and component outsourcing to subcontractors. The building industry is still a piece-by-piece assembly process on the building site with a strong sequential character. The prefab industry is closer to a parallel production and higher component integration found in the other industries. However, the degree of automation is much lower, than in other industries.

Often the potential for cost savings is seen with an increased and leaner production. This approach may be questionable to a certain extend for the prefab house industry. Although the productivity of the European prefab house producer is more than 7 times less than the one of Japanese companies, there still seems to be a market which allows profitable companies.

### *Sales and Services*

Different industries have adopted different sales strategies. For instance, car industries have adopted a franchising system very early on and the produces according to market expectations. Shipbuilding is a built-to-order industry similar to the Airline industry where manufactures adopted a system where production only begins when enough buying options are sold. The building industry is more complex. Architects are not allowed to advertise. This is a major difference, when it comes to regarding architecture as a product. However, prefabricated housing companies are allowed to advertise. Japanese and American prefab industries adopted the franchise system as well, whereas the European industry is operating with sales on provision. With the collaboration in the prefab associations, the major part of the industry is maintaining exhibition colonies, where people can visit houses and talk to sales representatives. As some car companies started direct sales over the Internet, some Japanese housing companies started to do so as well. In Europe, the Internet seems to be only an extended catalogue instead of direct selling, of the prefab housing companies.

### *Economic Significance*

The economic significance of the vehicle industry is often emphasized as a worldwide trade, but also national interests for technology leadership and defense are linked to it. Many do not regard residential construction as such a market. However, if looking at the figures in Table 7, the preconception may change. The value of residential construction in the developed world is about double the value of the non-military vehicle industry together. Also the annual investment is still more than of all other industries together. If we make a modest assumption that ten percent of these housing units are factory-made, industrial

manufacturing of houses are still an annual market value of 75 billion Euro, not as much as the automotive industry, but nearly as much as the civil aircraft industry. This may cast another light on the housing industry and its potentials.

	HOUSING	CIVIL AIRCRAFT	LARGE SHIPS	CARS
Pieces <sup>1)</sup>	400 mio	415.000	38.564	500 mio (220 mio in the US)
Value[EUR] <sup>2)</sup>	60.000 billion	20.000 billion	6.000 billion	5.000 billion
Unit price <sup>3)</sup>	5 EUR/kg	1000 EUR/kg	8 EUR/kg	10 EUR/kg
Annual Production <sup>4)</sup>	5 mio	2000	400	50 mio
Annual Value <sup>4)</sup>	750 billion	100 billion EUR	62 billion EUR	500 billion EUR
	<sup>1)</sup> Estimate based on national statistics <sup>2)</sup> Economist <sup>3)</sup> estimate by Author	<sup>1)</sup> International register of Civil Aircraft <sup>2)3)4)</sup> estimate by Author/www.luftfahrt.net	<sup>1)</sup> Fischer Weltalmanach 2001 <sup>3)</sup> cruise ship <sup>2)4)</sup> estimate by Author	<sup>1)</sup> Wikipedia <sup>2)3)</sup> estimate by Author <sup>4)</sup> VDA

TAB. 07 Rough Order of Magnitude of value and production show the significance of the housing industry compared to the vehicle industry.

## 02.05 CONCLUSION

The building industry is a relatively loosely organized industry consisting of a majority of small companies with low entry and exit costs. Thus, it shows considerable differences to other industries and mass-produced products. However, the prefab housing industry works as a factory-based industry, but has never achieved the industrialization level reached by other industries. Furthermore, the industrial method of fabricating buildings never has been able to rule out traditional building methods as it has happened in most other industries. The consumer product house, compared to other consumer products like the car, is much less refined in its design and marketing. Many potentials here are left uncultivated. Production of the whole building industry still lacks a closed CAD chain and the computer-supported simulation of processes is completely underdeveloped. Still the relation of potential savings downstream to the simulation costs seems not to be enough to change that. Much of the causes lie in the organization of the building industry, which is still to a big extent divided by architects, engineers and builders and all fields seem to have strong incentives of protecting their own interests. An overall industry organization that can be found in automotive and aerospace is not taking place within the housing industry. For each new building, the pack of cards is newly mixed and efficiencies developed before are lost. The other industries have a much closer network and relation with their subcontractors. Because of this low degree of organization and low investments, the implementation of the industrial process in the traditional building industry becomes difficult regardless of its benefits. This would certainly be possible for prefab companies, but they don't seem to

want to exploit it as the fear of strong market fluctuations prevents them from making high investments. The manufacturing process in the building industry is not highly automated and still stays a piece-by-piece assembly as compared to the highly integrated and subcontracted components used in other industries. For the prefab industry, sales systems could be investigated more. Most companies operate only on local and well-known markets without further developing other potentials. This is astonishing, given the actual economic significance and tremendous market value of the industry, which is much higher than all the vehicle industry together.

#### BIBLIOGRAPHY

Aerospace Industry. [No Date]. Encyclopædia Britannica. Retrieved February 5, 2005, From <http://www.britannica.com/eb/article?tocid=9108308>>

Agile Manufacturing. [No Date]. ]. Retrieved February 2005, From [http://en.wikipedia.org/wiki/agile\\_manufacturing](http://en.wikipedia.org/wiki/agile_manufacturing)

Automotive Industry. [No Date] Encyclopædia Britannica. Retrieved February 5, 2005, From <http://www.britannica.com/eb/article?tocid=9108316>

Bestmann, U. [2001]. Kompendium Der Betriebswirtschaftslehre. Munich: Oldenbourg.

Building Construction. [No Date]. Encyclopædia Britannica. Retrieved February 5, 2005, From <http://www.britannica.com/eb/article?tocid=9106103>

Busse, R. [1998]. Was Kostet Design? [How Much Costs Design?] Frankfurt Am Main: Verlag Form.

European Parliament Fact Sheets. [2004, September 13]. Shipbuilding – Global View. Retrieved 31. July 2005, From [http://www.europarl.eu.int/facts/4\\_7\\_3\\_en.htm](http://www.europarl.eu.int/facts/4_7_3_en.htm)

Hoffmann, H. W. [2003, January 8]. Schöner Klonen. Karikatur Des Eigenheims: Warum Gibt Es Kaum Vernünftig Gestaltete Fertighäuser. Die Welt. Retrieved November 5, 2005, From <http://www2.welt.de/data/2003/01/08/30837.html>

Industrial And Manufacturing Engineering. [No Date]. Retrieved February 2005, From [http://en.wikipedia.org/wiki/industrial\\_and\\_manufacturing\\_engineering](http://en.wikipedia.org/wiki/industrial_and_manufacturing_engineering)

Jung, H. [2001]. Allgemeine Betriebswirtschaftslehre [General Business Economics] [7. Überarbeitete Auflage]. Munich: Oldenbourg.

Kotler, P., Saunders, J., & Armstrong, G. [2004]. Principles Of Marketing: European Edition. Harlow, England: FT Prentice Hall/Pearson Education.

Lorenz, C. [1990]. *The Design Dimension: The New Competitive Weapon For Product Strategy And Global Marketing*. Blackwell Pub.

Möser, K. [2000]. *Das Auto Und Die Autogesellschaft*. In Brockhaus-Redaktion [Ed.], *Brockhaus Mensch, Maschinen, Mechanismen* [Pp. 375-409]. Leipzig: Brockhaus.

Nam, C.H., & Tatum, C.B. [Jun88]. *Major Characteristics Of Constructed Products And Resulting Limitations Of Construction Technology*. *Construction Management & Economics*, Vol. 6 Issue 2, P133-148.

Ship Construction. [No Date]. *Encyclopædia Britannica*. Retrieved February 5, 2005, From <http://www.britannica.com/eb/article?tocid=66760>

Stern Trendprofile 2/03. [2003]. *Bauen Und Renovieren*. Stern. Gruner & Jahr. Retrieved November 03, 2005, From [www.trendprofile.stern.de](http://www.trendprofile.stern.de)

The 100 Top Brands. [2005, August]. *Businessweek*. Retrieved November 21, 2005, From [Http://www.businessweek.com/pdfs/2005/0531\\_globalbrand.pdf](http://www.businessweek.com/pdfs/2005/0531_globalbrand.pdf)

The Case For Brands. [2001, September 08]. *The Economist*, P. 11.

Ulwick, Anthony W. [2002, January]. *Turn Customer Input Into Innovation*. *Harvard Business Review*, Vol. 80 Issue 1,, 91-97.

Who's Wearing The Trousers? [2001, September 08]. *The Economist*, Pp. 26-28.

# 03 THE MARKET: POTENTIALS AND RESISTANCES

*„Thus any attempt to evaluate the present status of prefabrication must begin with recognition of the fact that the most important factors in such an evaluation are still not established [...]. Widespread application of prefabrication for ... housing will depend primarily upon the development of superior sales methods and a more saleable product, [...]. Technological considerations are, in the last analysis, subsidiary to these more important questions. Even a house which represented no important structural advances [such as the conventional “ready-cut”], if available on a standardized basis for quick delivery at a fixed price, would be a bigger step towards house manufacture than a more advanced system of construction minus a practicable merchandising plan.“*

Bruce & Sandbank, 1944

Bruce and Sandbank [1944] realized very early, where the key to the product ‘House’ may be: marketing. This notion though has been ignored through to the end of the century. Architects continued to develop clever technical systems, but they are distancing from industries and felt very uncomfortable with marketing. At the same time, industries have not developed their own strong identity, their major effort was to work against their negative image, but unfortunately not in a positive way. This chapter will discuss some aspects of the product house, which have often been mentioned as problems against its industrialization, although we have seen that the major problem may be the continuous competitiveness of the traditional building sector. Further it will be discussed what the interests and proposals of the major market players client, industry and architects are.

The understanding of what a 'product' is, dramatically changed during the last 5 decades when markets changed from producer's markets to consumer's markets. Up to the 1970s a good product was a product that worked, with longevity and the possibility of cheap repair or even self-repair. A good example would be one of the most successful cars ever built: the Volkswagen Beetle. It rarely failed, and if it did, it was often a fast and easy repair. Looking into an engine of a modern car today, digital sensors have replaced the wrench of a car mechanic and make self-repair difficult, if not impossible.

Today, in a consumer's market, the product is expected to work. Many organizations and certification procedures take care of that. Product liability and consumer's rights dramatically increased in the last decade. This not only led to much better products from the consumer's point of view, but also to harsh competition for the producers. How does one differentiate products for a buying decision, if all products have a similar technical quality? Marketing experts understood that a product is more than just its functionality and thus, modern marketing was born.

### The Classification of Products

'What is a product?' and furthermore what is the product 'house'? To identify the product of 'house' in the range of other products, it may be helpful to look at product classification and rating systems as they are used in our economy. Products are commonly classified in either consumer or non-consumer (industrial, commercial, business) categorizations. Depending on if it is used for private consumption or production, if it is a consumer good or capital good. Consumer goods are differentiated by their lifetime into soft goods and hard goods. Hard goods are also called durable goods, which do not quickly wear out, or more specifically, it yields services or utility over time rather disposable. Usually durable goods have a lifetime of more than 3 years. Thus, the (private) house is a durable consumer good.

Gaulden [2004] is proposing integrated product taxonomy based on 'utility' and identifies at least four approaches for consumer products:

*"Over the years, a variety of classification systems for consumer goods have been proposed. We may handily bookend those between Copeland [1923] and Murphy and Enis [1986]. Such goods classification schema have focused primarily on consumer response variables, such as willingness to exert effort [e.g. Copeland, 1923], or on specific characteristics of the product such as durability or frequency of purchase [e.g. Aspinwall, 1962]. Enis and Roering [1980] proposed a synthesis on two dimensions of consumer behavior [expected effort and perceived risk] and two proposed congruent dimensions of marketer behavior [product differentiation and marketing mix differentiation]. They cast the two into a unified taxonomy. Their model emphasized consumer behavior and marketer*

behavior variables, albeit in an integrated framework. In the same era, Kotler [1980] presented a slightly different product taxonomic treatment. He proposed a series of now familiar, concentric concepts: core product, formal product and augmented product.”

Enis and Roerings model would put the house compared to other products at the top end of expected effort and perceived risk and at the low end of product differentiation and marketing mix differentiation.

Wikipedia [Product [business], 2005] describes the Aspinwall Classification System as one useful technique in understanding a product. It classifies and rates products based on five variables:

- 1 Replacement rate – how frequently is the product repurchased
- 2 Gross margin – how much profit is obtained from each product (average selling price less average unit cost)
- 3 Buyer goal adjustment – how flexible are the buyers’ purchasing habits in regards to this product
- 4 Duration of product satisfaction – how long will the product produce benefits for the user
- 5 Duration of buyer search behaviour – how long will they shop for the product

A quick comparison with consumer electronics and cars shown in Table 8 reveals the special situation of the house, which has a very low replacement rate, the gross margin in percent is relatively low, the buyer is usually a first time buyer or a relatively inflexible re-buyer, since they know what they want. Duration of product satisfaction is usually very long, with the exception of kitchen und bath equipment, and buyers are usually well informed and take a long time to find the right house. This already touches on some important points in comparison to most other consumer products.

Aspinwall Classification System			
	Consumer Electronics	Car	House
Replacement rate	high	Medium	low
Gross margin	low	high	low
Buyer goal adjustment	high	medium	low
Duration of product satisfaction	short	medium	long
Duration of buyer search behaviour	short	medium	long

**TAB. 08** The Aspinwall product classification system reveals some key differences of the product house compared to other consumer products.

It is important to note here that cars as well as electrical equipment and furniture have been perceived as long time investments about 40 years ago. But there is a clear trend in all products to an increased replacement rate and a shorter duration of the consumer satisfaction. This happens although many of these products, especially cars, may actually have a longer product lifetime than before. Increasing wealth and falling prices through globalization, but also through design and product innovation support this trend. The lifestyle and the perception of products have strongly changed through the last generation. For our parents' generation, furniture probably still was a lifetime investment, usually inherited from their parents. Today we buy furniture according to our life situation as child, student, family etc. and we change furniture when we change our lifestyle and taste. The German Trendbüro [1999] even predicts, that in future furniture will be so cheap, that we change it much more frequently to reflect our moods and will be thrown away and recycled. In a consumer society where the high consumption and the decreasing lifetime of products is increasing its waste, recycling of used products is an environmental obligation and product laws clearly show that it is heading to that direction. Whereas in production reducing waste is vitally reducing costs [Orzech, August 10, 2005], products which are designed for easy and cost-effective recycling will likely not decrease the product replacement rate, but spur the trend towards 'throw-away' products. Probably a new word will be invented soon for these products like 'convenience-furniture' or 'convenience cars'. The 'convenience house' may be well possible, if all parts are engineered towards a short lifetime and considerable costs could be saved. In any way, it has often been argued, that the low replacement rate and long duration of customer satisfaction speak against the house as a mass-produced industrial product. But people constantly work on their houses, as seen by the big and ever growing DIY market. Kitchens get renewed, along with bedrooms and bathrooms, for instance. This would support the thought-change to how we see houses as 'product baskets' or 'product-platforms', rather than a single original product. The technological challenge would be to design the exchange platforms as 'plug-and-play' products, which can be updated. Today's remodeling of a house is still too arduous to accelerate within this possible market. Kotler's [2004] concentric model of the product [Figure 59] is putting emphasis on the core product, which is often forgotten by industries: What is the buyer really buying? It must consist of the core, problem solving benefits that consumers seek to fulfill their needs. Kotler points out, that a woman buying a lipstick buys more than a lip colour. Charles Revlon of Revlon Cosmetics saw this early on when producing his line: "In the factory, we make cosmetics; in the store we sell hope." Theodore Levitt has pointed out that buyers 'do not buy quarter-inch drills; they buy quarter-inch holes'. The core product, may be less helpful for classification of a product but it is very helpful to identify often hidden and forgotten values from the customers perspective. A common misunderstanding that is that people actually don't 'buy' houses but invest money into a place, which they hope to call 'home'.

### Marketing of Products

Kotler [2004] defines marketing as a social and managerial process by which individuals and groups obtain what they need and want through creating and exchanging products and value with other. Marketing has actually a much wider spectrum than selling and



advertising, as many people think. Core aspects of modern marketing are to communicate value and achieve consumer satisfaction. This is also the basis for the marketing mix. A product never stands alone, but is part of a marketing mix, which is based on the 'four Ps': Product, Promotion, Price and Place [Table 9]. The marketing mix and the four Ps are a dominant idea of modern marketing and covers many important aspects of a product from the marketing point of view.

Marketing Mix			
Product	Promotion	Price	Place
Variety	Advertising	List Price	Channels
Quality	Promotions	Discounts	Coverage
Design	Personal Selling	Allowances	Assortments
Features	Publicity	Payment period	Locations
Brand name	↓	Credit terms	Inventory
Packaging		↓	Transport
Services			↓
Warranties			
↓		↓	↓
Target Market			

TAB. 09 The four Ps of the modern Marketing Mix [source: Kotler (2004), p. 34].

For all of the four Ps, there is a very clear development: they all have become increasingly better through the development of the consumer society and still are developing in that direction. Products have become better in quality, design, variety, warranties etc. Promotion and advertising is ubiquitous (which is not seen as an improvement by everybody.) and usually of high quality and less deceptive. Prices have come down in real terms or in relation to the actual value of the product and the means of financing have become much easier and widely available. Availability has increased tremendously and delivery times decreased. All these developments basically have been induced by an open and global market, which is ruled by competition. Although producers have to stay much more alert to changes than before, there is still a lot of money to be earned. The conditions for the consumer become better, which result in a much higher willingness to buy more in quantity and in quality. The average lifetime of products in terms of use has come down dramatically especially in electronics, where product innovation is driving consumers to buy new computers every three years and new models are released every six months. The implications of these developments for the product house are, that we gradually change the way, how we make our buying decisions, which may also influence in the long term how we buy a house.

Prefab industries mostly cover the four Ps of marketing, but not as elaborated as in other industries. As an example serves the price. Prefab industries often play with fixed prices, something difficult to obtain in the traditional building industry. But the prices very often relate to a very basic standard model of the house. All special wishes are possible, but often surcharges are relatively high. This gives the clients the counterproductive feeling that he is forced into a standard model. Also prices become similar to an architect-built house. Furthermore, clients often deal with salespeople, which is completely different than if they deal with an architect. The architect creatively develops solutions for the client within a price range, whereas a salesperson is just offering options within a standard.

For most people, buying a house is the biggest and most difficult investment they undertake in their life. If they decide to build their own house, it is even more risky, since they are buying something that they cannot see and test beforehand. There is no test drive available for designed-to-order houses and a lot of trust in the architect is required. Considering prefabricated houses one would think the risk could be lowered in many aspects like exhibition houses, but still acceptance is quite low. Several reasons can be identified for this.

03.02

## RESISTANCES

### Limited Markets

Many resistances to the house becoming a product mostly comes down to connection to the land. Although the land markets mainly work by supply and demand, the properties of the product 'land' or 'building site' becomes more individual in turn. The unique local characteristic of each building plot makes it difficult to place the same house in a different location. The house market is further limited by the geographical availability of sites and the immobility of the houses. The place for a family to live is usually close to the employment of the adults, which is tends to be in close proximity to cities. Thus single-family house neighborhoods were developed within the perimeter of the cities, called the suburban ring. This is not only because there is land available, but also because the further away from the center of a city, the cheaper the land. However, commuting becomes longer and often the right location is a trade-off between commuting time and costs versus land costs. With the pressure of a growing city, land value rises and new buildings sites move further out. Adding all other site parameters like availability of shopping, childcare and so on, the actual choice of housing placement becomes rather limited. Although more land for houses has been made available since the boom of the 1960s, land cannot be 'produced', it is limited and a single family house is not necessarily the highest profit one could gain out of a piece of land. For this reason communities balance the usage of the land by zoning laws and development plans. As a result, many communities near cities have a kind of competition to attract house owners and also attract potentially good taxpayers.

### *How Could Such A System Change?*

It has been claimed that, if houses would be mobile and thus very easy to transport, markets for houses could develop independent from markets for land. Further, if land ownership would not be linked to an actual geographical site, but rather the right to put your house in a equally valued site, markets could change. A system similar to that, can be found in the US, where Manufactured Homes [so-called HUD-Code homes] have historically been subject to zoning-based restrictions. In so-called trailer parks or manufactured home parks, a plot can be rented, while the inhabitant privately owns the house on it. Usually a good efficient use of the land can be achieved as a potentially high quality, avoiding the high initial land costs. Unfortunately these trailer parks are often associated with low-income groups and separated in the community, and their reputation is not highly regarded. Nevertheless, the US is one of the very few countries where there is actually a part of the market, where people bring the house to the site on wheels!. However, reality shows, that only 3% of these mobile homes in the US are ever relocated after their first installment [Bernhardt, 1980, p. 19].

Traditionally in Europe the relation to the actual family-inherited land has been closer than in the US, but with upheavals due to World War I and II, and growing modernization, this has become less relevant, despite people being more regional orientated and perhaps not as mobile as in the US. Mostly people are looking for land and a house as one package. A different thought idea from Japan, where the family inherited plot of land is still very predominant and usually just the house is bought.

### *Regional Markets*

Regional characteristics of the house building markets do not just comprise the actual geographic location, but also that of local knowledge and tradition with industry and building laws. Local knowledge signifies a whole set of information, which is usually difficult to acquire in a short term as well as local belief and trust systems. Next to local data like ground properties, possible archaeological sites, contamination, which is often enough difficult and expensive to acquire, it can also comprise much difficulty to get information such as preferences of the inhabitants, behaviors of neighbors, local differences in ground properties, changes of zoning etc. The experience of building is full of stories of expensive ventures but important bits of information is sorely lacking. Also local building traditions and preconceptions from clients on how a house should look, make it difficult for industries to introduce serial production. Acceptance of prefabrication is usually higher where timber construction traditions found in countries such as Scandinavia, the US or Japan, rather than in plastered brick stonewall regions. From century old history of industrialization, it has come to be known what resistances are from local builders, who as small-scale enterprises, might feel threatened by industrialization. A famous historical example is the village of Pessac from Le Corbusier in 1925, where not only local builders resisted the project, but also local architects and the community, which delayed building permissions and water connection. At the end a Paris company built it and when after 3 years the

community provided the water, the houses could only be sold by massive support by the law 'Loucheur' [Boudon, 1989]. However, local architects made such negative publicity around it, that nobody wanted to move there. As 'lesson learned' Le Corbusier introduced the hand-made local stone wall in his later 'Maison Loucheur' project, to involve local craft at the very beginning and then deliver the whole factory-made house-kit. This local resistance has only gradually changed today, where builders often put higher prices to new production techniques, even if it would be more competitive on the long term. This is not just due to an inherent resistance to change but also due to lacking knowledge of the mainly small companies in the construction sector about industrial processes [Bärthel, 2002].

Passive resistance of local authorities is still known today, but a more difficult problem for prefabrication industries are local building codes. This is especially true and still applicable in the European Union. Since the emergence of a single European market in 1992, considerable efforts have been made to remove trade barriers between member states and efforts to harmonize standards have begun. The European Committee for Standardization [CEN] has developed many European standards in the past, which have been referenced by some national building codes. But still there will be a long way to go. The Canada Mortgage and Housing Corporation [CMHC, no date] notes that regional differences will stay:

*"The new harmonized standards and ETAGs [European Technical Approval Guidelines] create common approaches to test methods and assess compliance, and may prescribe minimum performance levels. However, building codes will continue to determine the level of performance. For example, thermal resistance requirements will be higher in Scandinavian countries than in the Mediterranean region. Building codes are cultural as well as technical, and reflect differing social values on safety, the environment and aesthetics. Also, the constitutional rights of states and municipalities to have their own codes vary greatly from country to country. Therefore, at this stage it appears unlikely that national, state and local building codes will be harmonized in Europe in the near future."*

Ball [2003] argues, that it is this 'reflection of social values' and the importance of local information, which make the markets so regional and prevent the house-building industry from globalization.

The introduction of the federal 'Manufactured Home Construction and Safety Standards' or 'HUD-Code' in North America serves as an example to show the opposite. In 1976 the already prosperous, mobile home industry came under the unified national HUD-Code, which started the era of the modern manufactured homes [NAHB Research Centre, October, 1998]. The industry was able to comply with one code and deliver the product to the entire nation, thus allowing them to build up an integrated system of production, distribution and land development. They also adopted the franchise sales system from the car industry. Modular builders in the US still had to comply with the regional building laws, however. Local market players are mainly made up of the regional's architects, engineers and builders. Their influence should not be underestimated and it is advisable not to exclude them, but rather make the product 'house' more attractive to them.

## *Volatile Markets*

It has often been claimed that the highly volatile market of construction does not lend itself to capital-intensive mass-production. Business cycles do exist in all industries and it is typically in the consumer durable or investment goods industry where the existing stock of a good is far greater than current output of it [Ball, 2003]. New housing represents only a relatively small percentage of all the houses bought and sold. In the UK, for example, new building average only around 15% a year of total owner-occupied house sales [Ball, 2003]. To compare that to the automotive industries, new passenger car sales were 39% of all car sales in 2003. The low production rate causes a steep price rise when demand is rising, which usually overshoots the long-run equilibrium and can collapse very quickly when incomes or interest rates are changing, which is always the fear of housing booms. Ball identifies this as one of the reasons as to why market cycles are inevitable in the housing market.

One reason why house prices fluctuate more than the prices of many other durable goods arises from the structure of housing markets. In industries like cars and domestic appliances, which also face similar 'stock-adjustment' demand characteristics, economies of scale in production tend to generate oligopolistic industrial structures. These enable firms to hold prices relatively steady during downturns in demand. They prefer to accept the resultant, possibly greater fluctuations in volumes in order to sustain the margins necessary to finance their large amounts of fixed capital. Such strategies are not realistic in house building, as the ease of entry and the competition in the housing market come from existing house owners. This means that in downturns, there are always large numbers of suppliers prepared to cut prices for a quick sale when financial pressures dictate. Ball further writes: "This pricing characteristic of house building is ignored by those who, over the decades, have argued that housing production should become far more capital-intensive, like a 'real' consumer goods industry." Unless supported by huge public subsidies, house-building firms that attempt to become highly capital-intensive in their production methods almost certainly go bust during the next major downturn. Although in a number of European countries this output fluctuations has been compensated by government social housing programs, most of the large house-builders that grew up during these programs disappeared as soon as public funding ceased, as did the innovatory building systems they sometimes used. House building fluctuations may vary markedly over time, but overall house-building fluctuations are not atypically large when compared with other capital goods industries, which experience significant output fluctuations as well. Other industries usually compensate downturn on domestic markets with upturn in other regions. These international differences in macroeconomic cycles, which do also exist in housing, have encouraged firms to globalize. Ball presumes, that this did not happen in house building because low scale economies and the importance of local information on construction, land and housing markets militate against it. Nevertheless, the Canadian manufactured timber house industry managed to generate substantial export to Europe and Japan recently. Usually German, Austrian and Swiss companies export houses to each other, but rarely beyond these region, which often has parallel business cycles. Recently some German companies showed market entrance in the UK, where the high prices and the

average low quality of building makes German prefabricated houses, like the upper market 'Huf-Haus' competitive. Bien-Zenker is developing a house that can be shipped by cargo container for the markets in China (Stocker, 2004). However, the region and the mechanics of the markets make it difficult to reach the point of no return for industrialization in house building. For instance, a house cannot be returned to the shop when the client is not happy with it. A full service around the product would have to be developed to create trust around the product, which may have come from a far away country, such as Japan. This makes it difficult to compete against the local builder who might have been established regionally for the last several decades. Unless a house can be successfully made into a product which people can identify with considerably added values like their own life-style or has a whole product package and are in turn, willing to considerably pay more for the additional services even in a highly competitive environment, it will be difficult if not impossible to change the housing market.

### Location

The house buyer must face the fact that in reality, it is two products that are bought: the land and the house. And very quickly the four P's of marketing turn into the 3 L's: Location, location, location. But it is this combination which makes the dream of the single-family house so strong: to live on your own property, such as described in the British publication *An Inquiry Into People's Homes*: "You're on your own, your dirt's your own" (Mass Observation, 1943). Land is usually considered as a safe investment and house-buyers are always advised that they really should buy a location, not a house. The location is the most valuable aspect of the product. Location can have many aspects to make it desirable: geography, direction in relation to the sun, safety, communication, infrastructure, neighborhood and so on. Thus, these aspects often prevail the actual details of the product house. The Halifax Happiest Home Report from the Social Issues Research Centre (2005) shows this aspect very clear. Although the amount of space ranks top of the factors that contribute to the happiness with the home, security, relationship with neighbors and personal gardens are high ranking. Although one buys freedom and independence with a private property, the way one can built on it is usually quite restricted by building laws as well as social pressures from the neighbors. The land and the house are two different products. The house is usually losing in value and requires considerable maintenance, whereas land is usually gaining value without further intervention, thus making buying a house a financial investment, rather than buying a consumer product.

### Consumer Goods and Investments

Housing is one of the last 'bastions' against industrialized mass production. One of the reasons often cited is, that the house is not a consumer product, but an investment. While this might be partly true, in actuality, it is both. Let's compare a house with the car again. An average car costs about 20.000 EUR and loses value over roughly 10 years. The initial loss is highest at the beginning. New cars lose about 25-35% of their re-sell value in the first 2 years. Except for classic cars, after 10 years most cars only have a symbolic or sentimental value left, if any at all. This is the case for most consumer products. This

situation has been further sharpened by digital electronics, where even products like cameras, which used to have a long-term resell value, can become redundant with no value in a very short time as better and cheaper models are available. If modern products break, it is usually cheaper to buy new ones than to have them repaired. Buying a consumer good at resell value is usually not expected. With the car, only a minimal resell value is usually expected over its 10 years lifetime. Houses as such, without the land, are following the same mechanics of devaluation in principle, but not in reality. Why? In practice of real estate calculation the lifetime of a standard solid construction house is often estimated to be 100 years [Mannek, 2000]. This results in a devaluation of 1% per year. This would reduce the value of a house to zero, if old houses would be measured in relation to new houses on the market. Based on house price indices for Germany a house built in 1913 would reach a rise of value over 100 years of about 2300% without land. The price indices reflect the increasing costs of building a new house over the years. For a price estimate of an old house usually 1% per year age devaluation are deducted. This means, that a 33 year old house, built in 1970, although it would have lost one third of its value, was worth about 210% of its initial value in 2003. The house, if well maintained, does not lose its performance or user value as much as other products do. The product house did not considerably change over the decades, as it did for instant technology in cars: you still can drive in an old car, but technological innovation have made new cars continuously safer, less fuel consuming, and less polluting. Houses still do compare nearly one-to-one over the years. Usually upgrades in insulation and building technologies happen over the years along with necessary maintenance. Houses are some of the few products that consistently gain value over the last few decades alongside the land they are built on. Thusly, although the consumer is looking for a product to consume, aka a place to live, all considerations for buying are towards an investment of capital. Since the perceived capital risk for an average family is relatively high, the expected resale value is a major part of the buying decision. Now, one could set up the hypothesis, that if houses would lose their whole value during their lifetime, that they would become cheaper by competition and thus a mass product. Their lifetime would reduce down to a normal rate of amortization, which is about 20-26 years for houses, depending on interest rates. As a consequence building quality would come down considerably and different construction methods would become interesting, since design-life for structure and skin could be reduced down to 26 years, possibly maintenance free. A similar situation to what we see in Japan. The average lifetime of a Japanese house is 26 years and thus much shorter than in the US and Western Europe [Fumiaki, 2003]. Its resale value declines to almost zero in 20 years, similar in case to automobiles. Japan does indeed have the largest and most advanced prefabricated housing industry, however, the quality of the houses is pretty low. Walls are thin and have single-glazed windows, which deteriorate quickly from air-conditioning and a hot humid climate in summer. This would all fit the above theory, but the question of 'are the houses cheap?' comes up. Numbers suggest that that answer is, 'not at all'. In fact, Japan houses are not only a lower quality compared to those in the US and Europe, not only are they much smaller, but also they are the most expensive [Table 10]. Japanese homebuyers mostly own their land, which they had inherited and in turn, build a house on that land. They usually buy a new house each generation and face continuous amortization costs. Fumiaki points out, that Americans and Europeans buy after financing their first house, a weekend

house, and when the Japanese buy their third home Europeans buy a sailboat. Furthermore, although Japan has a very advanced prefabrication industry which has adopted the best lesson from car production, prefabricated houses only count for 15% of new houses built, about the same value as in the US and Europe. Very small companies, who are always ready to reduce the price if competition is high, build the rest. But, although the quality is low and the industry is highly automated, houses in Japan are not cheap. A Japanese person has to spend 4-5 annual salaries, much more than an average European. Recently this has even been going up to 7-8 annual salaries. Markets just work differently. As a consequence of the short lifetime the renovation market in Japan is very small.

	JAPAN	US	GERMANY
Population (millions)	127	281	82
Housing Starts	1.213.000	1.569.000	377.000
Market value (houses)	-	-	54,6 bio EUR
Market Value (all housing)	175 bio EUR	370 bio USD	115 bio EUR
Average Floor Space of New House (m <sup>2</sup> )	107	211	140
Average Property Size (m <sup>2</sup> )	157	1200	500 [est.]
Price of New House (Including Land)	300.000 EUR	180.000 EUR	250.000 EUR (est.)
Change of Economist House Price Index from 1997-2004	-24%	+57%	-3% (Germany is an exception, most European countries had a rise between 50-60%, Britain even 132%)

TAB. 10 Source: US Census Bureau (2000), Survey of Housing Loan (fiscal year 2000) by Government Housing Loan Corporation as cited in Fumiaki (2003)

The example of Japan where the house has no investment value and is a pure consumer product, shows that the market and the way houses are produced is not fundamentally different from US or Europe, where houses are considered to be good investments. The reason for this would require more comparative research, but probably can partly be contributed to the industry structure, which was outlined by Ball (2003), where the large number of relatively small firms, which use labor intensive techniques and have very low entry and exit costs and are thusly more flexible to market fluctuations. Houses in the US and Western Europe combine aspects of consumer goods and investments and the aspect of an investment prevails buying decisions. The argument that because the house is an investment and in turn, industrialization does not happen, is not necessarily true as seen in the statistics coming from Japan.



## Product Lifetime and Life Cycles

A coherent trend in the consumer society in the last few decades shows that the lifetime of products has been reduced. Over 100 years ago, products were designed to last for 'a lifetime'. For example, several generations ago, people still inherited furniture from their parents. When they married they usually bought new sleeping room furniture and lived with it for the rest of their lives. This situation gradually changed starting with the 1920s when new furniture designs also expressed a new life-style and to about the 1980s most of the expensive, heavy traditional furniture shops have been replaced either by design companies or IKEA. IKEA contributed a lot to the reduced lifetime of furniture by standardization and mass-production, as well as introduced the concept of self-assembly. All concepts that was uncommon in the furniture industry before. Some IKEA furniture have become so cheap, that it is easier to just buy a new one instead, rather than moving or repairing them, especially with the fact that they would not survive being disassembled and assembled again. Trendbüro [1999] saw an increasing trend to throwaway furniture, an idea that furniture reflects a mood and life-style such as one is changing clothes. The trend can be seen in houses as well. Although houses in Germany have a lifetime of 60 to 100 years [Bundesministerium für Verkehr-, Bau- und Wohnungswesen, 2002] and maintenance cycles for major constructive building parts are between 40 and 50 years, experience with houses from the 1960s shows that these cycles have become considerably shorter. A cycle of major modernization of 20-year-old houses seems not to be unrealistic in the future [IFB, 2004]. The reason for this could be in the technological advancements in building technology and insulation and the increasing environmental awareness as well as rising energy prices. But, it should also be accounted for, that with increasing wealth and leisure time, people like to 'work' on their house as an ongoing project. In this aspect the 'product' house is different, as it becomes more like a pair of jeans where people expect them to become individual by wearing them\*. In their exemplary work *A Pattern Language* Alexander, Ishikawa and Silverstein [1977] suggest that a couple should find a place that they can change gradually over the years, and not build or buy for themselves a "dream" home from scratch. There may be a reason besides the cost savings, why in Germany the market for self-built homes has been steadily growing. The idea would be appealing if the house could be designed like modern computers, which while initially developed from grey boxes to machines, can be easily customized by the consumer and parts like the processor, the graphic card or the hard drive, can be exchanged individually. Also, the computer has – as architecture – a structural case, functional units and aesthetic components, which are considered to be very important by many users. The house is, as many products, composed out of different structural and functional components with different lifetimes. Where some components like furniture or appliances are very easy to change, structural components can become very costly. The lifetime of a house or any product is influenced by its construction, production, maintenance and its actual use and environmental impacts. Table 11 shows estimates of the lifetime for different structural, functional and aesthetical elements of the house. Although some of them can vary quite a bit, depending on their main drivers, it can be seen that the structure has usually the longest lifetime. Structural lifetime is influenced by the construction method along with the material used and its exposure. It is also dependent on building tradition and the feeling of safety. As we have seen Japanese houses only have a lifetime of approximately 26 years, which also happens to coincide with the traditional rebuilding of the timber-made Shinto shrine "Ise-jingū" every 26 years.

Scandinavia is quite happy with light timber houses, which can last easily up to 200 years, whereas Central and Southern Europe prefers solid walls. Functional lifetime is dependent on the abrasion and appliances lifetime as well as the changing needs of the inhabitants, completely dependent on their life cycle. In recent years traditional family and working patterns have dramatically changed and life has become much more flexible. The traditional sequential flow of life with education, career, family and pension accompanied with increasing wealth, will be replaced by a patchwork of changing periods of education, work, family and unemployment. This will have an impact on economical constraints of the family, which may require rent out a room or converting one to an office. A big source of income for the construction industry and headache for many clients is the refurbishment of the bathroom. The main reason for this is that all the medias are plastered into the wall, up to 5 different trades have to work on it and that standardization, compared to a kitchen refurbishment is relatively low. Whereas traditionally the refurbishment of the bathroom was induced by abrasion, today's building technology allows building quite durable bathrooms. Nevertheless, kitchen and bathroom are mostly subject to changing taste and life-style and strongly driven by aesthetics. Aesthetical lifetime is influenced by changing trends in the society and personal life-style. The fashion trends in the modern consumer society have become shorter in cycle. The increased wealth and competition in industries is also creatively creating new markets driven by aesthetics and life-style more than by actual function. An example is the wellness trend in bathrooms. Up to the 1980s, the bathroom has been seen and treated as fairly functional personal hygiene equipment. Changes in social patterns, leisure and working life have seen it turn into a personal wellness-oasis. People and industries have re-discovered bathing and personal hygiene as a relaxing environment. Although the bathroom is often the least used room in terms of hours per day, it is often the most important in terms of design and equipment. Although changes of bathrooms are still quite costly, it is expected their lifetime will reduce and this because of aesthetical reasons. Some hotels have to reflect changing trends by bathroom lifetimes of 5 years.

A family house has to accommodate changing needs, and this will rarely happen by replacing the whole house. So the question is, what would happen if parts of the house can be replaced and changed at ease, as it could in a computer? This question of modular, interchangeable and plug-in building parts is not new and has been the basis for many architectural designs. But none of them really succeeded, when it came to replace whole space units and change the layout. The reasons why for sure would require a more in-depth research, but some of the points can be listed here:

- Initial costs are too high: The client would have to pay for later options, which may not have been needed at the beginning of building. This takes away the advantage to let house grow and shrink to a budget. Foundations have to be strong enough for future expansion, land had to be acquired, interfaces need to installed and often costly building part connections and double outside elevations have to be added to allow flexibility.
- The interfaces for all the different medias like water, sewage, electric installation, heating are costly and mostly not plug-and-play.
- Multiple planning permissions may be needed.

- Industry and market structure make it difficult to keep modules on stock and provide them cheaply. Many different variations would be needed to accommodate local and social preferences.

Estimated Lifetimes of Different Components of a House			
	Component	Lifetime (years)	Driver
<b>Structural Lifetime</b>	Foundations	>100	Environment
	Main structure	100	Lack of maintenance, Construction
	Roofing	40-60	ditto
	Wall	100	ditto
	Wall Finish	40-80	Protection, environment maintenance
	Insulation	40	Energy prices, environmental legislation and awareness, product innovation
<b>Functional Lifetime</b>	Layout of Rooms	20	Changing Life cycle of Family
	Size of Rooms	20	ditto
	Kitchen	20	Abrasion, Appliances
	Bathroom	20	Abrasion, Appliances
	Heating System	30	Appliances, Energy prices, environmental legislation and awareness, product innovation
	Electric System	60	Safety
	Plumbing	30-60	Safety
<b>Aesthetical Lifetime</b>	Layout of Rooms	15	Life-style, increased wealth
	Kitchen	10	Abrasion, Life-style, increased wealth, product innovation
	Bathroom	10	Abrasion, Life-style, increased wealth, taste, product innovation
	Wall Finish	5-10	Abrasion, taste
	Floor Finish	5-10	Abrasion, taste
	Furniture	5-10	increased wealth

TAB. 11 Different aspects can strongly vary the life-time expectance of different elements of the house.

What have seen more success were experiments where structure and technical installation were allowed to be more flexible. Called “The Flexible Plan”, it has a successful market in office buildings even after its failure in housing in the 1960s. Advances in building technology where providing amenities such as easy-to-remove, lightweight plaster walls with good acoustic properties, might also allow new plans for housing and apartments which can thus adapt to different life-cycles of the inhabitants [Table 11].

### The Dream And The Reality: The Image Of The House

There are two paradigms in the house-building sector that seems to prevent change, both originating with clients. The first is the preconception of the house and how it has to look, the second is the preconception that factory-made is cheap, unoriginal and of lesser value. Changing these standards might be a most difficult task towards modernizing industrialized architecture. Many first-time house buyers seem to have a very clear image of the house they want where, often enough, their 'dream house' might be a romanticized image of a last century cottage, an English castle or a Mediterranean style house. For an architect, it is often a tedious task to balance these dreams with reality and initiate a learning process for the buyers about modern concepts of space and architecture and environmental and cultural adequacy. Although none of these 'dream houses' would ever been published in a recognized architectural magazine, more than 90% of the houses built meet these images on a international level. Usually, the more money available, the more these fantasies are met, even up to complete ridiculous castle-like interventions in the landscape [Figure 86]. Usually the smaller the budgets the more modest the houses are, but yet, still try to meet these fantasies in some regard [Figure 87]. Although a majority of universities are teaching students to look at these houses as 'non-architecture' and to snobbishly disdain them and wonder about the tastelessness and missing adhesion of architecture as today's culture of the owners, it is important to try to understand the reasons for this. Unfortunately, there is limited within this field that has so much creative energy and research power as architecture does. The little research there is comes mostly from the 1960s. Rather, than to understand the origins of these resistant and permanent symbolic images, architects praise their own inventive forms and hold them against it, with the result, that the quality of architecture in most single-family housing areas is at lowest level, because the ends don't meet.



FIG. 86 The dream home: A Lot of roof with many bay windows and chimneys. A last century image of a world in order. The multi-million home of pop singer Mariah Carey.



FIG. 87 Also prefab companies serve this image. [source: Regnauer]

First we need to understand the symbolic meaning of the house. The house is a strong symbol for shelter and safety. Christopher Wolfgang Alexander, an Austrian architect [1977] among others connects this symbol strongly to the pitched roof, which is the most powerful

symbol of shelter. The house is one of the first objects found in children drawings between the ages of 5-8 years. The symbol is so strong that even children growing up in flat roof apartment blocks draw small cottages with two windows and smoke curling up from a chimney on the [pitched] roof [M. Gregoire, "The Child in the High-Rise", *Ekistics*, May 1971, pp. 331-33, as cited in Alexander, 1977, p. 571]. Such evidence as this can perhaps be dismissed on the grounds that it is culturally induced, but children's drawings are more influenced by their experiences, than from the visual world [Figure 88 & Figure 89] as they reflect an 'inner model' of their world. This inner model of the house and its symbolism of shelter and safety seem to live on into our adult life. Especially large fast food chains like McDonalds and Pizza Hut, who might consciously use the symbolism of the pitched roof in their marketing. But, this symbol of the pitched roof also comes back to many of us, when it comes to thinking about buying a home.

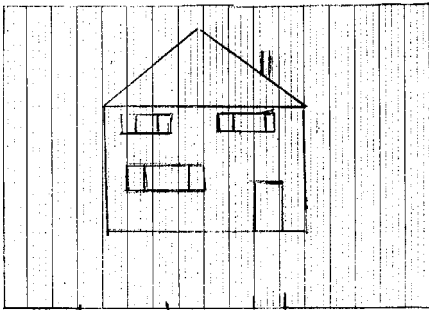


FIG. 88 Drawing her home of a 6 year old girl, who grew up in Pessac. [Source: Boudon, 1984]



FIG. 89 Pessac does mainly have flat roofs.

It is interesting to note, that another product, which is often found in the typical children's drawing of a "House, Tree, Person", the car doesn't seem to be as symbolically loaded as much. Cars represent modern vehicles with four wheels, a body and a cabin. Wheels do not have spokes, as one would have expected if the drawings were kept up to date with houses drawn. On the other hand, trains are often drawn as steam trains similar to what one sees in toys and seem to have become stuck in about the same time frame as houses. Nevertheless, as much as the symbolism of the pitched roof house seems to be implanted into our sub-conscious, the image can be changed. Many architecture students have had the experience of their ideas of architecture change through education. They learn about form, proportions and function and learn about architecture as a historical and cultural development. They start to become more interested in the modern relation of inside spaces to outside spaces and try to neutralize symbolic meaning or play very consciously with it. Many architects thus have attributed the low architectural quality and intrinsic conservatism in home building to the lack of education of both clients and builders. It is indeed astonishing how fluent and sophisticated many people are in relation to the design of consumer products and cars, which mostly come from top-level modern design. On the other hand, people and even responsible politicians are fairly uneducated about the building environment and can be hostile against modern architecture. In consumer

products and much more in the automotive industry the design of the product is an important and intrinsic part of the production and marketing process. Many people still have the preconception that good design with the involvement of an architect raises costs unnecessarily. Although many architects have proved this preconception wrong using smart cost saving designs, the image persists. Further reasons why most single-family houses tend towards a more conservative look may be found in the thought that to preserve the resale value, one must make a safe investment by going the traditional route. Such is the case in middle-class neighborhoods where conservative designs are plenty to be found, and provides backlash against modern looking houses as it might bring the value of the surrounding houses down. A famous example is Frank Gehry's House in Santa Monica, which was strongly criticized for being too different. People fear, maybe unconsciously, that their neighbor's house, which may not fit common taste, may degrade the value of their own house. As a consequence, houses are not only the last defenders against industrialization; they are also the last defenders of self-preservation in a highly modern and fast-changing world. But, in the end only the image of middle-class safety is preserved. This social preservation of the conservative image of the house is seconded by the stigmatization of prefab as being 'cheap'. The 'run-of-the-mill' idea is strongly against the dream for individual expression.

### The Bad Reputation of the Prefabricated House from the 1960s and 70s

The negative image of prefabricated houses can be found throughout the world. Most of it derives from the post-war times, where housing was needed, but good material and craftsmanship was scarce. The British Department of Trade and Industry [2001] reports that many of the [prefabricated post-war] systems have also suffered from water penetration as the jointing materials aged. Poor thermal performance has also been a feature of many of these dwellings. The frequent consequence of condensation on cold connection points led to concern and dissatisfaction among tenants. Many of the problems that have occurred with these systems are a result of poor workmanship rather than design. They have however left a perception of poor quality in prefab buildings. In Germany, it was in the boom of the 1960s when some prefab companies provided cheaply made, inexpensive housing which helped to coin that image. In turn, prefab houses have a lower resell value and can be difficult to sell. The industry still claims that their major problem is this negative image, however, timber frame buildings and a higher quality most prefab companies are providing now is slowly changing that image. The Bundesverband Deutscher Fertigungsbau e.V. [2005] reports that half of the potential German homebuyers might potentially consider a prefab house. People state the short construction time; cheaper price and the easier construction process are its main advantages. The advantages are not new, but it is interesting to note that in the 56% of people asked, believe that the quality of prefab houses have improved considerably in the last ten years. Having house exhibitions have helped in this image as it allows people to have a personal look at the houses. Most of these houses do not look different than any other brick-stone house, but the core are made of a timber-frame construction that makes it easier and faster to build. The environmentally positive values and the emphasis from the industry on low-energy houses are further promoting a positive image.

## Results and Discussion

As we have seen in the previous chapter, the market volume for houses is very big and one might think that the entire housing sector should have been already industrialized. However, this did not happen. Next to the strong competition from the traditional building sector, there are various other factors to be investigated. It would be worthwhile to investigate the numbers from Table 9 in more detail using an in-depth analysis of the existing prefab industry. For too long the emphasis in prefabricated housing has been on the price alone. We have seen by the different markets in USA and Japan, that the price of the product does not have actually have an influence on its overall market share. Additionally, scrutinizing the product house in a comparative study with the Aspinwall classification system might lead to interesting results. We can already assume that if we compare Japan with Europe, that a reduction of the product replacement rate from 76 years down to 26 years does not result in an increase of market share. So, where would the critical point be in 13 years? Does the paradox effect, where in the case of increasing quality, the replacement and renewal rate becomes shorter, would then apply for a product house? Many argue, that this short lifetime of houses would be a tremendous waste of resources and not sustainable. But, a house could be engineered towards a shorter lifetime and there is actually a strong argument for a higher rate of building replacement coming from environmental concerns. Keller [2004] makes the point, that with the current replacement rate of buildings of about 1%, after 50 years only 35% of the energy even introducing the highest standard could save consumption of buildings. Buildings use about 50% of all energy; the rest comes from transportation and industry. There are several resistances against the product house, but these could be regarded as potential towards the competitors, who don't see it as such. Some prefab companies are doing pretty well in their niche markets, and there is no reason why there shouldn't be more of these niche markets. The resistances are rarely hard facts, but rather that of diffused factors. Usually arguments against the prefab house that "it doesn't allow for flexibility and individuality" are simply not true. The German prefab industry offers more than 3.000 types in all variations. However, tough price politics show that you quickly end up with equal or higher prices compared to the traditional construction market if customization reaches beyond a certain level. This is where the industry has not been able to prove their competitiveness. The hard fact is that prefab houses have a lower resell value, based on the preconception of low building quality of houses from the 1960s. New houses with higher quality first have to prove their increased quality. Warranties by the industry could help increase customer trust such as the example as some Japanese manufacturers offering warranties for 35 and even 65 years on their houses. If this was the case with prefab houses, a client could protect against a potential loss. If one assumes a 10% savings towards a traditionally built home with a 100-year lifetime, one would have to invest the 10% with less than 2% interest rate to make up the loss. This does not include maintenance costs. Over a perspective of 60 years, it is easy to reach an annual average of 7% in investment. But, as we have seen also the argument of the shorter lifetime is not clear. Buildings do not lose their value in a linear way. Their value moves along with the comparative cost to build a new house and is strongly linked to the location.

The industry has long moaned how they suffer under the negative image of the prefab house. On the other hand they have not been very inventive to work against that. In terms

of design, which is an important element of a house, they have been leaving the customer alone. They tried to serve the image, which they thought is expected by the clients, without forming a character. To analyze what people want and how a product is brought to the people are pure marketing terms and still offer a lot of potential for the prefab industry, since they cannot rely on the regional network local traditional builder do. Also the only way to deal with unconscious images, bad reputations and other preconceptions is by providing facts and us modern marketing methods.

## BIBLIOGRAPHY

Alexander, C., Ishikawa, S., & Silverstein, M. [1977]. *A Pattern Language: Towns, Buildings, Construction* [Center For Environmental Structure Series] New York, USA: Oxford University Press Inc.

Aspinwall, L.V. [1962]. *The Characteristics Of Goods Theory*. In: *Managerial Marketing: Perspectives And Viewpoints*. Lazer W, Kelley E [Eds.], Homewood, Illinois USA. 633-643

Ball, Micheal. [2003]. *Markets And The Structure Of The Housebuilding Industry: An International Perspective*. *Urban Studies*, Vol. 40, Nos 5-6, 897-916.

Bärthel, J. [20. August 2002]. *Industrielles Bauen. Leitfaden Für KMU-Geschäftsführer Vdf Hochschulverlag An Der ETH Zürich*.

Bernhardt, A. D. [1980]. *Building Tomorrow: The Mobile/Manufactured Housing Industry*. Boston, Massachusetts: The MIT Press.

Boudon, P. [1989]. *Die Siedlung Pessac. 40 Jahre Wohnen A Le Corbusier*. *Sozio-Architektonische Studie*. Bertelsmann Vlg., M..

Bruce, A., & Sandbank, H. [1944, Reprint From 1972]. *A History Of Prefabrication [Technology And Society]*. New York: Arno Press.

Bundesministerium Für Verkehr- Bau- Und Wohnungswesen. [2002]. *Wertermittlungsrichtlinien 2002 [Wertr 2002] [BS 12-63 05 04-30/1]*

Bundesverband Deutscher Fertigbau E.V. [2005, November 15]. *Institut Für Demoskopie Allensbach: "Image Von Fertighäusern Wird Immer Besser"*. Retrieved November 22, 2005, From <http://www.bdf-ev.de/german/presse/index.html?NID=83>

CMHC. [No Date]. *New European Standards*. Canada Mortgage And Housing Corporation. Retrieved 30. August 2005, From [http://www.cmhc-schl.gc.ca/en/homadoin/excaprex/suexin/suexin\\_027.cfm](http://www.cmhc-schl.gc.ca/en/homadoin/excaprex/suexin/suexin_027.cfm)



Corbett F. Gaulden, Jr. [2004]. AN INTEGRATED PRODUCT TAXONOMY. Proceedings Of The Academy Of Marketing Studies, Volume 9, Number 2, Maui, Hawaii, October 13-16, 2004 Allied Academies International Conference.

Department Of Trade And Industry. [30 November 2001]. Current Practice And Potential Uses Of Prefabrication [DTI Construction Industry Directorate Project Report Nr. 203032]

Fumiaki, K. [2003]. Opportunity And Challenge Changing Housing Market In Japan [Powerpoint Presentation]

IFB. [2004]. Lebensdauer Der Baustoffe Und Bauteile Zur Harmonisierung Der Wirtschaftlichen Nutzungsdauer Im Wohnungsbau [AktENZEICHEN: Z 6 - 5.4-02.05 / II 13 - 80 01 02 - 05] Hannover: Institut Für Bauforschung E.V..

Keller, B. [2004]. Perspektiven Energieeffizienten Bauens [Perspectives For Energy-Efficient Construction]. In W. Roos [Ed.], SATW-Bulletin. 4/04 - Nachhaltigkeit Im Bauen Zürich: Schweizerische Akademie Der Technischen Wissenschaften.

Mannek, W. [2000]. Profi-Handbuch Wertermittlung Von Immobilien Regensburg/Berlin: Walhalla Fachverlag.

Mass Observation [1943]. An Inquiry Into People's Homes. [Ed.], The Fourth Of The "Change" Wartime Surveys London: John Murray.

NAHB Research Center. [October, 1998]. Factory And Site-Built Housing - A Comparison For The 21<sup>st</sup> Century Washington, D.C.: U.S. Department Of Housing And Urban Development.

Orzech, D. [August 10, 2005]. At Clean Plants, It's Waste Not. Retrieved August 17, 2005, From <http://www.wired.com/news/planet/0,2782,68448,00.html>

Product [Business]. [2005]. Retrieved [http://en.wikipedia.org/wiki/Product\\_%28business%29](http://en.wikipedia.org/wiki/Product_%28business%29)

Stocker, F. [21. November 2004]. Deutsche Eigenheime Für China. Welt Am Sonntag. Retrieved March 2, 2005, From <http://www.wams.de/data/2004/11/21/363446.html?prx=1>

The Social Issues Research Centre. [January 2005]. Halifax Happiest Home Report Halifax General Insurance.

Trendbüro [1999]. Wohnen 2040 - Trendstudie Schöner Wohnen. In Wippermann, P. P. [Ed.], Hamburg: Trendbüro.

Trendbüro [1999]. Wohnen 2040 - Trendstudie Schöner Wohnen. In Wippermann, P. P. [Ed.], Hamburg: Trendbüro.

*"I would never consider a prefabricated house," [...] "They're made of cheap materials and slapped together like Lego blocks. You can't compare the quality, even if they are cheaper. ... Also, I can spot a prefabricated house a mile away -- they have thin walls that look like cardboard. I just don't like houses with thin walls."*

Ingo Bauer, a Cologne based businessman who recently spent a troubled year having a house built to his specifications. [as cited in: Abramsohn, 2005]

A scientific and marketing approach to the product house would be to research what the consumer really wants. Now, although it is important to know that, as architects and other professions know, that this cannot be translated one to one. If people were asked in the mid-80s what they needed and wanted, we would not have mobile phones today. But this is exactly what the prefab home industry is doing as they try to offer what the client wants and then wonder why people don't buy it. Ulwick [2002] makes the point that customers only know what they experienced. They cannot imagine what they don't know about emerging technology, new materials, calculation methods and the like. What customer, for example, would have asked for the microwave oven, Velcro, or Post-it Notes? At the time the transistor was being developed, radio and television manufacturers were still requesting improved vacuum tubes. The reason is also quite simple. Customers should not be trusted to come up with solutions; they aren't expert or informed enough for that part of the innovation process. Rather, customers should be asked only for outcomes - that is, what they want a new product or service to do for them.

Having said that, it is important to know the customer and understand the complex issues that come together, if someone buys a house. Probably no homebuilding program was so profoundly based on studies and surveys than the British post-war temporary housing program. By 1948 almost 125.000 'prefabs' had been built. Resident's satisfaction with them was very high; perhaps because they combined the two essential qualities of the universally desired country-cottage type, where it was compact inside but with a large garden. Many people were sorry to leave their prefabs [Short, J.R. 1982 *The Post-War Experience: Housing In Britain*. London: Methuen, p. 42-43, as cited in Vale, 1995, p. 37-38]. Also the Halifax Happiest Home Report [Social Issues Research Centre, 2005] recently revealed, that Britain people who live in bungalows were the happiest, followed by the ones in detached houses\*. The bungalow, like no other home also represented the modern [American] life-style of the 1960s. Most of the buildings of the 'First International Exhibition of Prefabs' in Quickborn, Germany in 1963 were bungalows with a flat roof. But, a survey showed, that over 70% would have preferred the more commonly known red-tiled pitched roof. However, a survey cannot give you the whole truth all the time. Many flat-roofs were sold in the 1960s, but a leaky roof due to poor craftsmanship gave them a bad reputation. On the other hand a recent survey, maybe not that representative, showed that 70% regarded the majority of houses in Germany as dull and boring [Thomas, 2005]. Many people in Germany were critical against the bungalow-style of some of the prefab

houses exhibited in Quickborn. Nevertheless, the offered new amenities and the market were fast growing. The fitted kitchen based on a modular design was new at that time and mostly people came from minor quality living conditions moved into the new homes. Schäfer (1998, p. 86-87) quotes Hildegard L., who moved into one of these prefab houses in the 1960s, "She was impressed by the modern kitchen, the comfortable bathroom, the heating and the electric warm water supply in kitchen and bathroom. Her husband appraised the technical details: The straight walls, not warped as in other buildings: 'You don't believe, how important this is, if wallpaper yourself. It's very easy. But everything in the house is much easier to do. And not to forget: We have four rooms with a total of 100- m<sup>2</sup> living area and the whole house only costs 44.000. - DM [22.000. - EUR]. We extended the roof later ourselves. You don't get that anymore today.'" (Translation by author). At that time prefab houses were up to 65% cheaper than site-built houses. The editor of the German magazine Stern initiated the exhibition in 1963. Over 30 years later in 1996, they tried again to define the 'dream house' of the Germans. A survey asking over 70.000 people resulted in the unsurprising result that most people would like to live in a single-family house, which is "smart, ecological, affordable, detached and practical." An architect's competition was held and prefab company Bien-Zenker built the first prize. The winning design by the architect team 'Baufrösche' proposed two individual small houses (Figure 90), which allowed a lot of flexibility in the user scenario and also provided private spaces even on a small property.



FIG. 90 Two houses instead of one. Winning design for the 'Dream House' competition of 1996. [source: [www.baufroesche.de](http://www.baufroesche.de)]

The problem of the design became apparent very quickly: two houses cost considerably more than one house. The prefab company could not offer them at a competitive price, which should have been below an architect-design single house. In result, the competition did not provide a solution other a blurb of marketing for the prefab company. And so, the German dream house remains only that, a dream. As frustrating as the cultural misery found in single-family neighborhoods is for an educated architect, as much there is a chance for hope. With the late baby-boomers and the post-baby-boomers coming into homebuyer age, expectations seem to change as well as demands towards the product house. The German magazine 'Schöner Wohnen' asked over 100.000 of its readers, how they imagine their 'Home for Life' (Ein Haus fürs Leben, 2005). The standards of the Mediterranean 'Finca' were preferred by 17%, the Friesian and Swedish farmhouse with 10% each. The astonishing result was that 43% voted for a house in 'Modern Architecture' with a lot of glass. It must be said; the magazine has naturally a large reading audience interested in the topic of living, but didn't seem to favor modern architecture. The full results are as follows:

- 60% favor a three-generation house, if everybody can keep his own realm. The house should have flexible walls [40%] and should be easy to extend [40%], so the family can stay together also in case of a divorce. Only 10% would sublet rooms of their house.
- People favour French windows [40%], a garden [45%], a location near the city [60%], an American kitchen [52%] with pantry [76%], bathroom with windows [87%], wooden floors [91%] and an open fire place [64%].
- Invisible closets [56%], floor heating [50%], outside blinds [66%] and not more technology than necessary [55%]
- Sustainability is highly rated: 65% wish rainwater use, 72% low energy standards and 65% solar energy
- Still 69% wish a massive [non-timber] construction

Based on the results of the survey, architect Jürgen Lohmann designed a house, which was built with the support of the German Cement and Concrete Industry and opened for the public on September 30, 2005 [Figure 91 & Figure 92].



FIG. 91 The 'House for Life' is based on a consumer survey and design by architect Lohmann. The project was built in 2005. [source: [www.livingathome.de](http://www.livingathome.de)]



FIG. 92 The floor plan allows in three layers and with movable partition walls allows flexibility in the use.  
FIG. 93 [source: [www.livingathome.de](http://www.livingathome.de)].

The house was built using a prefabricated concrete element, but it was not designed as a 'prefab-house'. The new openness of consumers towards open floor plans with flexible installations is also emphasized by a survey conducted by the German magazine Stern in 2001 [as cited in umzugsratgeber, no date], where 78% voted for these technological innovations, as well as central control systems. Also 89% are interested in high ecological standards and the use of alternative energies. Also this survey returned a newly built detached house in modern architecture in a near city environment at the top of their wish list.

Understanding the user stays an important element of the product house. User preferences are changing. In the limited choice homebuyers often have within the location they are looking for a home, they often have to do compromises in the design quality. Buying a car, one has more choice and manufacturers compete with quality and design for the customers. Also, the dreams, wishes and needs of a car buyer are much more analyzed, than the ones of a homebuyer. The high preferences of a potential house buyer for bathrooms with windows, pantries and wooden floors, show traditional elements which have been ignored by making houses more cost-efficient during the 1970s without asking the user.

## 03.04 WHAT DOES THE INDUSTRY DO?

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The question should rather be: "What does the industry not do"? Compared with other industries the prefab home industry has the persistent image of producing 'cheap' homes. Cheap is not necessarily the price, but the image they convey in their designs and the light construction as opposed to solid masonry walls, which are favored by many. It does some of the companies injustice, but as a whole the industry has not proven to be very innovative and has not achieved to reach the client on another level other than the price. The industry reacts differently on the market. Mostly they are guided by costs and traditional preconceptions of home. Innovation and life-style is not a marketing tool as in other industries. Industries offer maximum choice within their limits, often without the necessary architectural support for the clients. When the choice goes beyond their standards they behave like traditional builders and prices go up. It is almost as if there is a wait for traditional builders to fall out of favor, before the prefab companies find an opening. An unlikely scenario. However, it is crucial to pay attention to the production of and marketing of house building in general.

### Production

There have been substantial investments into production facilities quite recently. Prefab company, Europahaus, a timber-frame construction with structural insulated panels called SIP. An invention that heralds from stressed panels used in American architect Frank Lloyd

Wright's Unisonian houses in the 1930s. Alden Dow, a student of Wright, had invented the insulation to be installed into his teacher's houses. In Europe the system is offered as Kingspan Tek by British company Kingspan.

### *Europahaus*

The company Europahaus had a highly ambitious objective for modern house production. Their planning was to build up a large factory to allow mass production of big houses, similar as what one can find within the automotive industry. The use of fully automated computerized production technologies should have been able to build an architect-designed houses for less than 750 EUR per square meter, which is about half than the average site-built home, and produce an entire house every 72 minutes [Europahaus, 2001]. A round building of 234m diameter would have served to accommodate the production processes and highly automated assembly lines. Like the modern glass factories of the automotive industry, the Europahaus factory would have been completely dust free and allowed visitors to watch the modern production process. State of the art robots and computer-controlled production facilities would have allowed full customization of elements within the house, essentially producing any design of any architect for a much lower cost and while still maintaining a client – architect relationship.

Unfortunately, Europahaus' concept did not see fruition, as they were not able to find enough financial support it needed despite already having 200 partners, and declared bankruptcy in 2004.

### *Pulte Homes Sciences*

The research and development group Pulte Homes, the second-largest builder in America, has been exploring component manufacturing as one approach to improve home building [Figure 93]. The firm built its first plant in Manassas, Va., a suburb of Washington, D. C., and started producing in December 2003. They rethought the building process from the foundation up to the roof, and had five years of trial and error where they designed machines and built houses in the Detroit area. Pulte Homes works with SIPs [structural insulated panels], combining them with steel to prevent warping and deforming of the timber construction [Figure 94]. Pulte essentially makes the shell of a house and after the components such as the foundation, walls and flooring, all is loaded onto flatbed trailers and taken to their building sites.

With the new system, the shell of a small house can be made in factory and assembled at the home site in three to five days, whereas a larger house will take five to seven days. Since many skilled tradesmen, such as carpenters, are not required in the factory, labor costs for the builder will decrease as well [Deane, 2004].

The company says the quality of their home is more uniform than a traditionally built house because it is not dependent on the skill level of the tradesmen performing the work. At Pulte's 115,000-square-foot factory, 60 machines and 50 employees complete 16 separate automated processes [Deane, 2004]. Although it has been claimed the factory works similar to a car factory, reports say that the company is not necessarily more advanced than Space4 in the UK or a modern German or Austrian producer. What is more interesting about the Pulte system is that they try to tackle the entire building process and work with prefabricated concrete foundation elements. There is a lot of space to improve the system in a comfortable basis for the company and has been successful as a result. Pulte predicts the economic viability will be achieved only at higher volume levels, basically when the factory is at full capacity, or making some 1,800 houses a year. Pulte never published how much money they invested into the factory, but with a net income of \$987 million in 2004, the investment could pretty soon pay off for the company.



FIG. 94 The PHS factory made home looks like any timber frame house build in the USA, but achieves higher precisions and less distortion. [source: www.pulte.com]



FIG. 95 Structural insulated panels in combination with steel are used to build the homes. [source: www.pulte.com]



## Space4

Westbury Homes located in the UK follows a similar route as Pulte Homes. As one of the top ten speculative house builders in the UK, Westbury Homes invested 22 million Euros to set up Space4. Space4 is located near Birmingham and is specialized for panel construction. Up to 5.500 units a year can be produced, but has only been producing 3000 units insofar. Similar to Pulte, Space4 produces timber frame homes [Figure 95]. They also use high-volume production lines driven by CAD CAM software and JIT [just-in-time] delivery system. While the methods used are not very innovative, it is a bold move for Westbury Homes to invest in a prefab factory, as there is not much market for it in Scotland and England despite an ongoing discussion from the government on how to solve a housing shortage. The attitude towards prefab housing in the UK is working against them, as the predilection for prefabs is very low. 'An Inside Housing Survey' [4 July] showed that while a third of social housing tenants would not mind living in a home manufactured off-site, 46% would object.

The success of the Space4 factory stems from selling a house directly to speculative homebuilders instead of having to sell the system to a middleman, and also the fact that even though it is a prefab house in the end, it still looks like a traditional brick-stone house [Figure 96].



FIG. 96 The Space4 factory in Birmingham is producing timber-frame houses for the British market. (source: [www.space4.com](http://www.space4.com))



FIG. 97 The factory-made houses are not distinguishable from the traditionally built home. (source: [www.space4.com](http://www.space4.com)).

## Marketing

The 1990s has seen many successful examples of modern marketing. For instance, Adidas and Puma saw a reinvention of their brands after experiencing a drop in popularity. By using pop-culture, they made their products desirable in both the fashion world and in youth culture. The prefab industry is attempting a similar approach, but without a long-term concept or strategy. An example of an attempt comes from a company named Okal who tried to work with the low-cost airline Hapag-Lloyd Express: a no-frills airline that operates out of Germany and flies to many destinations within Germany and select cities in Europe. The market of those who fly the cheap airline, also happen to be of the same age group of first time homebuyers. The passengers get a brochure of the houses and can use the flight time to learn about the prefab houses. It was even planned, that a salesperson should fly along to offer individual consulting (HLX, 2003). If a passenger were to buy a house, Okal would offer a discount of €1000 and two HLX tickets as an incentive. The combination of prefab house and modern methods of transportation is interesting, but unlikely to show much success. But it is promoting the brand of Okal, which once was Europe's largest prefab home producer.

### *BoKlok – IKEA Homes*

Swedish home-furnishing firm Ikea is a modern day story of success. Founded in 1943 by Ingvar Kamprad it is by now the largest furniture firm of the world with catalogues prolifically distributed. The Ikea catalogue for 2002 was distributed 110 million times in 34 different language versions offering approximately 10.000 different products. It was a question of time when Ikea would enter the housing market. In 1996, IKEA began their first housing development called "BoKlok" in Sweden, with "bo klok" meaning, "live sensibly". Collaborating with the Swedish building company, Skanska Bostäder, they based the concept on marketing research and in turn offers a small-scale housing development with the qualities of a detaches house but with competitive prices that only prefab could provide (Figure 97). With a demographic of single people and couples with young children, BoKlok provides 1 – 2 bedroom apartments in a site development with six 2-story houses with 6 apartments in each building. All units provide certain amenities such as a private garden area and washing machine. Upon moving in, each resident was given a gift of two free hours with an IKEA interior designer and a voucher for furniture (Arieff & Burkhart, 2002). The clean and modern interior design focus, unpretentious architecture of the Swedish farmhouse style (Figure 98) and the combination of privacy and community, has garnered much interest. Over 2 000 of the apartments have been sold in Sweden and the company is active in Finland, Norway, Denmark and the UK.



FIG. 98 The Ikea BoKlok apartments are offering small-scale, affordable entry market housing. [source: [www.boklok.co.uk](http://www.boklok.co.uk)]



FIG. 99 The houses are not special, but of good quality and unpretentious Swedish looks. [source: [www.treehugger.com](http://www.treehugger.com)]

In 2005, Boklok signed a £25m deal with UK-based Optima Homes to bring the flat-packed Swedish homes to Britain. Around 500 modular units, complete with a communal garden with apple trees and benches, are expected to spring up around the country over the next three years. The first sites, likely to be complete in Newcastle, Edinburgh, Brighton and the New Forest are expected to be finished in Spring 2006. The houses are aimed towards first-time buyers with an annual household income of £15,000 to £30,000. Cartwright Pickard Architects, who set up Optima along with Pace Timber Systems, has been involved in the development of ‘off-site’ housing, which involves the houses being transported around Britain and bolted together to become living space. Ikea have admitted there is already “intense” interest in the BoKlok homes from consumers [Adfero, 2005].

#### *Designer Series by Prefab Companies*

In 1997, the German prefab company, Allkauf, brought the prefab home back into discussion by ordering several design by well-known architects for a new program they were working on called “The New Standard”. The house designs were widely published, but none of the house built either due to low demand and/or high prices. Normal clientele of Allkauf did not have much interest as the press did, and new clients were not drawn in as was hoped.

However, Austrian architect Gustav Peichl, best known for grand public buildings like the Bundeskunsthalle in Bonn, Germany, designed a house for Austrian company Hanlo in 2000 and received a lot of attention and enquiries. In the end though, the house was built only twice due to the arched, zinc roof not meeting building codes in most German neighborhoods [Figure 99].



FIG. 100 The Gustav Peichl Haus by Hanlo attracted a lot of interest. [source: www.hanlo.at]

Nevertheless, the last years have seen an increased interest in ‘prefabulous’ prefab houses and the companies make an effort to keep themselves in press by offering the ‘3-litre’ house and once in a while a famous designers name. Suddenly ‘off the rack’ seems to become fashionable? The same cities can buy star-architect designs to upgrade certain neighbourhoods, house buyers could.

Frank Gehry, known for the Guggenheim Bilbao, designed the “Court Yard House” for the German firm WeberHaus [Figure 100 & Figure 101], a single story house of 145 square meters.. Or ‘O sole Mio’ house by Milan based star designer Matteo Thun [Figure 35]. The passive-energy house designed for Austrian firm Griffner Haus has nevertheless led the company, who used to do fairly traditional homes, to discover a clientele for fairly modern houses. The design guru Luigi Colani, known for is streamlined bio-mimic shapes and articulated design ideas, designed the “RotorHaus” for Hanse Haus [Figure 102] where the small house for a single person consists of a 6 x 6 meter square plan, which contains a rotating cylinder. The cylinder is divided into three sectors, which contain a bed, the kitchen and a bathroom [Figure 103]. Since rarely these functions are used simultaneously, they can be rotated into position according to their use. Thus saving walls, doors and circulation spaces.

Some companies have also asked architects that were not so well known for a modern design as well, such as the sleek, cubist mini-home at 66 square meters “Option” from

Weberhaus [Figure 104] or Baufritz's modern, L-shaped energy saving home "Terra 2" [Figure 105]. Both are examples that have been awarded in the last several years, despite not having star architects behind them [Table 12].

How well the houses will sell, we will have to see. There are no indications for a volume market, but the houses, polish the image of the industry, being known so long for dull and boring design work.



FIG. 101 Star architect Frank Gehry designed this house for Germany prefab company Weber Haus. [source: Deutsche Bauzeitung, 6.August 2004]



FIG. 102 Frank Gehry's home for Weber House may have interesting interior spaces, but costs will be high and church-like looks may not attract many. [source: Abramsohn, 2005].



FIG. 103 The Rotorhaus designed by Luigi Colani for Hanse Haus is a 36 m<sup>2</sup> house for one person. [source: www.hanse-haus.de]



FIG. 104 The rotating cylinder inside the house contains bedroom, kitchen and bathroom [source: www.hanse-haus.de].

COMPANY	DESIGNER	PRODUCT NAME	YEAR	PCS.
<b>Star Designers</b>				
Allkauf	Diener & Diener, Ingenhoven, Kollhoff et al.	div.	1997	0
Elk	Pininfarina	Ultra-Energiesparhaus 141	1998	1
Hanlo	Gustav Peichl (architect)	Gustav Peichl Haus	2000	2
Griffner Haus	Matteo Thun	O Sole Mio	2000	5-10
Hanse Haus	Luigi Colani	Rotorhaus	2004	1
Weber Haus	Frank Gehry	Courtyard House	2004	0
<b>Other 'Avant-garde' Houses</b>				
Weber Haus	Bauart Architekten	Option	2004	N/A
Griffner Haus	-	Design Box	2004	N/A
Bau Fritz	Stephan Rehm	Terra 2	2005	N/A

FIG. 12 Several prefab companies from Austria and Germany have been taking designs by famous architects into their program in the last years to create attention for their product.



FIG. 105 The 'option' designed by Swiss Bauart Architects for Weber Haus is a small 66 m<sup>2</sup> house. [source: www.weberhaus.de]



FIG. 106 The Terra 2 design by the small company Baufriz received a design price. [source: www.bau-fritz.de]

### 03.05

## WHAT DOES THE ARCHITECT IMAGINE?

The third edge in the triangle of house building is the architect. Although the single-family house long time was the core product of architecture and it was the lead element of defining the modern movement, architects managed to orbit themselves out of the business. In Germany it is estimated, that less than 3-5% of all houses build are designed by an architect with a degree. The ratio will be about the same within the prefab houses. Who wonders the architect is left alone to dream about wonderful house designs, which we can enjoy in the magazines, just not in the neighborhood next door. As the mass

production of houses was a major topic of the modern movement, most architects pulled out of it during the 1970s. The building system boom in the 1960 showed its effects. During the 1970s and 1980s only the British High-Tech architects showed interest in mass production system houses, although rather on an intellectual level. Few houses were built and a serious attempt to collaborate with industry was not undertaken. Recently the interest of young architects into the prefab houses seems to be growing. Again magazines are full of 'prefabulous' houses, some of them built as prototypes. The website [www.fabprefab.com](http://www.fabprefab.com) lists a whole range of available systems and concepts, which reach an acceptable architectural level. Architects try to look into the problem of mass-customized houses. However, they will never succeed, if there isn't a close collaboration with industries established. The amount of intelligent inventions and ideas published for free by the architects is actually admirable. Stupendous, though, is how ignorant the prefab industry is against these ideas. The automotive and aerospace industry has to pay substantial money to get top level design work, the prefab industry gets it all for free and doesn't use it.

However, the projects here are just examples to point out, what professional design quality for the product house would mean. To build the products at economic prices is not only the challenge of the architects, but of the industry as well, which so far found its comfortable niche locating their prices just slightly under the traditional building market.

### Skydeck

The British architect Richard Horden sees cars, airplanes and boats as pieces of architecture that can reach design excellence by top engineering and design. In 1984 he designed the Yacht House system, which used aluminum profiles found in sailboat masts to build a house while also employing the aesthetics of yacht design. The system was used in own designs several times, but was never offered as a product by industry. In 1988 he proposed a complete factory-made "European House System" system called Skydeck (Figure 106). The system was based on standard container sizes (Figure 107), but did not stop at the pure and dull functionality, which most of the container systems in use do. The system was thought further to become an architectural product, which communicates design elegance and life-style. The analogy to the boat and the car, which are built in factories as well, served to communicate that industrial systems do not have to look like inhumane, boring structure as seen all around the world (Figure 108). Pointing out that many houses and apartment buildings in cities throughout time have had similar dimensions, Horden proposed a module based adaptable system (Figure 109). The core frame module was the base and the client could select the interior and exterior features. Later changes of these features would have been possible, as well as re-usage of the modules. The heart of the study was not the technical system, but the integration of a marketing and logistics concept. This happened at a time when the majority of architects regarded vehicle industries as not comparable to architecture and distanced themselves strongly from the concept. Today these topics are discussed more often in architecture magazines and a convergence is seen.





FIG. 107 The Skydeck study by Richard Horden looked at employing modern life-style and marketing concepts for a prefabricated system. [source: HordenCherryLee Architects].

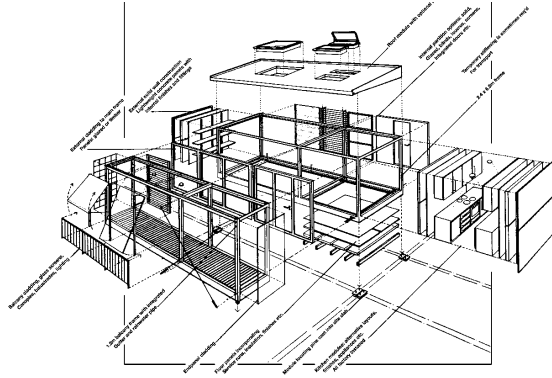


FIG. 108 Based on a standard steel frame a variety of interior and exterior features could be set into the frame. [source: HordenCherryLee Architects].



FIG. 109 The analogy to car and yacht industries serve to communicate, that modern housing systems do not have to look industrial nor traditional. [source: HordenCherryLee Architects].

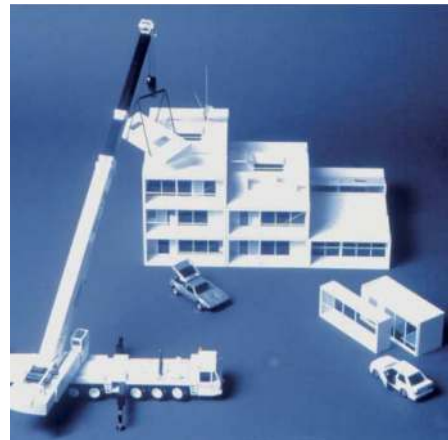


FIG. 110 Modules are delivered fully equipped by truck and set up on site. [source: HordenCherryLee Architects].

In 1998, when a professor in Munich, Horden was contacted by the German prefab company Ofra, which used a similar steel frame modular system to provide temporary office buildings. A further study was done to adapt the Skydeck ideas to the Ofra system to offer modern housing based on a modular, industrial system. Unfortunately after the study, the company pulled back due to a declining German housing market.



### MCH – Micro Compact Home

The Micro Compact Home is another experiment by Richard Horden for prefabricated housing. The 2,6 meter cubes provide a temporary small scale living unit for students in Munich (Figure 110). The student housing organisation in Munich was very enthusiastic about the concept and the mobile phone provider O2 could be gained for the project. The shortage of student housing and the possibility for the student housing organisation to use land on a temporary basis, before it is developed called for a mobile system, which could be set up. The organisation experimented with standard containers, but was not very pleased with the result. The Micro Compact Homes provide on a cleverly use minimal space all functions of a house: kitchen, toilet, shower, bed and table. The important difference to caravans is, that the interior has a clean and clear design language, similar to 'business class' interiors of aircrafts as Horden emphasis (Figure 111). Seven of the units have been realized together with Haack and Höpfner Architekten in October 2005 and are currently tested by students. The cubes were manufactured by the Austrian company Gatterbauer, which has been active in the construction of winter garden before. Horden formed a own company called 'Micro Compact Home Ltd.' And plans together with the Austrian company to go into mass production, which will also bring the price and weight down of the current prototypes. Horden is in contact with several universities, but also Hotel chains showed interest.



FIG. 111 Seven test units of the Micro Compact Homes have been set up as student village in Munich in October 2005. (Source: [www.microcompacthome.com](http://www.microcompacthome.com))



FIG. 112 The interior represents an optimised use of the small space and a clean 'business class' design language. (Source: [www.microcompacthome.com](http://www.microcompacthome.com))

### Optima Houses

In the UK, British architect company Cartwright Pickard have teamed up with leading timber-frame manufacturer Pace Timber Systems to create a new off-site building system called Optima Homes. Optima is a small panel open frame system in which panels are delivered to site almost completely finished, with ducts ready to accept services and only the minimum of dry-lining required (Figure 112). Architect James Pickard says: "We believe this is the only system of its kind to have totally integrated M&E built into the panels.

We have managed to reduce the amount of second-fix to a minimum, and yet the system is extremely flexible – it can look however you want it to.” Optima Homes is the result of a three-year research and development program. The system, which will be manufactured by Pace in a newly acquired production center in Milton Keynes, maximizes the use of off-site construction and advanced manufacturing techniques. A prototype has been built at the factory [Figure 113]. Optima has been designed for terraced and semi-detached houses up to three stories, but will also be capable of providing five-story apartment buildings following further product development. It will reduce time on site, significantly improve quality and help house-builders address the issue of skills shortages that are severely affecting the construction industry. Primarily aimed at the social housing sector, Optima is promoted as a solution to the problem of a severe and worsening shortage of affordable homes in the UK. After three years in development, the system was launched earlier in 2004 with its first order – a £500,000 contract for 10 houses and two bungalows in Dumfries for the Home Group [Taylor, 2004].



FIG. 113 Optima Homes represent a timber-frame based customizable panel building system. [source: [www.optimahomes.co.uk](http://www.optimahomes.co.uk)]



FIG. 114 A prototype built at the factory demonstrate different elevation options. [source: [www.optimahomes.co.uk](http://www.optimahomes.co.uk)]

## BIBLIOGRAPHY

- Abramsohn, J. [2005, April 28]. Picking Designer Homes Off the Rack. Deutsche Welle Online. Retrieved November 26, 2005, from <http://www.dw-world.de/dw/article/0,2144,1566660,00.html>
- Adfero Ltd. [2005, August 11]. Flat-Packed Homes To Arrive In Britain. Retrieved November 25, 2005, from [http://www.rics.org/BuiltEnvironment/Buildingmaterials/ikea\\_flatpack110805.html](http://www.rics.org/BuiltEnvironment/Buildingmaterials/ikea_flatpack110805.html)
- Arieff, A., & Burkhart, B. [2002]. Prefab. Salt Lake City: Gibbs Smith.
- Davies, C. [2005]. The Prefabricated Home. London: Reaktion Books Ltd. Deane, D. [2004, December 11]. Home From The Factory. [washingtonpost.com](http://www.washingtonpost.com). Retrieved February 15, 2005, from <http://www.washingtonpost.com/wp-dyn/articles/A55765-2004Dec10.html>
- Ein Haus fürs Leben. [2005]. Die Ergebnisse der Fragebogenaktion "Ein Haus fürs Leben" [The Results of the Survey "A House for Live"]. Retrieved 4 November 2005, from [http://www.livingathome.de/wohnen\\_einrichten/specials/haus\\_fuers\\_leben/ergebnis/](http://www.livingathome.de/wohnen_einrichten/specials/haus_fuers_leben/ergebnis/)
- EUROPAHAUS - Wohnungsbau der Zukunft. [2001] Retrieved 2 Mai 2001, from <http://www.europahaus.de/startplain/methode.html>
- Hlx Will Passagiere Zu Häuslebauern Machen. [2003, October 1]. Die Welt. Retrieved February 20, 2005, from <http://www.airliners.de/community/forum/viewtopic.php?topic=13834&forum=963>
- Schäfer, I. [1998]. OKAL - Pionier im Fertighausbau 1928-1998 [Eine Studie zur Wirtschafts- und Technikgeschichte]. Lauenstein: OKAL.
- Taylor, D. [2004, October 28]. The Prefab Sheds its Social Stigma. *Construction News*, pp. 28-29.
- The Social Issues Research Centre. [January 2005]. Halifax Happiest Home Report Halifax General Insurance.
- Thomas, N. [2005, May 9]. Wer Baut All Die Hässlichen Häuser. Retrieved November 22, 2005, from <http://www.sternstadt-forum.de/data/thema/index.php?IDD=1115642790&IDB=1&IDDLINK=&IDDPARENT=0>
- Ulwick, Anthony W. [2002, January]. Turn Customer Input into Innovation. *Harvard Business Review*, Vol. 80 Issue 1., 91-97.
- Umzugsratgeber.Net. [no date]. Marktinformationen. Retrieved November 4, 2005, from <http://www.umzugsratgeber.net/fertighaeuser1.html>

Vale, B. [1995]. Prefabs : A History Of The UK Temporary Housing Programme [Studies in history, planning, and the environment ; 17]. London: Spon.

Weiss, K.-D. [06.11.1997]. Eisenbahnwaggons Fürs Familienglück. Berliner Zeitung, p. 15.

# 04 CONCLUSION

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The single-family house is the most favored form of living worldwide. Yet the product house does not deliver the high quality for competitive prices achieved in other industries. The client has a limited choice and is not able to influence the market to their needs. However, current and future clients deserve the best possible product our society can produce. Usually this is the case in the free market economies. Not so in housing. The majority of houses are planned without architects, built on-site by small companies with arbitrary quality control and efficiency. A lot of creative and financial energy has gone into the industrialization of house building since nearly 200 years, but the outcome is relatively poor. Why? There are many reasons as were discussed at great length in the course of this book, and the solution is not, and will not be easy. However, it seems that the unrelenting competitiveness of the traditional building industry, seems to be the main factor in finding a solution. Small companies, who rent their means of production, employ people when needed and sack when they don't. Thus, they are very competitive compared to a factory with fix costs and high investments. On the other hand, the prefab industry missed to present the 'hard-to-resist' product. They have been following too closely the traditional builders, producing 'Me-Too' designs of already poor designs by speculative house-builders, just a little bit cheaper. They resigned themselves to their market share, making the bad reputation from the 1970s accountable for the limited success of their products. In fact, they completely failed in developing a product with character, a product, where the question, if it is prefabricated or not doesn't count anymore, since people just like it and it gives them benefits and extra features. They missed to present the CD Player, when people still were playing vinyl records. To present something, which the traditional builders cannot do, just because of their low investment costs. Although the single-family house long time was the core product of architecture and it was the lead element of defining the modern movement, architects managed to orbit themselves out of the business. In Germany it is estimated, that less than 3-5% of all houses built, are designed by a licensed architect. The ratio is about the same within the prefab houses. Who wonders the architect is left alone to dream about wonderful house designs, which we can enjoy in the magazines, just not in the neighborhood next door? While architects since the 1960s made wonderful design of houses 'intended for mass production', millions of prefabricated houses were built without any architect involved. Davis [2005] points this out very clearly and further pleads for the architect to get down from their elite position and get involved

into problems of mass production and industrial building again, which does need the design skills and sense about places and environment architects have. But, also the industry is asked to invest into professional design skills to improve their products, as is indispensable in other industries. The architect has to learn how to design for industries under modern market conditions. The 'industrial architect' is a missing profession, a missing education.

It has been long assumed, that industrialized housing means mass production. This is not necessarily true. The development towards industrialization may actually come on small feet, rather than on big ones. As an example may serve the Huf-Haus, one of the very few prefabricated houses with character and designed by an architect. Since 1972, the company only builds slightly more than hundred houses of the same type per year. It is recently successfully exporting houses to Britain as well. This indicates, that there are potential market niches, where small companies and architects go together and produce not a 'we-do-everything-what-you-like' house, but a house, a product with character, meaning ultimately, a home.

# AUTHOR'S BIOGRAPHY

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Andreas Vogler, Swiss Architect, b. Basel 1964

Vogler studied Art History and Literature and worked as an Interior Architect before attending Architecture School at the Swiss Federal Institute of Technology [ETH]. After graduating from ETH in 1994, he went on to work with British Architect Richard Horden and German Architect Christoph Ingenhoven. From 1996 to 2002, Vogler worked as Assistant Professor at the Institute of Prof. Richard Horden, University of Technology, Munich [TU Munich]. The institute has been focusing on small-scale structures, so-called micro architecture. Several student projects have been built in close collaboration with building industries. In 1998, Vogler initiated and led an Aerospace Architecture design studio at TU Munich in collaboration with NASA Johnson Space Center [JSC] in Houston. Integral to this studio, students generated products and habitat concepts for the International Space Station and a future human mission to Mars. The students tested their models and prototypes in weightlessness onboard parabolic flights at NASA JSC. During his tenure at TU Munich, Vogler was instrumental in combining teaching with research and actual fabrication. He has been researching prefabricated houses in collaboration with the Royal Academy of Fine Art School of Architecture in Copenhagen and as an external researcher of the Concept House Research Group of the research program Building innovation of the faculty of Architecture, TU Delft, The Netherlands.

In 2003 he founded the company 'Architecture and Vision' together with Italian architect Arturo Vittori, working in the fields of aerospace, art and architecture. Vogler has been working on the development of Mars and Lunar Rovers with European Space Agency and Thales-Alenia. He has been developing cabin interiors for Asiana First and Business Class and the new

cabin harmony of the fleet of French airline Corsair, based in Paris. He is also involved in the patenting of robotic surgical equipment. Since 2014 he is director of 'Andreas Vogler Studio' based in Munich. The studio recently did a refurbishment of the Swiss General Consulate in Munich, including the implementation of all security standards and is currently working together with the German Aerospace Agency DLR on a feasibility study for a new High Speed Train for the United Kingdom.

Vogler sees the highest potential for future innovation in a global vision and applying the architectural design methodology to transdisciplinary projects. Projects of Andreas Vogler have been exhibited internationally as in Centre Pompidou, Paris and are included in the permanent collections of the Museum of Modern Art MoMA, New York and the Museum of Science and Industry, Chicago. He is a member of the Bavarian Chamber of Architects, Deutscher Werkbund, the German Society of Architects BDA and the American Institute of Aeronautics and Astronautics [AIAA].

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# 05 POSTSCRIPTUM



Mick Eekhout

The Larsen and Nielsen Foundation made this research possible through a donation to the Royal Danish Academy of Fine Arts School of Architecture. Further, I would like to thank the Dean of the School of Architecture Sven Felding and the research director Ebbe Harder, who passionately support research in the field of architecture. My special thanks go to the lively Department 11. This is Professor Anders Brix and his colleague Karina Mose. Further the department's teachers Steen Ejlers, Lisbeth Gasparski, Helle Daugbjerg, John Lin, Finn Hagen Storgaard, Friederike Faller, Irene Lønne, Mads Quistgaard, Marcel Schwarz, Flemming Wagner and Willem van der Beek. Last not least Jesper Nielsen, who has been proposing me for this research position. For her great support, I also wish to thank the charming secretary Lillian Mogensen. Most importantly, I must thank my wife Katarina, who has supported me during my time between Copenhagen and Munich.

The Concept House Research Group was established at TU Delft in September 2004 by Prof. Dr. Mick Eekhout in order to do research and developments in the field of industrialized customized housing. Its funding was supplied by a number of Dutch companies: Isover, Raab Karcher, Inbo, Trespas and Bouwfonds. The external researchers in the group were supervised by Dr. Wim Poelman: Sannie Verweij, Ties Rijcken, Marlous Vriethoff, Stef Janssen, Jelk Kruk and Jaap van Kemenade. These were all young engineers who wanted to continue their architectural and building technical or industrial design education with a postgraduate education as PhD student or external researcher. In their midst Andreas was quite an experienced architect and technical engineer with a portfolio in experimental designs of extreme houses. We met in Munich at the Technische Universität München, where Andreas was an assistant of Prof. Richard Horden. Prof Horden has been asked to participate in the Concept House group as an external peer in 2007 and designed and produced his micro compact home MCH in the same line of thinking of like the Concept

House program. I invited Andreas to pursue his professional scientific career as an external PhD student of the Chair of Product Development. He visited the Concept House group regularly during 2005 and 2006 and collaborated with the researchers and organized symposiums and workshops. His experienced, yet mature and balanced influence in the group was highly appreciated. However his impulses were slowed down as he was simultaneously starting his own office 'Architecture and Vision'. He is a sharp observer, a good designer, a thorough thinker and a fast writer. His future no doubt is to stand with one leg in academia, and the other designing and experimenting with prototypes. I challenged him to write his Phd dissertation on the topic of extreme houses or houses in self-sufficient environments. Up to this moment we have agreed to publish his study 'The House as a Product', which he wrote as a guest lecturer of the University of Copenhagen, and finished as a Concept House researcher. This was agreed in order to stimulate the information and communication around Concept House in Delft. We look forward to his further writings on extreme housing. The Concept House is a sub program of Building innovation [[www.buildinginnovation.nl](http://www.buildinginnovation.nl)] and Green Building Innovation. In 2015 the Chair of product Development was terminated with my retirement as a full professor of that chair.

A handwritten signature in black ink, reading 'Mick Eekhout', followed by a long horizontal line that extends to the right and then curves back down to the left.

Prof.dr. Mick Eekhout,

*Chair of Product Development, 1991 - 2015*  
*Faculty of Architecture, TU Delft, the Netherlands*

# 06 EPILOGUE



Richard Horden

Andreas Vogler expertly analyses and explains a very deep issue in this book and most especially for those of us involved and so sincerely concerned with progress in the design and building of our most personal of constructions, the family home.

In England this year we require 245,000 homes to be built to keep up with population and commercial demands but the industry and more importantly local authority permits cannot possibly accommodate this level of production. We have tracts of under-utilised ideally located brown field sites, for example within the eight kilometres between Heathrow and Chiswick that could easily accommodate this number of new homes with higher acoustic and environmental specifications than the existing inappropriate low rise 1930s suburban semi-detached houses.

Repetition is well known and indeed highly valued in traditional well groomed house design. The Georgians, Edwardians and Victorians developed an expertly designed hand built kit of parts which led to the highly valued 'pure white' street architecture we see in Central London and many parts of the most expensive real estate in Chelsea, Kensington Mayfair and Belgravia. The challenge is still there for designers, industry and government to deliver a contemporary kit of parts like our forefathers achieving not only what people want but better than they ever expected. New low-carbon factory technologies using high rise, fast build, cross laminated timber panels are but one example of how we can progress economically, environmentally and lightly. With his most international experience and vision Andreas Volger gives us a wide perspective on the issue. Reading his most well researched book he offers all of us a renewed and exciting challenge: the eternal designers dream of the 'private house' produced like a 'private yacht' with all the opportunities, elegance, efficiencies and flexibility together with reduced energy consumption which may ultimately allow the dream to awake.

Richard Horden  
London

