

LIVING BUILDINGS AND THE ASSOCIATED R&D BASED MANUFACTURERS - *The Revolution towards Evolutionary Construction*

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Abstract

The construction industry is not sustainable. Expressed in percentages of the totals in the Netherlands and when calculated over the total lifecycle, from the early start to the processing of waste after demolition, energy consumption is more than 50%, CO₂ emission is more than 50%, waste production is 35 %, road transport is 25 %, failure costs is more than 15 %, average profits of construction companies are less than 2% of the turnover. The contribution of the construction industry to the GNP is 11%. The global figures will probably be worse as cooling requires disproportional more energy than heating. Obviously, the construction industry should be changed fundamentally. In this paper a great design of a sustainable construction industry is presented. Using "attribute listing" as method, the contours of a future Construction Industry are described in 50 typical characteristics and attributes each of them in full contrast to the current situation. The result can be considered as Evolutionary Construction with Living Buildings, which are able to survive in a faster and faster changing world. These sustainable buildings are created by variation, selection and reproduction. Like car producers, building producers will develop new buildings from existing buildings. All properties, attributes and features with respect to architecture, quality, quantity and costs of these buildings should be described in a Parametric Knowledge Model which is continuously fed by each realization. Hence, each new or adapted building will contain the experience and knowledge accumulated during a long series of already realized buildings. A main condition is that each building of the family of buildings should have the same structure, which is the set of architectural, structural, mechanical and physical relations between the elements. But at the same time each building is unique by a large variation of elements. These buildings are fully (de) mountable and composed of standardized industrial elements in order to cope with changing environmental circumstances. As the lifetime of most elements and components are longer than the expected lifetime of buildings as a whole, a major part of buildings can thus be reused after dismantling. This Darwinism for construction industry manifests itself in adaptability not only over generations of buildings but also in each building that should survive in its own lifetime. In result, the Big Picture of the future culture and structure of the construction sector can give us some hypothetical benefits. An estimate: The value of buildings will be at least twice as much, the prices at least 50 % lower and the delivery time at least 50 % shorter. Moreover the energy consumption and CO₂ emissions will be halved. In this paper the basic principles and thoughts, which have been used for this design work and the 10 most important changes out of 50 are presented. In 2012 a book will be published on Evolutionary Construction.

Keywords: Living Buildings, Sustainable IFD Buildings, R&D based Buildings, Parametric Design, Integrated Supply Chain

INTRODUCTION

Practitioners and scientists all over the world agree that the construction industry shows systemic failings resulting in disappointing production, effectiveness and efficiency. The first movements aimed at substantial changes date from the early nineties of the last century and was initiated in the UK by the Latham commission (Latham,1994), followed by Rethinking Construction (Egan ,1998). After Australia and Finland also in Holland started an initiative after the big fraud affair (Tweede Kamer, 2002 and PSIB,2004). Measures were mainly aimed at change of the adversarial culture of the construction industry which manifest itself in lack of respect of its employees and uncapability of delivering for its customers. During the last decades improvements were achieved by creating more openness, cooperation, trust, honesty, commitment and teamwork in projects (Egan,2002).

In the late nineties of the last century, the notion of sustainability emerged in the world when facing the climate problems. Here, the construction sector plays a critical role, as its contribution is rather bad (Dubois &Gaddle,2002; Nam & Tatum, 1988). Expressed in percentages of the totals in the Netherlands the energy consumption during the utilization phase is 35 %, the CO2 emission during the utilization phase is also 35 %, the consumption of energy and the CO2 emission due to the production of materials is 35 %, the waste production is 35 %, road transport is 25 %, failure costs is more than 15 %, which is about 10 billion Euros per year. Moreover the average profits of construction companies are less than 2% of the turnover. These figures are rather bad when compared with the 11% contribution of the construction industry to the GNP (Lichtenberg, 2006). The global figures will probably be worse because cooling requires more energy than heating.

The reason behind this bad performance is that every building is treated as a unique product. The world is covered with billions of unique buildings and unique structures. Each of them is not only the result of a unique project, but it is also developed by a unique combination of people, built under unique circumstances, delivered to a unique client, to be used by unique users, erected at a unique location, surrounded by a unique environment and constructed for a unique long lifetime. For each building the wheel is invented again and again (London & Kenley, 1999). For buildings as a whole neither learning curves, nor repetition effects can be observed throughout the supply chain (Vrijhoef & Koskela; Woudhuysen & Abley; Lansley,1994; Koskela,2003). In all, buildings and structures have an artisan character and show suboptimal performance).

With the current credit crunch, the coming energy crisis and the booming construction activities in Asia, it is perhaps time for the international community in and around the construction industry to make a very fundamental change of the whole system with its associated cultural and structural aspects. In this paper a Big Picture of a sustainable construction sector is presented.

METHODOLOGY

The method used in this paper is called "Attribute Listing" and developed in design theory for innovation. Attribute listing, as used and adapted for this special purpose (the change of a complex and complicated system), contains 8 subsequent steps:

Step 1: Take for granted that the construction industry is not a good system. Based on the figures as presented in the introduction, this starting point can easily be defended.

- Step 2: Make a list of typical characteristics and attributes associated with the present construction industry. This is rather difficult because this step requires a generalization of the construction industry. It is generally accepted that "the construction industry" as a whole does not exist. Therefore this step is quite debatable and can only be based on general reports of governments (see paragraph 2). Nevertheless this step suffers to personal interpretation.
- Step 3: Provide each characteristic with theoretical and practical objections. These comments are essential for the directing the possible changes. These objections can be found in the general reports (see step1)
- Step 4: Develop, using the objections of step 3, an idea about a new system, that is not only understandable for everyone but also imaginable for everyone. Obviously the first idea used is the normal industrial market for consumer products. It fulfills the two requirements and it is far more sustainable than construction industry. A problem is that buildings should be tailor made and should also have a large lifetime. Therefore a second idea was added. That is the analogy of the termitarium. All information of the termitarium is contained in the combination building/builder. It is stored in the DNA of the termites. Each building is slightly different in shape but totally similar in structure. The structure is the most important factor, where the final shape depends on local environmental circumstances. It seems to be that termites have the disposal of build-in learning curves and build-in repetition effects. That is exactly what lacks in the construction industry.
- Step 5: Change the characteristics and attributes of the old system as much as possible towards associated characteristics and attributes of the newly to developed system. This is a difficult step because the construction industry has some specific characteristics that are totally different from the normal consumer's articles. For instance, buildings are fixed on the ground, have low value per kg material and a long lifetime.
- Step 6: Cluster the characteristics and attributes on mutual relations. The reason behind is that the relations imply a combined approach for change
- Step 7: Try to arrange the clusters of step 7 in a causal order. This is important because some changes have to be started first before other changes make a chance.
- Step 8: Provide the characteristics and attributes of the new system with individual examples that show those characteristics and attributes already or in a certain rate. This is an important step, because people only want to change a system when they clearly see not only advantages and benefits but also working examples (not presented in this paper).

The main 10 changes

The basic topic of the construction industry is to develop a building frictionless in its environment (Alexander, 1961). The fit between building and environment is given in a large set of conflicting variables like capacity, costs, safety, reliability, etc. This is sketched in figure 0, that is the main reference of the description of the present construction industry at one side and the prescription of a future construction industry at the other side.

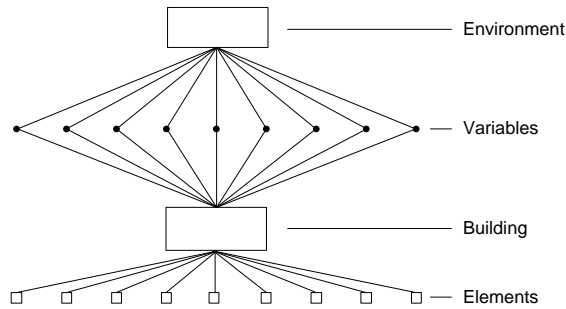


Figure 0: Fit between building and environment

1. The present practice to fix all variables in a set of output specifications for the building should be changed into the creation of a solution space (see figure 1).

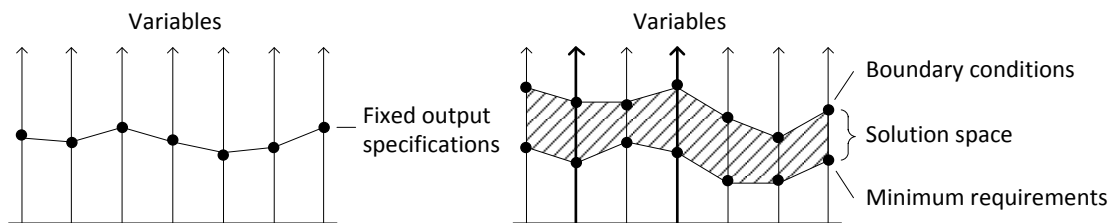


Figure 1: Change in specification

All variables are wishes (as much/less/large as possible), provides with weighting factors, minimum requirements (internal) and boundary conditions (external). This was applied for the €400 million Storm Surge Barrier in Rotterdam in The Netherlands (de Ridder, 1994).

2. The present price competition should be changed into a competition on value price ratio (see figure 2).

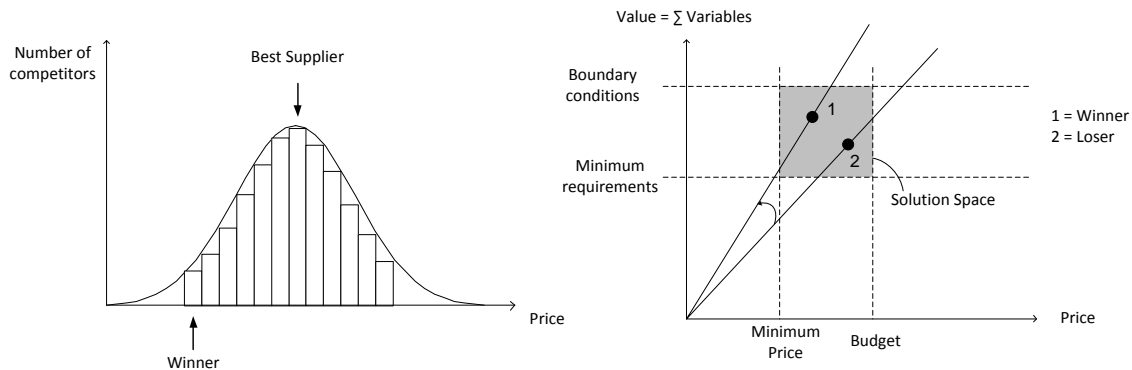


Figure 2: Change in competition

The lowest price bidder is in most cases not the best builder. When considering the weighted scores on the variables and checking whether the bids are inside the solution space (specific validation) , it is easy to select the bidder with best value price ratio. This was applied for the Storm Surge Barrier in Rotterdam.

3. The present focus on the building of all players in the supply chain should be changed in a focus on the solution space (context) at the demand side and the building at the supply side (see figure 3).

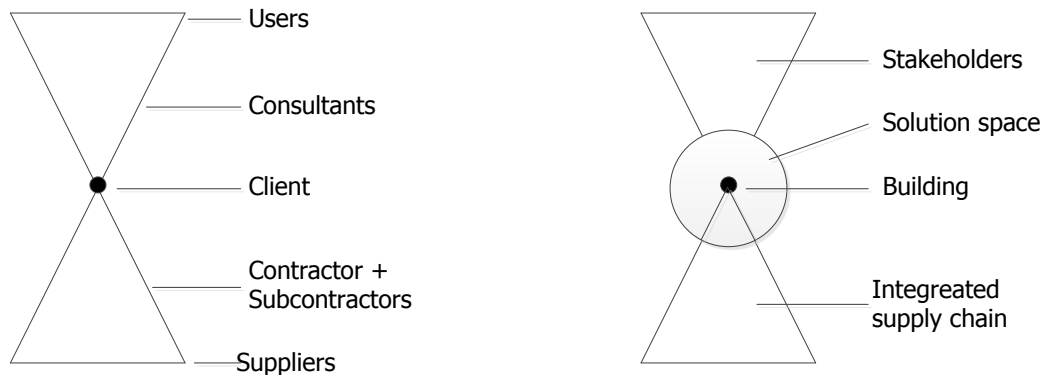


Figure 3: Change in supply chain

The main consequence is that the demand side and the supply side have their own responsibility. In result building companies are able to develop their own specific buildings and will be specialized. It also allows for creation of learning curves and repetition effects.

4. The present practice of the client to ask a series of consultants to make a complex design with associated output specifications should be changed into a situation in which the client asks consultants to define the complicated solution space (see figure 4).

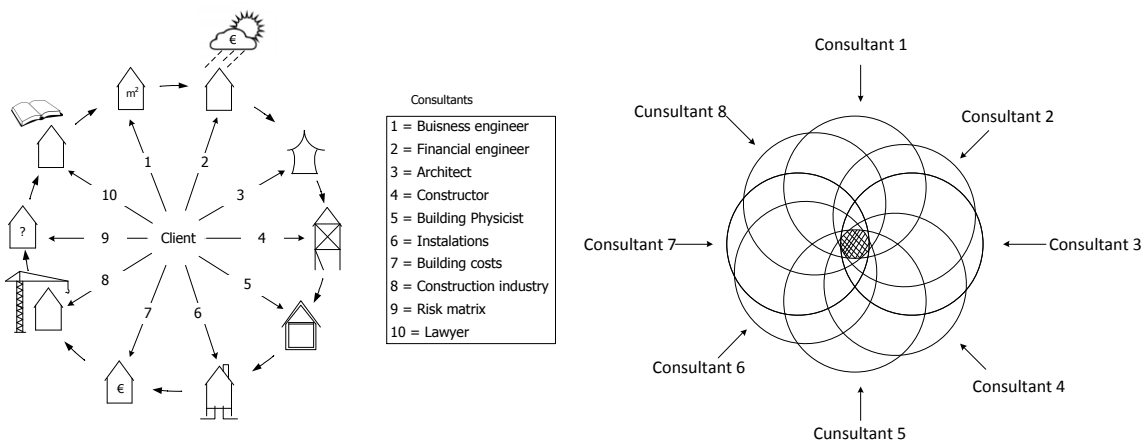


Figure 4: Change in consultants' work

Because complexity can't be decomposed the serial design work of consultants without obligations for the final result is not advisable. The building will not be specified correctly. It is better for the client to stay out design work because it attracts responsibility. This was applied for the demand specification for a Living Building Concept hospital in Den Helder in The Netherlands (Gemini).

5. The present practice to focus design work on disciplinary interfaces, clenched in between fixed requirements and fixed industrial elements, should be changed into a focus on fixed relations between all variables (see figure 5)

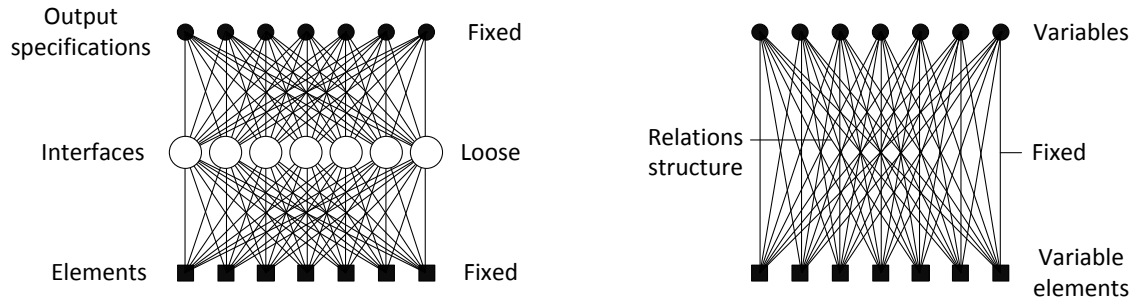


Figure 5: Change in system approach

When fixing the relations, the designer fixes the internal structure of the building. Design work then becomes adaptation. Design work becomes research and development. This is applied by Burggraaff in Leeuwarden, The Netherlands (Burggraaff).

6. The present practice to fit the building in between the fixed demand (output specifications) and the fixed elements from suppliers, should be changed into tuning the demand with its complicated context and the supply with its complex building (see figure 6)

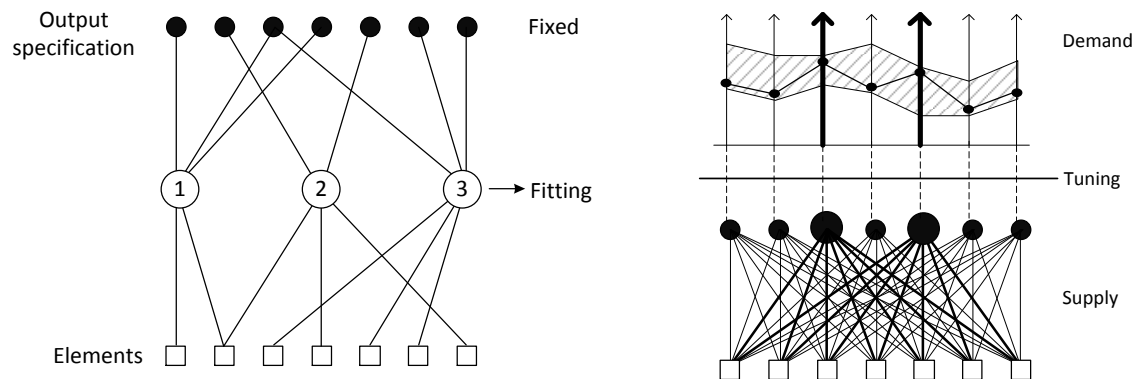


Figure 6: Change in design work

As can be seen in figure 6, the supplier can easily choose a magnitude for a variable in order to get a good score. Because the internal structure is fixed, the consequences for all elements are known. The tuning operation is in fact playing with elements. Due to the fast changing demand in relation to the long lifetime of buildings this leads automatically to industrialized flexible (de)mountable (IFD) buildings. The range however is limited. Exotic one shot realizations, which require specific internal structures, can't be offered. No examples in the construction industry yet.

7. The present organization of the supply chain based on outsourcing should be changed into a supply chain based on collaboration (see figure 7)

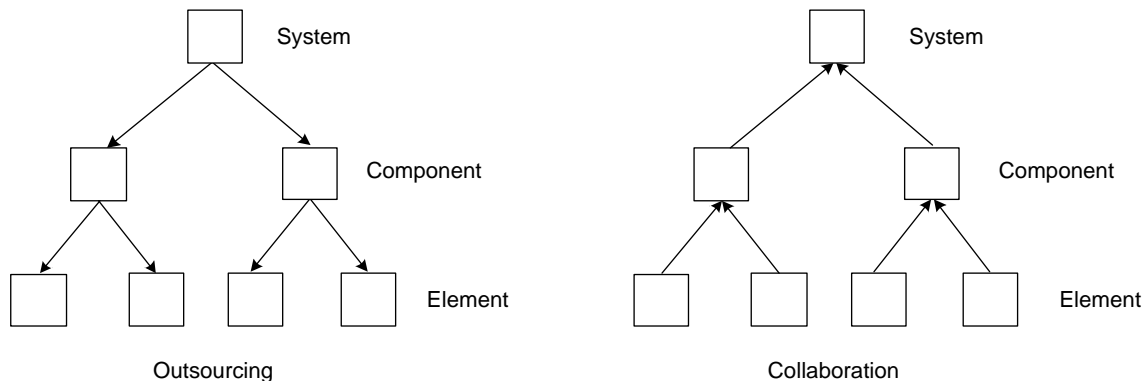


Figure 7: Change in supply chain organization

The major change is from an ad hoc project based supply chain towards a project independent supply chain. Outsourcing is top down specification and neglecting relations between parts. Collaboration is bottom up and making the whole more than the sum of the parts. No examples in the construction industry yet.

8. The present practice to produce and build on site should be changed into prefabrication in factories and assembly on site (see figure 8)

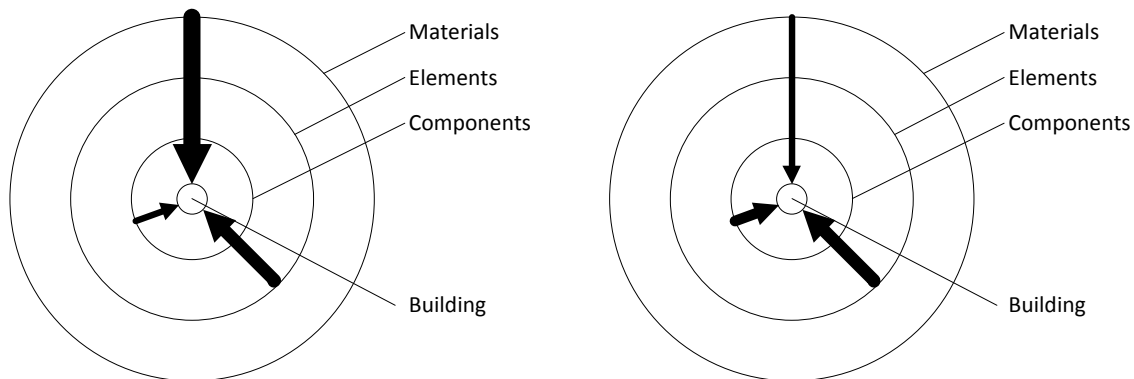


Figure 8: Change in logistics

The change into prefabrication is not only beneficial for the quality of buildings, but also for the speed in construction and mainly for the transport efforts in time, money, resources and emissions. This was applied for the 100 meter height Millenium Tower in Amsterdam without construction yard (Wessels Zeist) .

9. The present practice to downcycle all elements and components of a building after dismantling should be changed into a practice where elements and components with longer lifetime than the building itself will be reused (see figure 9). No examples yet.

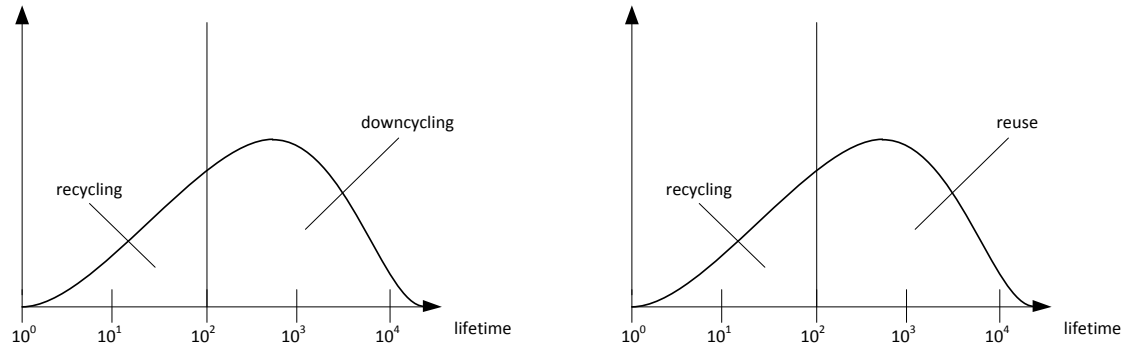


Figure 9: Change in recycling

10. The present Design & Construct practice should be changed into a Research & Development practice (see figure 10)

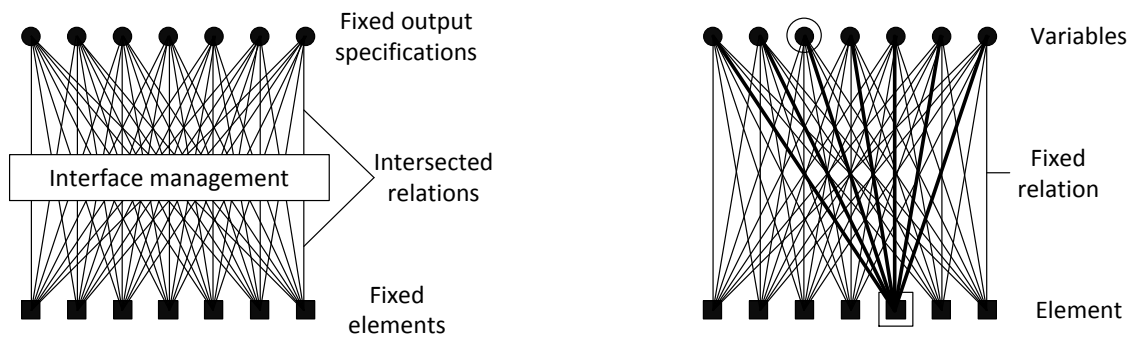


Figure 10: Change in knowledge

Inventing the wheel again and again with Design & construct of one shot, unique realizations should be replaced by a sound R&D supported with a Parametric Knowledge Model of Supplier specific Buildings. New buildings can easily be developed from existing buildings by researching the consequence for the elements when changing a variable or, reversely, researching the consequence for the variables when changing an element. This is applied with Burggraaff (Burggraaff).

CONCLUSIONS

When the construction industry is able to change itself in the description of the right sides of the columns, then producers and buildings together form living buildings. They belong to the set of living man-made systems. These buildings will be developed from a long series of already realized buildings. The buildings obey to Darwin's principle of the survival of the fittest. Producers experiment with variations on existing buildings and select the best variations for multiplication. A crucial condition is that producers fill their Parametric Knowledge Models of their buildings with each delivery, inducing continuous improvement. Each building has more or less the same structure but the final form is totally different as result of the interaction with the environment. The buildings are flexible and adaptable, keeping them up to date en fit for changing purposes provided with state of the art technology. This is very important as the world inside and outside buildings changes faster then the buildings itself. Living buildings and

structures are sustainable in any imaginable respect and at least doubles the lifecycle value, halves the lifecycle cost, doubles the profit of construction companies and halves the energy consumption and emissions. This will be achieved by increasing effectiveness by learning curves and increasing efficiency by repetitiveness. It is comparable with automotive and computer R&D. Each newly developed type contains all experience and knowledge of a long series of earlier types.

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