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# A dynamic building culture

## Sustainable architecture is based on changeability

If we are to believe the last years many exhibitions and books on sustainable architecture energy-saving and environmental improving principles for ventilation, daylight, indoor climate etc. are closely related to a radical expression. Very often those principles are manifested as a re-awakening of the former functionalist paradigm *form follows function* and we have seen products like cigar shaped skyscrapers with spiralling channels for natural ventilation or tall machines with pocket parks in high altitudes, fig 1.
As an architect you are always looking for functional alibis for giving the building a strong identity. Even though this propensity can be seen as a curious and cheerful approach to architectural practice, there is no doubt that parts of the profession has over-exploited the task of producing sustainable buildings to revel in the freedom of design, a temptation which has been heavily supported by the demand for commercial icons as well as software technology facilitating non-euclidian geometry[1]. Sustainability in architecture has, even in the hands of renowned offices, often ended up as an eco-futuristic style exercise.

However, when shape is functionally defined, when the functional matter becomes an alibi for the formal design, or when design becomes an uncontrollable media for a functional agenda, the risk is, that the designed shape not only becomes a manic over-exposure of function but also unduly specific. And that is a problem; Specific compliance between shape and function is difficult to reconcile with a practice of sustainability. The explanation is that a sustainable practice per definition must have a long-term perspective, and also functionally specific solutions in the long run fall short because the functional needs, by experience, is subject to substantial changes during the building's lifetime.

In the following, it is argued in favour of a rationale which takes its point of departure in the probability of changes in use during the building's lifetime, and that this fact will have consequences for architect's choice of strategies in order to obtain sustainable measures. Furthermore, it is argued that these strategies

[1] E.g. Rhino, ArchiCad eller Catia. These media are extensively co-producing factors in the architectural sketching process and contributing to promote non-euclidian design. In this sense the architect becomes 'the media of the media'.

Fig. 1 Integrated design by respectively Foster (left) and Yeang (right).: Spectakular design with certain limitations in operational energy for ventilation and cooling as the point of departure.

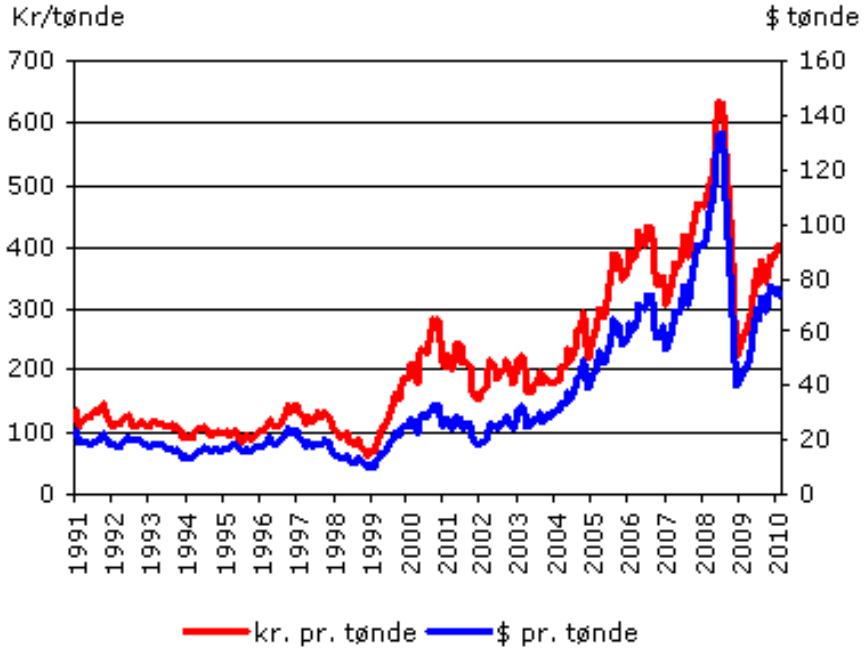


Fig. 2. Fluctuation of energy prices within a ten year period. Source: Energistyrelsen

contain a challenging radical potential for architectural practice in terms of a change in the traditional modernist concept of an architectural work.

**From operational energy to process energy**

In the wake of the oil crisis in 1973, which aroused the awareness of the dependency on limited fossil fuel resources, a paradigm was formed in the management of resources related to buildings which focused exclusively on operational energy. This paradigm aimed at reducing the energy consume in accordance with an investment rationale for energy consumption which was closely related with the equivalent economic – a total-economic rationale: An investment in energy saving is rentable if the saving at least covers the expense of the activity within a period of repayment equivalent to the maturity of a mortgage loan.

On the basis of this rationale, a progressive legislation on insulation standards has been evolved, resulting in a massive saving of energy for heating as well as many reasonable energy refurbishment projects for all types of buildings. The rationale is far from exhausted, since energy refurbishments in most cases continuously is a very good business – in terms of both the economy of finances and resources. In this field there are still low hanging fruits to pick.

However, the concept of total-economy has increasingly become insufficient as especially three conditions have changed:

1. During the period of growth through the last decade, energy prices have fluctuated enormously with a long term tendency to raise, fig. 2. Energy prices has become a major factor of uncertainty as the contours of a regular crisis in energy supply appears in the horizon. Thus, the conditions for reliable total-economic calculations have become increasingly difficult.
2. The smouldering supply crisis has been accompanied by a crisis in the global climate where the consequences of burning fossil fuel have reached a level which demands acute action[2]. Towards this problem, the paradigm of total-economy becomes insufficient because the time horizon for action has been shortened. There is not time to wait for the market mechanisms to solve the crisis.

[2] I UN's climate panel IPCC, AR4 3d report from May 2007 advocates the necessity of terminating the increase in greenhouses gasses before 2015 if raises in global temperature below 2.4 dg. C is to be avoided. If this aim is not reached, changes in the ecology of the planet are likely as well as accompanying social conflicts and humanitarian catastrophes.

3. Technological development in HVAC-systems and sealing methods has enabled a decrease in buildings' operational energy consumption to an extreme low level, fig. 3.

These changes have induced the relevance of shifting the focus from operational energy to process energy - e.g. for mining, processing, transportation, assembly and building site operations. Through such processes, the assembled building and its materials represents an accumulated energy capital which should be administered appropriately. Therefore, resources consumed in relation to buildings must be viewed in a lifecycle perception which implies a perspective beyond operation and amortization, fig. 4.

Thus, the critique of the previous resource saving strategies is double; both the functionally specific design and the one-sided focus on operational energy can be accused for being a short sighted, respectively an insufficient, practice. Towards both shortcomings, the argument in favour of building culture based on changeability can be maintained. Because when the attention is called to the saving of process energy, a long lifetime of buildings becomes a crucial target and adaptability to changes becomes an essential tool for obtaining this object, fig. 5.

**Resource-conserving building principles**

Overall, the outline is appearing of a new rationale for the handling of resource-consumption related to building, according to which the involvement of process energy will have far-reaching consequences for architectural practice and priorities. Architectural design based upon lifecycle considerations demands far more holistic strategies than needed for saving operational energy only. These strategies poses a new framework for the architects freedom to design which is in many ways more restrictive but is simultaneously containing a potential for architectural renewal, and possibly a change in the cultural practice of coding and decoding building identity.

*Cultural protection*

Which principles are available for ensuring adaptability of buildings, and thus the likelihood of a long lifetime? In his modern classic on change-based building culture 'How Buildings Learn'[3], Steward Brand points towards two main strate-

[3] Brand, S.: How Buildings Learn – and what happens after they are built, Penguin 1994

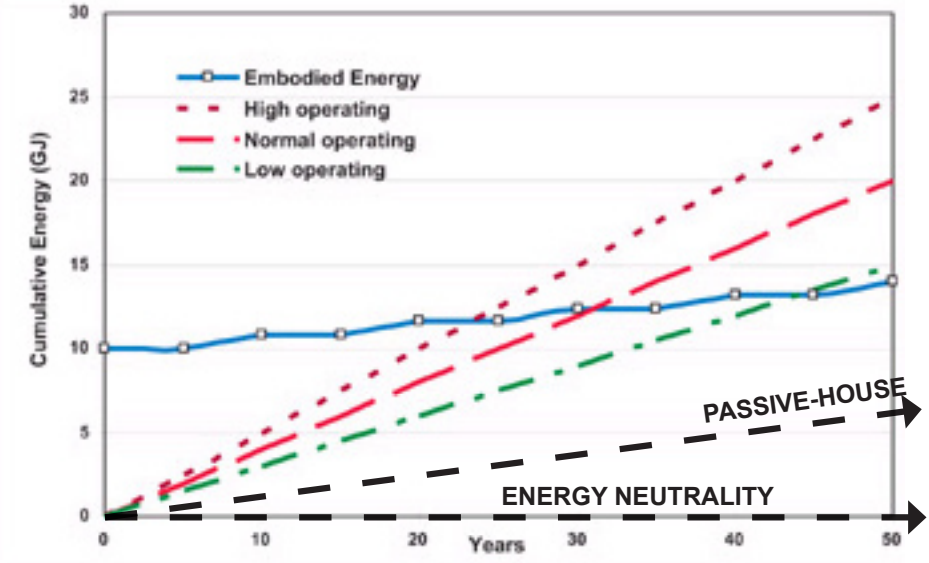


Fig. 3. Process energy (blue curve) compared with operational energy in buildings with different performance. By passive house building operational energy is minimal, by energy neutrality it is zero. Source: www.recovery-insulation.co.uk/energy.html. Black curves are additions by the author.

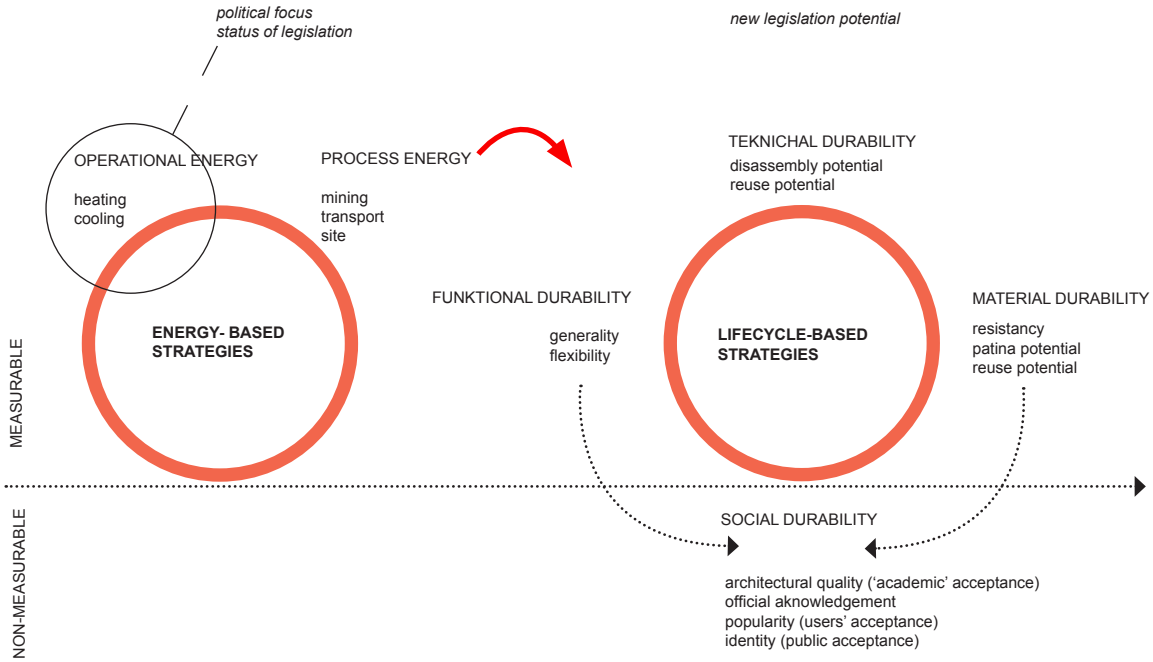


Fig. 4. Diagrammatic illustration of the relationship between energy-based and lifecycle-based strategies. Focus shifts when process energy becomes a matter of concern.

PASSIVE-HOUSE PRINCIPLES

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LOW OPERATIONAL ENERGY

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FOCUS ON PROCESS ENERGY

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LIFETIME AND REUSE

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***BUILDING CULTURE BASED ON CHANGE***

Fig. 5

gies: On the one hand, the cultural acknowledgement which leads to veneration, protection or even conservation of buildings, and on the other, the robustness of changeability and generality. In concordance with the first strategy, Dietmar Eberle[4] advocates the architect's responsibility for a careful design of the interface between building and public space in order to make the building a subject for '*public love*'. Eberle consider this '*love-factor*' a significant strategy for sustainability because it increases the probability of saving the building including its embodied energy through a long lifetime.

However, the cultural protection can not stand alone since not every building can count on being equally assigned with this privilege; loved, awarded, protected by conservation etc. The excellent and extraordinary will at all times stand out as a difference with a minority. Therefore, the aim must be to invent strategies which consider a resource saving building practice in average building, fig. 6.

*Adaptability*

Adaptability is a strategy which makes a long lifetime probable - though without a guarantee. Partly, it is a general principle applicable to the majority of buildings, and partly it is a ceteris paribus consideration. Some circumstances related to adaptability are contradictory; for instance, there might be a risk that adaptability weakens the conditions for obtaining a strong identity, often indicating a high cultural value, which in turn protects it from demolishing. Significant functionally specific buildings often have a particular strong identity which provides a basis for emotional attachment no matter if they are not flexible.

Therefore, it can be noted in advance, that the challenge for a resource saving building practice consists in providing principles for architectural design which is at the same time open to future functional needs and able to add identity to the buildings. While building identity is the specific domain for the responsible architect's individual expression and contextual adjustment, adaptability can be obtained through the following general strategies:

*Generality and flexibility*

A suitable point of departure for ensuring a long lifetime is to avoid functionally specific geometries in plans and sections. Large spans, few load-carrying dividing walls and generous room heights enable the use of buildings for multiple purposes such as housing, offices or shops. On short terms, there might be a certain increase in resource consumption connected with providing the condi-

[4] Nerdinger, W. (ed.) 2007.: Baumschlager+Eberle, Recent Projects 2002-2007

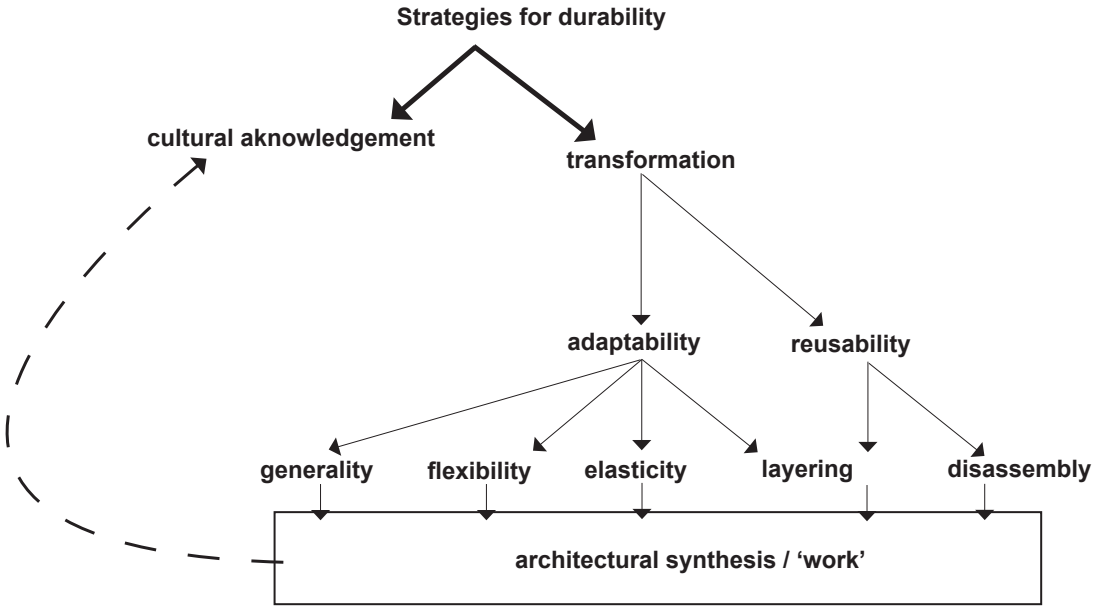



Fig. 6 Main strategies for durability. A strategy of transformation does by no means exclude cultural aknowledgement.

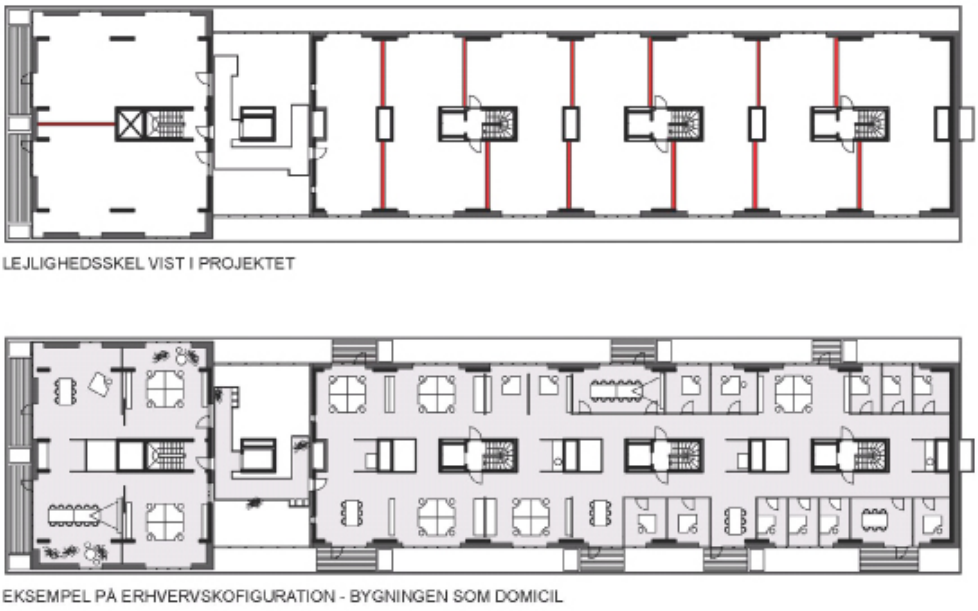



Fig. 7 The unspecific plans of the warehouse typology enabled change of functions. Scenarios for respectively housing (top) and office (bottom) is documented in this example. Vandkunsten 2009: Bolig+ konkurrenceforslag.

tions for multi-functionality, for instance an ample room height or a surplus constructive capacity. In return is obtained robustness towards changes in the urban context and changing market conditions. An example of building types with a general usability is the warehouse-typology, which relatively easily can adapt to industrial production, workshops, offices, storage, hotels, housing or shops, fig. 7.

*Layering*

Layering is a prominent strategy for handling the different lifecycles of building elements, and often illustrated by Francis Duffy's[5] diagram, fig. 8, where the stroke dimension indicates differences in expected lifetime for respectably facade, construction, installations, space dividing and furnishing. The idea of shearing layers in a building is to technically separate the layers. Hereby it becomes possible to make changes with a minimal use of resources and costs.

The strategy of shearing layers combines the total-economic and the resource-saving paradigm because the accumulated expenses on conversions exceeds by far the initial expenditure, fig. 9. By making conversions easier and cheaper, a total economic gain can be obtained which in turn diminishes the probability of demolishing. However, the layering principle is not always a necessary prerequisite for adaptation to varying lifecycles; small and lightweight building modules can sometimes offer a similar flexibility[6].

*Disassembly*

The layering strategy is particularly executed on the technical level in joints and fixations between building elements and components. Separation of layers is of significant importance in order to enable an individual dismantling of a layer without damaging consequences for other layers.

Disassembly technique is a new discipline within the field of architectural practice and theory. It is absolutely not a part of the current daily routine or responsibility among professional architects to plan for, or to explain how, buildings are demolished, or how materials can be reused, respectively down-cycled. However, in a resource perspective, this is a crucial ability to cultivate, and a professional field

[5] The architect Francis Duffy coined the concept of 'shearing layers' – the building as a system of layers with different lifetimes. Brand (1994) has adopted and further developped the concept by the addition of 'site'; the place / building site as the most permanent layer. This makes particularly sense in urbanity discourses.

[6] Nordby, A.S. 2009: Salvageability of building materials. Doctoral thesis NTNU, p.104. Nordby points towards nwe types of large brick-like blocks, and also the possible use of lime mortar for new building.

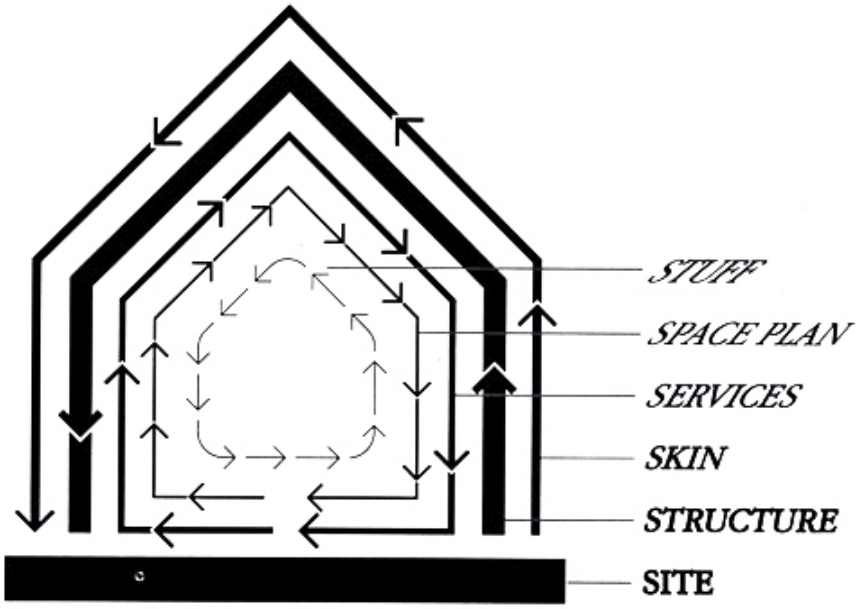



Fig. 8: Duffy / Brands diagram of shearing layers with variable lifetime. Source: Brand 1994

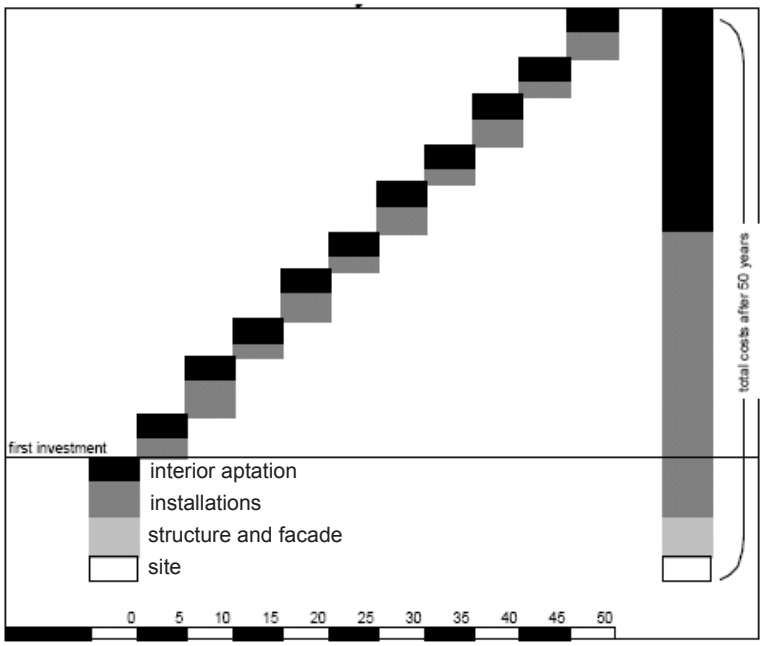



Fig. 9: The economic rationale of a transformable building culture: Over a period of 50 years the accumulated expenses on conversions and maintenance are - dependent on the building type - typically exceeded the aquisition costs by many times. Source: Brand 1994, Durmisevic 2006.

which might very likely be implemented in building regulations as injunction of documentation for possible disassembly similar to the documentation of operational energy use which today is required in most countries.

A requirement for disassembly will, on the other hand, result in an immediate confrontation with the unrestricted concrete regiment which monopoly-like is ruling the Danish building industry, building code and building practice. This is due to the fact that concrete building elements tends to be heavily integrated by being assembled in cast joints with reinforcement locks. Thus, conversions are hampered, flexibility is weakened, and reuse of building elements is made impossible. Concrete building demands a high process energy use, and maximum 20 % recycled material can be included in new casting processes. After demolishing, concrete can only be used in a *down-cycling* process as crushed rocks for road building and landfill purposes[7].

*Assembly hierarchy*

The Dutch architect Elma Durmisevic[8] has studied the principles for disassembly in order to enable assessment of buildings' ability to change – *the transformation capacity*. She emphasises the importance of building elements and component to be hierarchically organized to ensure the layering structure, and hence an easy change of building parts in accordance with their respective lifecycles. This can be proved diagrammatically by an organization of building elements which eliminates any short circuits between layers (crossing connection-lines in the diagram), fig.10. This type of diagram is easy to produce and might in the future be demanded as a statutory documentation for building disassembly and reusability of materials. Furthermore, chemical connections – such as cast joints, glued fixations and elastic sealants – must be replaced by mechanical connections – such as bolt assembly, frictional fixations and expansion sealants. In frictional fixations penetration of the material is avoided which make the component fully available for reuse, fig. 11.

*Reusability*

Another significant strategy for resource saving is localized on the level of materials; besides the ensuring of a long lifetime of the building, focusing on the reusability of materials is important - partly by integration in a demountable composition of building elements with the least possible deformation in processing, partly by choosing materials which can be reused without new processing, for instance

[7] Source: Miljøvenlig Betonproduktion, publication of Betonindustriens fællesråd 2006, p.9
[8] Durmisevic, E.: Transformable Building Structures, Doctoral thesis TUD 2006

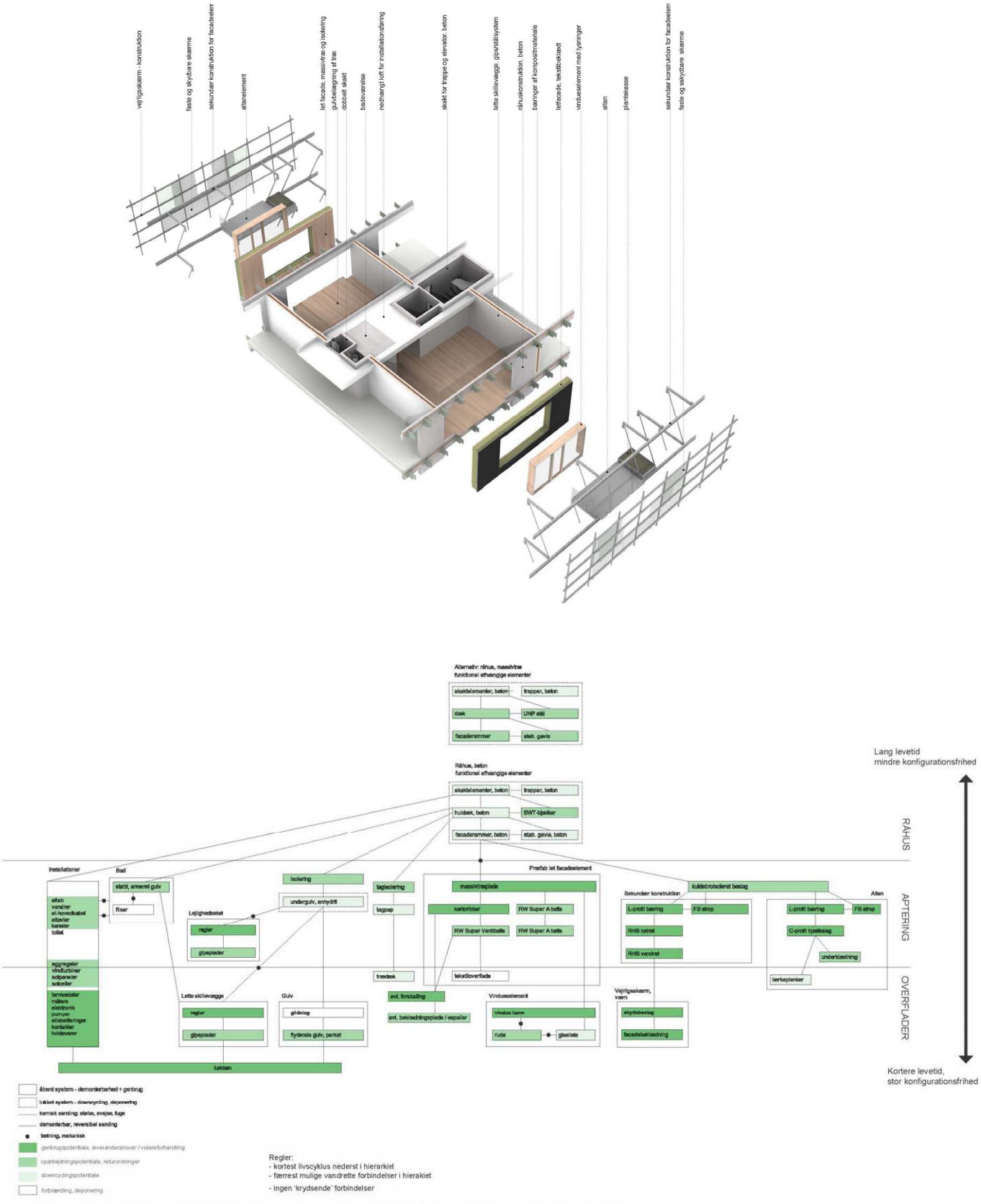



Fig. 21A: Konfigurationsdiagram for bygningsdele - dokumenterer graden af udskiftelighed / demonterbarhed og genanvendelighed

Fig. 10:
Top: Section of a building with a layered structure which permits exchange and converison at different tempi.
Bottom: Diagramme showing the same building's hierarchic assembly structure, which enables changes by layers. The colour code denotes the reuse potential of the component.
Vandkunsten 2009: Bolig+ competition proposal.

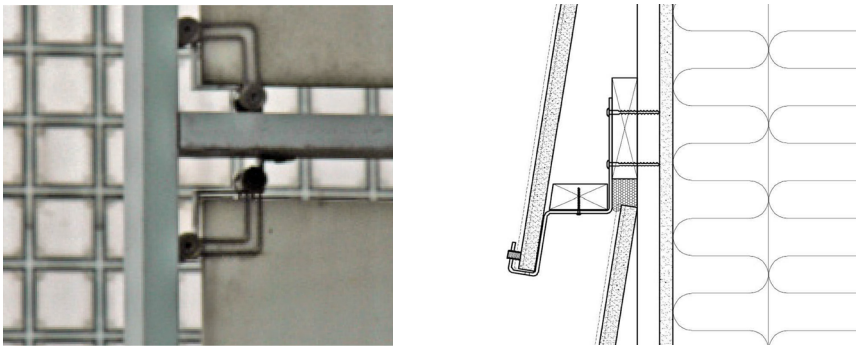
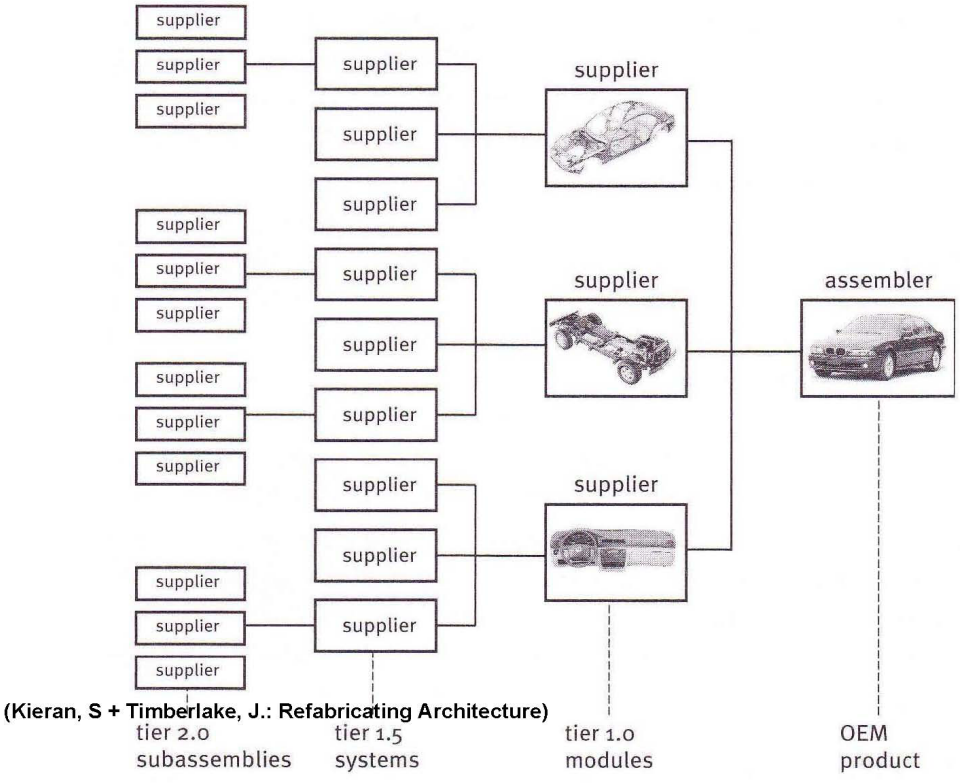


Fig. 11: Examples of frictional connections:
Tv.: Spring mounting of facade-tile, Jean Nouvel 1987: L'Institut du Monde Arabe
Th.: Squeeze-locked mounting of facade board, Vandkunsten 2009: Almen+




(Kieran, S + Timberlake, J.: Refabricating Architecture)

Fig. 12: The hierarchy of supply in car industry. Source: KieranTimberlake 2004

the articulation of 'the basic space' than those motivated by the special regards to general usability and flexibility. Rather, this paradigm unfolds on skins and surfaces, on treatment of materials, profiling of components, and above all joints and connections.

*Industrialization profits*

It is worth to remark that further industrialization of the building industry, which has always had difficult conditions on a volatile market, will get a helping hand from the constructive hierarchy presupposed by the disassembling strategy because this hierarchy establishes a logistic infrastructure suitable for a distributed production of building parts: The assembly hierarchy and the mutual independency of elements will fertilize the market for specialized and optimized sub-delivery products. In this way building industry will approximate itself to the structure of the vehicle industry in which a still better organized sub-delivery hierarchy for generations has resulted in ever increasing quality and equally declining prices, fig. 12.

*Distributed design*

The technical principles ensuring building convertibility, flexibility and disassembly have two highly interesting side effects which do not relate directly to resource saving but appears as a kind of 'bonus', automatically accompanying those qualities:

Firstly: The users obtain a radically increased degree of freedom to re-configure the buildings. When conversions to new or changed functions are made easier and cheaper, changes may happen with a higher frequency. The original design from the architect's hand will be elaborated and the value of the authorship to the architectural opus will be reduced as the arbitrary administration by the users soon will make its mark on the building. These changing conditions for architectural authorship will force architects to imagine their design as a framework for dynamic scenarios. In this sense, the building architect will be in a situation similar to that of the landscape architects who have to predict the spatial consequences of the different growth stages of the plantation. A building becomes, rather than a static object, a dynamic project; a work that unfolds itself gradually and unpredictably.

Secondly: Architecture must base its aesthetics on a concept of beauty different from that of the fully controlled opus. The discipline, which stands before its emergence, is the ability to predict the consequence of changes, and to arrange

bricks and lime mortar, or permits down-cycling through many generations of processing, such as wood.

The Norwegian architect Anne Sigrid Nordby[9] has demonstrated how the dimensioning of building elements has implications for their practical performance in terms of conversion and reuse; the smaller and less complicated elements, the better potential for reuse. From this study Nordby has produced the following advices for ensuring reusability:

1. Limit the number of materials and components.
2. Use durable materials and components with good tolerances and the ability to get patina.
3. Prepare for general usability by using standard dimensioning, modularity and small, lightweight elements.
4. Use reversible connections between elements and components, e.g. screws instead of nails, and mutual independency between elements.
5. Separate the construction in building layers in accordance with expected lifetime. This advice can be supplied with a specific technical methodology[10].
6. Document the building with as-built drawings, photographs of hidden components and connections, and produce advises for operation and maintenance which includes descriptions of materials and instructions for disassembly.

**The architectural potential**

The guidelines above inspire the investigation of a tectonic field which might be named ' tectonics of mechanical connections'. In the technical montage the tectonic, defined as the meeting of elements in *the joint*, represents the core of architectural articulation of buildings[11]. A legal requirement for disassembly has the potential to be a driver for architectural development of disassembly technology. The poetics of disassembly will evolve, often in the scale of the detail, where components such as squeeze-lockers, clamps, winged screws and nuts, springs and console brackets will be parts of the tectonic syntax. Architecture according to this resource saving paradigm does not necessarily include other changes in

[9] Nordby 2009: Op. cit. p. 143. The list in this article is a shortened version.
[10] Such methodology is thoroughly described by Durmisevic 2006.
[11] The concept of tectonics is formulated by Gottfried Semper in 'Die vier Elemente der Baukunst' from 1851. In this work, according to Hartoonian 1994, the architecture is recoded into the art of montage – as a consequence of conditions produced by industrial development. Hartoonian 1994, pp. 5-28.

conditions for change in such ways that attractive spaces and visual beauty is achieved. At this moment it is hard to imagine this potential fully developed but a prototypic, low-tech foretaste of this can be experienced in Alejandro Aravenas project Elemental – Quinta Monroy in Santiago, Chile[12], fig.13. In this project, the architects have produced a significant spatial basic structure containing access system and installations. The occupants elaborate on the structure by supplying additional floors and facades. This contrast between stringency and openness results in a complex expression of striking visual beauty.

*Open work*

In 1962 the semiotic Umberto Eco wrote the essay 'Poetics of the open work'[13] with a description of a category of work in which the interpreter is assigned to an active role as co-producer of the work. This understanding of a work inspired, along with Habraken's structuralist manifest 'Supports – an alternative to mass housing'[14], a number of realized building projects by architects such as Herzberger, Steidl, Dietrich og Utida, fig. 14. The ethical driver of structuralism was the intention of democratizing architecture by making buildings available for users' changes, and its aesthetical driver was the fascination by a free organic dynamism and the accompanying semantic openness. Hence it was for practical and artistical reasons the intention to make architecture a media of a radical, emancipatory agenda.

*New radicalization*

On the background of a necessity imposed by the climate agenda of saving and conserving resources, it is both paradoxically and gratifying that the resource saving principles described above, which emerges as a shear strategy of scarcity, is able to let in increased freedom and a radical culture of architectural work - through the backdoor, so to speak. With the principles of flexibility and disassembly, the architectural profession imposes restrictions but receives simultaneously the chance to develop methods which are able to realize the democratic ideals of the 60's and 70's that were by then executable only on the level of illustration. For no user did ever change the structuralist works of Steidle or Utida which were doomed to remain as images of user freedom since the available building technique was not able to deliver on promises.

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[12] The project entitled 'Elemental – Quinta Monroy' is an example of architecture used as a social tool when refurbishing a favela-quarter into a regular residential neighbourhood, and simultaneously creating local jobs.

[13] Eco, U.: The Open Work

[14] Habraken, N.J.: Supports: An alternative to mass housing,

Fig. 13: Distributed design: Top: The housing scheme at the time of delivery (the architect's completion). Bottom: Same view one year later after additions by the occupants. Alejandro Aravenas: Elemental - Quinta Monroy. Photo: Christobal Palma

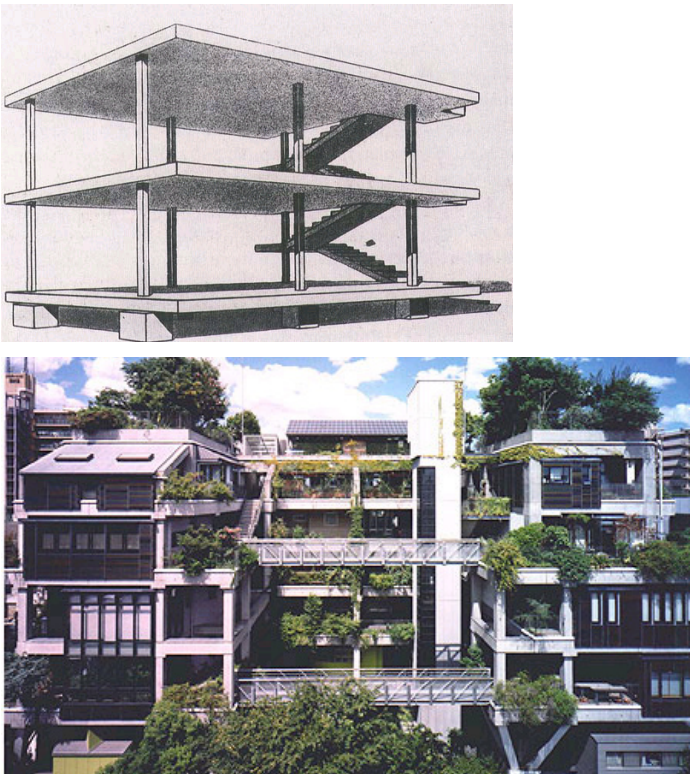

Fig. 14 Top: Le Corbusier's 'plan libre' in the Maison Domino proposal, 1913. Radical freedom for users, but not built. Bottom: Utida 1993, Next 21, boliger i Osaka. Built, but not transformed.
Photo: http://www.arch.hku.hk/~cmhui/japan/next21/next21-index.html#4.

*Identity and tradition*

But where is the limit for our society's cultural acceptance of volatility of buildings and cities? Disassembly, and the derived ability to change and adapt, is threatening the part of our self-understanding which is related to buildings and cities by virtue of their function as a collective memory and reference. This identity will in the nearest future be put to the test when energy refurbishments of the existing building stock are implemented, and buildings which facades make streets and squares recognizable will be masked by new layers.

Societies like USA and Japan are cultural sustainable despite of a far less degree of urban permanence than you find in Europe where it is probable to meet resistance towards dynamic architectural strategies. Partly because buildings and places here are characterized by a high degree of permanence – with the use of heavy and energy intensive materials like bricks and concrete, and partly because the needs for changing functional facilities has been met by a constant growth in the total building stock.

*Aesthetical potential*

Architects can contribute to diminish the resistance towards resource saving strategies based on change and adaptability by including flexibility and disassembly in the culture of the architectural work – in the 'opus' sense of the word. This task consists of the making it an architectural professional discipline to master the very relationship between permanent and volatile through scenario planning in all scales from planning to detailing.

The impetus for an aesthetical exploitation of open work strategies already exists as an architectural theme which through times has been cultured by architects with totally different leanings, fig. 15. In these examples the facades have a compositional openness which is the architect's depicturing and pre-radical interpretation of a process of change, likely during time. One can see the strategy as a compositional pre-patina, pleasurable used to create a matter of image resembling the old urban building stock, and inviting users to continue the process of change.

This approach is, according to Eco, open works of second degree, i.e. works which are completed but contains internal relations which the interpreter has to discover and prioritize[15]. In open works of first degree, i.e. works in movement and in which the interpreter is invited to make the work together with the au-

[15] Eco, U: 1989 (orig. 1962): The essay 'The Poetics of the Open Work' in 'The Open Work', Harvard University Press USA pp. 1-23

Fig. 15: Open work of 2d degree. Left: Tony Fretton 1994, Lisson Gallery, London. Right: Vandkunsten 1972, Tinggården 1, Herfølge

thor[16], a share of control over the work is delegated to the users. In practice, this distribution beyond the architect's control takes place whenever a conversion is made during the building's lifetime. As distinct from this very common situation it is in an open work strategy a part of the architectural work to point at possibilities for conversions and to predict the aesthetical potential of these changes. The architect seeks to influence on the unpredictable and uncontrollable, not by preventing it but by establishing a framework which optimizes the functional and aesthetical outcome. The compositional play between layers with different lifecycles has the potential of becoming a central tool of expression in an architectural practice based on change. In popular terms, the architect behind a an open work will be pleased by changes made by users because this redeems and enriches the work, whereas the architect in the traditional modernist work culture will be disappointed by the disturbance of the perfection of the completed work inflicted by changes.

**The implementation process**

The above described paradigm for an architectural practice which focuses on long term, change-based and resource conserving principles is today neither a part of the agenda set by legislation, private certifications, or the education in schools of architecture. The challenges are multiple:

- It is difficult to quantify, and hence to document, process energy because much essential information is inaccessible. Even the best lifecycle analysis is subject to considerable uncertainties, and when it comes to predict future process energy consumption it becomes pure guesswork. Anyway, there seems to be good possibilities of assessing buildings' capacity for transformation based on a number of specific technical parameters.
- The process energy related to building will hardly attract much attention before the last saving on operational energy is harvested in energy refurbishments of the existing building stock. Only when legal requirements in terms of documentation of disassembly and flexibility are adopted, a solid impetus for an architectural evolution can be founded.
- The development of information technology which creates still more precise simulation tool contributes to give primacy to static models and quantifiable parameters on the expense of dynamic, non-measurable

[16] Op. cit.

qualities. Thus, technology supports design based on function rather than change. However, software development is also driven by demand of the designing industries which makes it easy to imagine a future improved technological support of scenario-based design.

- The culture of the architectural work, nurtured by professional acknowledgement, is based on achieved qualities which are evaluated shortly after the completion of the building or on the basis of proposals for competitions or (in schools) for study. The assessments are made on the basis of static illustrations and momentary situations which generate little professional incentive for engaging in long term strategies.
- The demand for easily transformed buildings can hardly be noted, partly because there is little expectation that such a demand can be honoured, but also because there is a lacking coincidence between clients and users. The ownership of buildings shifts during the building's lifetime and buildings are often considered as an ordinary industrial product. Therefore, there is little incentive to include requirements for adaptability in building programmes and certainly not if it results in additional expenses. However, a favourable development can be noted in non-profit housing companies and operational contracts with public instance. Due to the long term ownership it is possible to focus on long term qualities including the buildings' ability to adapt to new needs and function.

Every architectural development is conditioned by examples, illustrated or built, and as soon as works are created which manage to stimulate visual or intellectually, the architectural industry will be willing to change its practice. References can not be obtained on command but the holding of thematic architectural competitions like Bolig+[17] might increase the probability of the emergence of useful references and demonstration projects. Before such are available, the potential of design based on adaptability is smouldering around the world in research environments and within a number of architect offices ready for change.

[17] Invited competition on energy neutral housing 2009, see www.boligplus.org

Literature:

Brand, S. 1994: How Buildings Learn – and what happens after they are built, Viking Press / Penguin

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