Design for deconstruction
Or why aluminium and glass is better than wood?

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CIRCULARITEIT

OP WEG NAAR 2050?

PETER LUSCUERE [ED.]

"Circular economy in the built environment should focus on recycling value rather than volume"

DESIGN FOR DECONSTRUCTION, OR

WHY ALUMINIUM AND GLASS IS BETTER THAN WOOD?

ULRICH KNAACK

ABOUT ULRICH KNAACK

Professor Dr. Ing. Ulrich Knaack (1964) is trained as architect and has worked as researcher in the field of structural use of glass at the RWTH Aachen/Germany. In his professional career Knaack worked as architect in Düsseldorf/Germany, building office buildings, commercial buildings and stadiums. In his academic career Knaack is appointed professor for Design of Construction at the Delft University of Technology/Faculty of Architecture, Netherlands where he developed the Façade Research Group. In parallel he is professor for Façade Technology at the TU Darmstadt/Faculty of Civil Engineering/Germany.

DESIGN FOR DECONSTRUCTION, OR

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ULRICH KNAACK

The first law of thermodynamics defines: Energy can neither be produced nor destroyed, but only converted into other types of energy [1]. From this it follows for us and our topic of circularity in the building industry that we must deal with the energy that the earth receives or has received, the solar radiation, and can feed our requirements from these. For Central Europe we can assume a solar radiation of 100 kWh/m^{2}a [2] – however, when using energy we do not limit ourselves to the current solar radiation but also use stored solar radiation in the form of coal, oil, gas, biomass / wood and geothermal energy. Here it is only a question of how fast the energy flow is – several million years as with coal, oil and gas or only years or decades as with biomass / wood [2]

Energy can neither be produced nor destroyed, but only converted into other types of energy.

Against the background of the emerging changes in energy production and performance control, this is an approach that must lead us to a closed loop economy in order to control our consumption energy requirements. An example is Prof. Dr. Dirk Althaus, a co-founder of the Ecological Building in Germany, who during his time as a researcher at the University of Hanover already interpreted

FIG. 1 PET bottles.

the ideas of "ex and hop architecture", an architecture that limits the energy required for a limited lifetime, or the search for the lightest possible architecture Frei Otto's textile architecture in a completely new light [5]. Althaus also discovered already existing concepts for sustainability with entire scenarios of the overall economy – for example the German national economist Johann Heinrich von Thünen, who, with his models of a sustainable city and thus also of society, is developing sensible overall solutions for a self-sustaining city based on the energy source sun with an agriculturally used surrounding area. Of course, in a modern society with megacities this can be questioned and we can observe similar topics in other places and certainly in less comfortable climatic zones than in Central Europe – but the sense of the solution remains obvious [3]. Against this background we must ask ourselves how we want to deal with the house energetically – operational and material-bound energy – embodied energy. When we consider how long we want to use a house, we can define what we want to invest in energy, knowing that the energy to build and operate is just an expression of different forms of energy. In concrete terms: short lifetime of the building implies – apart from other categories – the lowest possible use of energy for construction, possibly with the disadvantage that operational energy is not used in an optimized way for the corresponding function of the building. On the other hand, it may make sense to put a lot of energy into a building that we know will have a long lifetime to minimize operational energy. The only question is how this can be decided and how these parameters, which have a considerable influence on the design of the building – the choice of materials and construction – can be integrated correctly and early enough into the design.

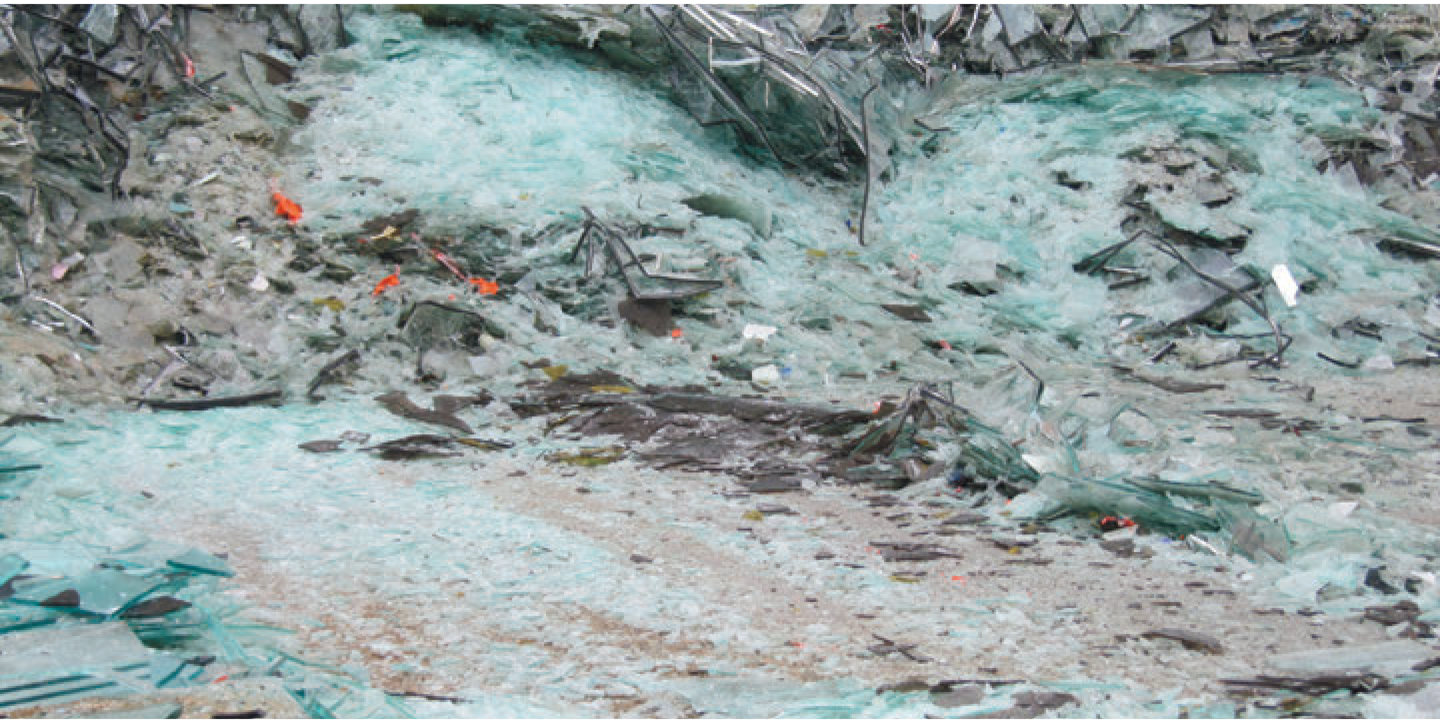

FIG. 2 Glass.

Nowadays several databases do compete with each other to be used for a calculation of the invested energy for a construction, allowing us to compare the construction, depending on the detailed level and the location. Even recycling rates are implemented in these data bases, so in general the opportunity to compare the circularity potential of a construction does exist. Obviously the results do depend of the detail level of the knowledge of the construction, the depth of investigation of the material production and recycling and its energetic performance and the accuracy of involved transport energy – all in all parameters, which can consequent a large range of results, but this can be solved by more knowledge and deeper research.

> And now comes politics and society. What do we want and where are we going?

And now comes politics and society. What do we want and where are we going? More importantly, how do we explain to each other what is good and what is bad? Another example: naturally renewable raw materials are better! Logically, since they grow again and are virtually automatically generated by using the sun as an energy source – the perfect solution for the Thünnische Kreise – the circles of use of material by Heinrich von Thünen . Wood is such a raw material, some processing and transport must be submitted, but otherwise it needs hardly

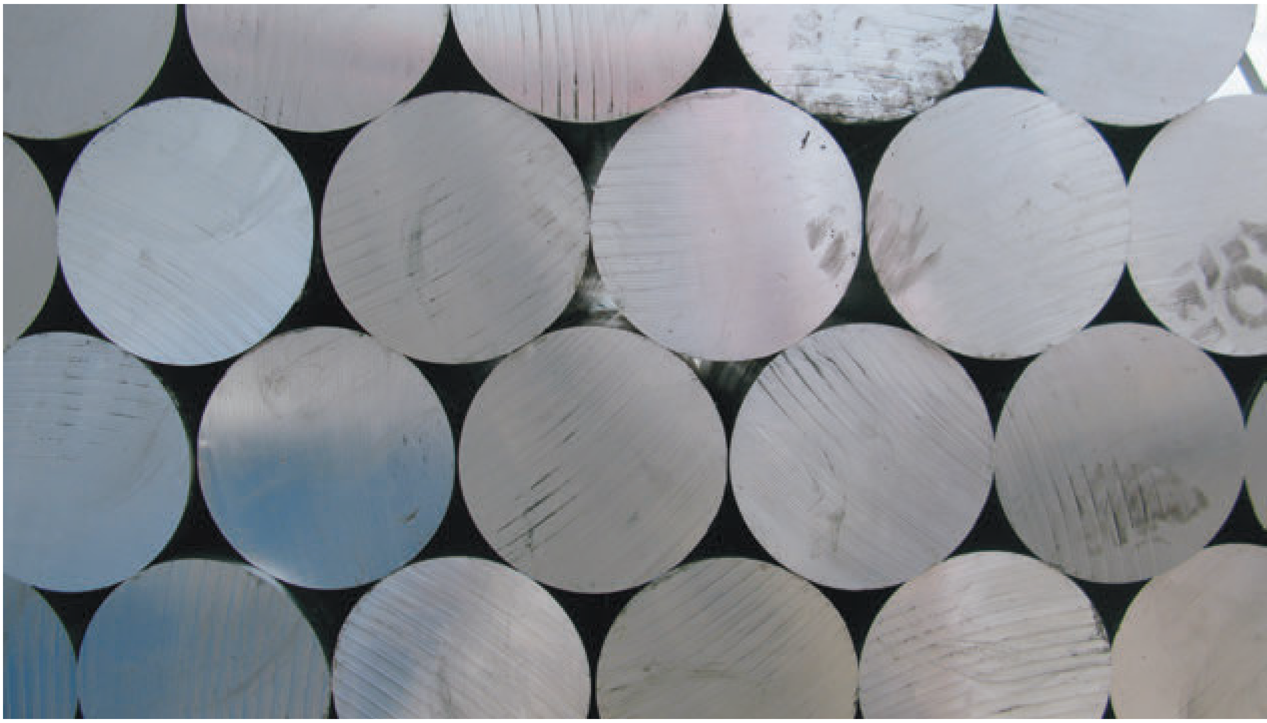

FIG. 3 Aluminum.

any energy for production. And even better, wood stores CO_2! Let us therefore compare the production of a brick wall in solid construction with a wooden wall, for example in block construction, in purely qualitative terms: While the brick is extruded from clay and must be fired, wood only needs to be harvested. In this assumption, we regard transport as less influencing due to distance. It is therefore logical that the clay requires more energy for the excavation from the soil and the production process, including the energy-intensive firing process. And then there is the advantage of wood to store CO_2! The European brick industry is accordingly agitated when this argument is put forward by the wood industry. And then recycling: bricks cannot be recycled in the same quality – only downgrading as aggregates is possible. Wood can be burned, i.e. it can be used as an energy source. However, it then releases all CO_2, which is bound, again!

> Bricks cannot be recycled in the same quality – only downgrading as aggregates is possible.

Here we also come to the problem that wood has as a material: yes, a natural, sun-fed origin and a storage of CO_2, but this is released when wood is used energetically – that is, burnt. This means that it can be used as a building material and later converted into energy, but can only be used once in a cycle. Direct recycling of the material is generally conceivable, but with the current

FIG. 4 Timber.

construction products with their small-scale dimensions it is almost impossible to realize – the material is just too efficiently used and processed into special components, so that only – as it is called so optimistically – "thermal re-use" is possible.

The advantage of aluminium, recycling at the same quality level is possible.

In contrast, a large amount of energy is used in the production of aluminium, since the raw material must first be extracted in opencast mining, then smelting takes place and the raw material must then be processed into components. Transport is also not insignificant, as aluminium is not as widespread regionally as wood. However, and there is the advantage of aluminium, recycling at the same quality level is possible – and this is considerable if we want to position ourselves fundamentally on the subject of circularity. A raw material that can be used again and again with as little loss as possible is an optimum material for this – especially in the construction industry, in which we use a comparatively large amount of material for the functions. And now again the question of representation and understanding: A colleague who cannot be named here but is very competent in his field complained to the aluminium industry that, for example, façades appear much worse than wooden façades against the background of the energy required for their one-time use – similar to the consideration with the target groups above. The façade industry considered suing these colleagues for damage to their reputation and was only prepared to deal with the subject through intensive efforts – with the result that it was understood that the raw material used to produce extruded façades is a good base material for recycling after its use and can very well be brought into a circular flow. Linda Hildebrand stated the potential in her doctorate [5] with approx. 60%, which can be increased to over 85% by means of more easily dismantled profiles. Once this was understood, the two parties were then good partners and the façade industry concerned claims today to use 90% recycled material – perhaps a bit too high value, but it shows the potential both in the technology of recycling and in its designability.

In the same way we can look at the materials glass and thermoplastics. Complex to manufacture but, if single type and / or simply demountable designed, good to recycle. A process that can be repeated indefinitely except for the losses in deconstruction.

> It is basically clear to us that burning crude oil as a raw material makes no sense.

If we look at the development of energy supply, it is basically clear to us that burning crude oil as a raw material makes no sense – both in terms of CO2 pollution and in terms of wasting the raw material, which should better be used for products and components, preferably those thermoplastics that are easy to recycle. This basic understanding presupposed – even though I am aware that we will continue on this wrong path for decades to come, thanks, for example, to new methods of extraction – the fundamental assumption that renewable energy sources such as wind and solar energy will eventually lead to the extraction and production of raw materials and further processing into building materials with this energy source being possible. And then the high expenditure in the production of aluminium, glass and thermoplastics will no longer be significant in terms of CO2 emissions. And the material wood: once stored CO2 is emitted during thermal recycling – a zero-sum game and thus entirely in the sense of circularity – but also no better.

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