Building Simply (SWD-10.08.18.7-18.32)

"Building Simple" is a research project under the direction of the Chair of Architectural Design and Construction in cooperation with four other chairs at the faculty. Over a period of two years, engineers and architects have sought to develop a new building culture of simplification.

The complexity of construction and building technology has been increasing steadily for decades. This concerns the requirements for stability, heat, moisture, fire and sound insulation, hygiene and health as well as general user comfort. This is reflected in an almost unmanageable and increasing number of standards and building laws. The goal of quality assurance is often not achieved: The consequence of complexity is a high error rate in planning and execution as well as excessive demands on building owners and users.

The aim of "Building Simply" is to mark the starting point of a new, opposing trend in construction and thus provide an important impetus for the German construction industry. The "Building Simply 1" research project, completed in October 2018, is part of the "Building Simply" overall project.

- Building Simply 1: Research into the principles of building simple.

- Building Simply 2: Practical application in three pilot buildings and development of a guide.

- Building Simply 3: Verification of the qualities by measurements during the use phase in order to understand the potentials of building simple in concrete terms.

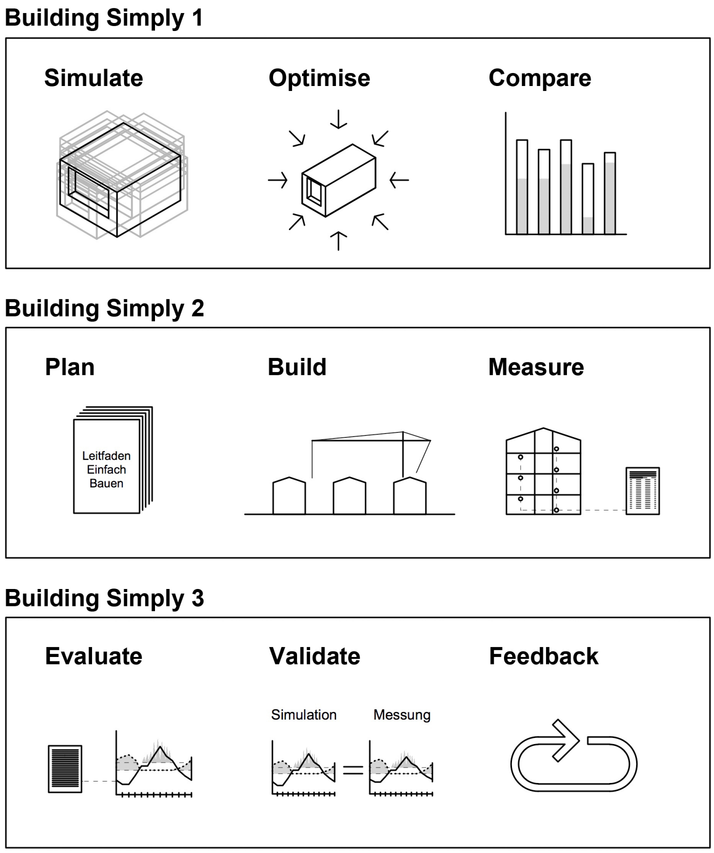


Figure 1: Schematic diagram of Building Simply research projects Simple construction 1, 2 and 3

The Building Simply 1 research project team is investigating the extent to which buildings with simple and robust construction as well as building technology can be constructed and how they compare in terms of environmental impact and life cycle costs - also in terms of user behaviour - with conventional residential buildings and low-energy residential buildings over a period of 100 years.

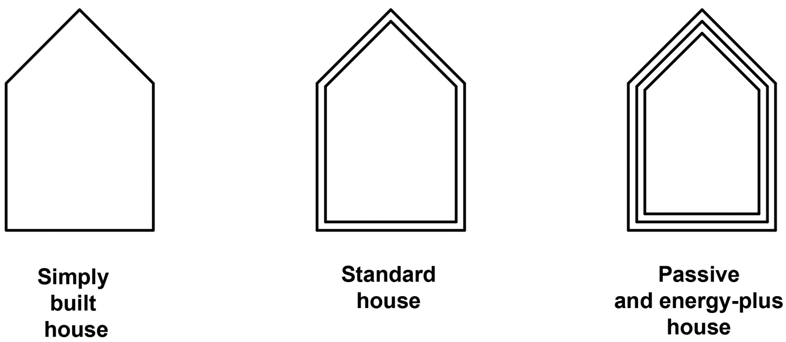


Figure 2: Hypotheses

Procedure

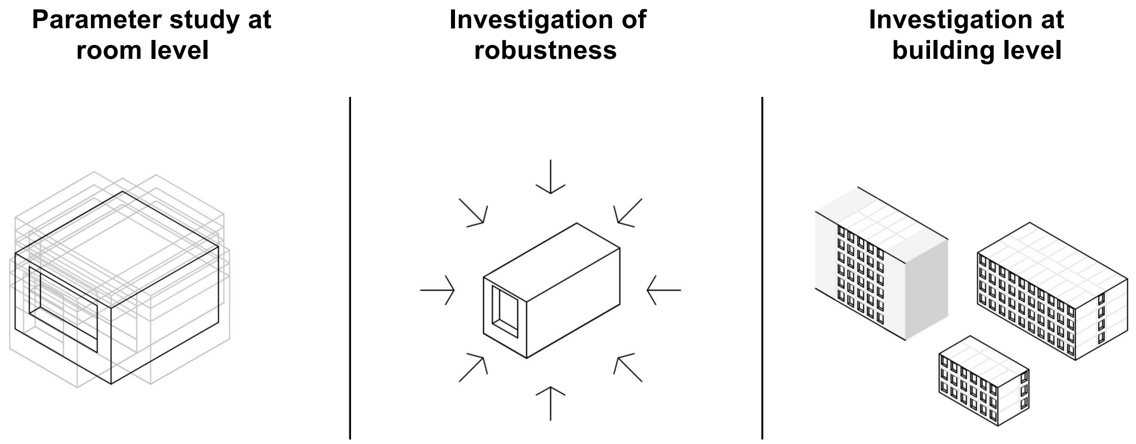


Figure 3: Stages of work

The starting point for the investigations were the highly developed construction materials solid wood, lightweight concrete and highly heat-insulating masonry as low-layer or monolithic wall structures. After extensive product and project research, the researchers developed optimised designs, spatial and technical concepts, as well as detailed solutions, and presented these in a comparative overview.

On the basis of these findings, they were able to design individual rooms and investigate their energy consumption. In the next phase, the results were added to schematic buildings and supplemented with building services systems. For this purpose, the research team determined the costs for construction and operation as well as the environmental impact.

<u>Investigation at room level</u>

The researchers defined a multifunctional room with a floor area of 18m2 as a "base case". The user behaviour and the heating technology were ideally applied and a constant weather data set was used. On this basis, the following room parameters were varied:

- room height
- room depth
- window size
- glass type
- outer wall thickness
- cardinal points
- construction

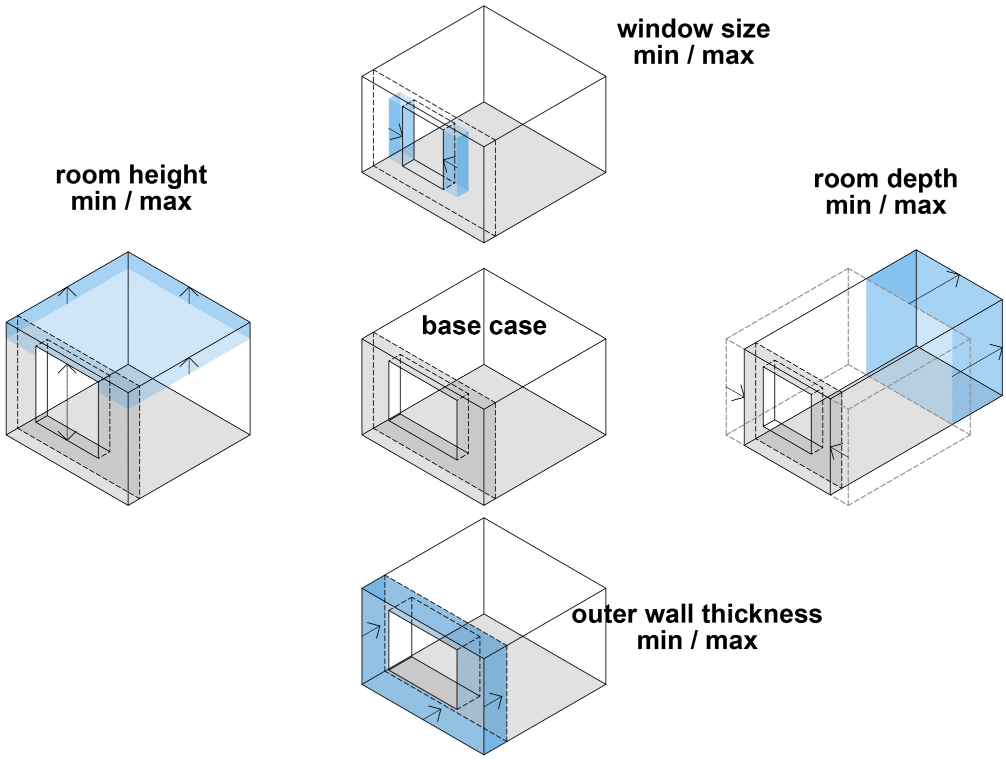


Figure 4: Parameter study at room level

The combination of 81 different geometries, four cardinal points, three construction methods and three types of glass resulted in 3,888 variants to be simulated. If the selected window size in combination with the type of glass and the room proportions admitted too little daylight (at least 2% daylight quotient was defined as the limit), this was not further investigated.

It was found that room variants with a reduced proportion of envelopes, thermal storage masses and optimised window areas with a daylight ratio of 2 % proved to be optimal with regard to low heating requirements and reduced overheating in summer. These successful room configurations were then used to investigate the robustness against unsafe boundary conditions.

Investigation of robustness

The aim of previous planning processes was to find the optimum solution for the task at hand. For example, a low-rise house achieves the best possible values in terms of heating requirements. However, there is often no consideration of the fact that the environmental parameters assumed to be ideal can change dramatically in reality. The team takes this assumption as the basis for the robustness analysis.

A system is defined as robust if it does not necessarily achieve the best possible result under ideal conditions, but instead reacts unsusceptibly to changing input variables. A robust system should therefore deliver good results even if the environmental parameters kept constant during the first simulation run vary:

- Weather
- ventilation behaviour of the user
- internal gains / presence
- storage mass (for timber construction)
- exterior sun shading
- sun shading outage

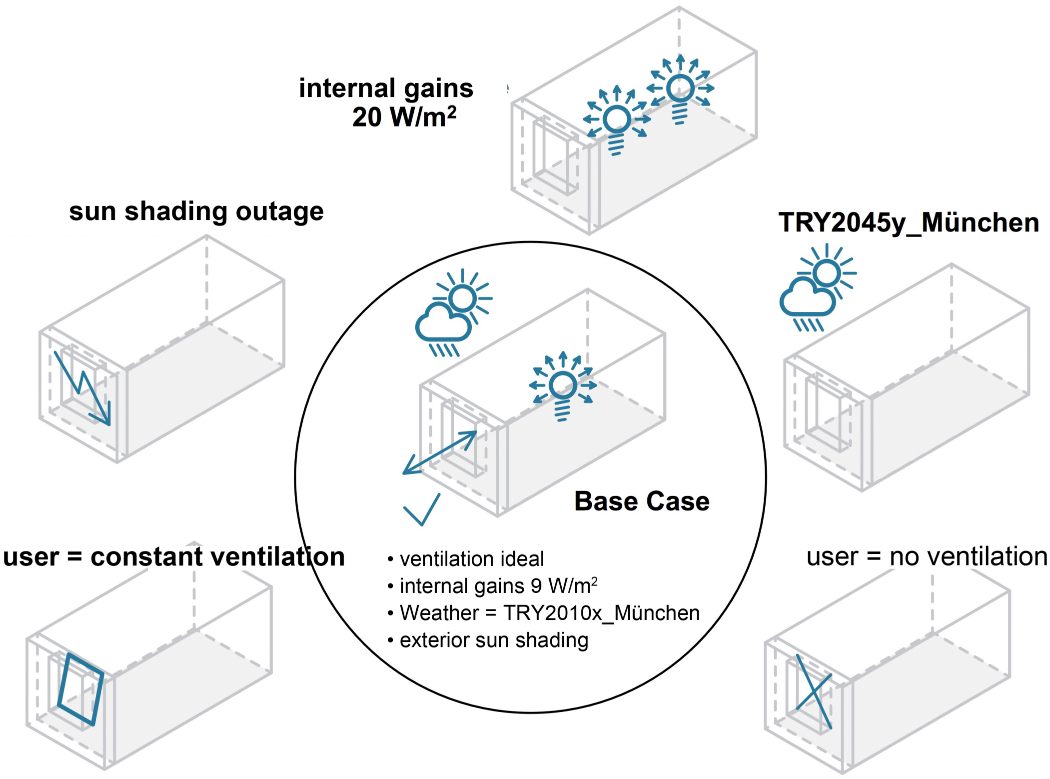


Figure 5: Uncertain boundary conditions = robustness

For comparison purposes, in addition to the three simple construction methods examined (masonry, infralight concrete and solid wood), a room model in standard construction and in low-energy construction was also considered, resulting in a variant number of 128.

The investigation showed that the ventilation behaviour of the user has the greatest influence on the heating demand, both in negative and positive terms. In summer, the weather and internal gains are the factors that have the greatest influence on overheating. Overall, simple construction methods are more robust against the influence of the user than the parallel room models with standard and low-energy concepts.

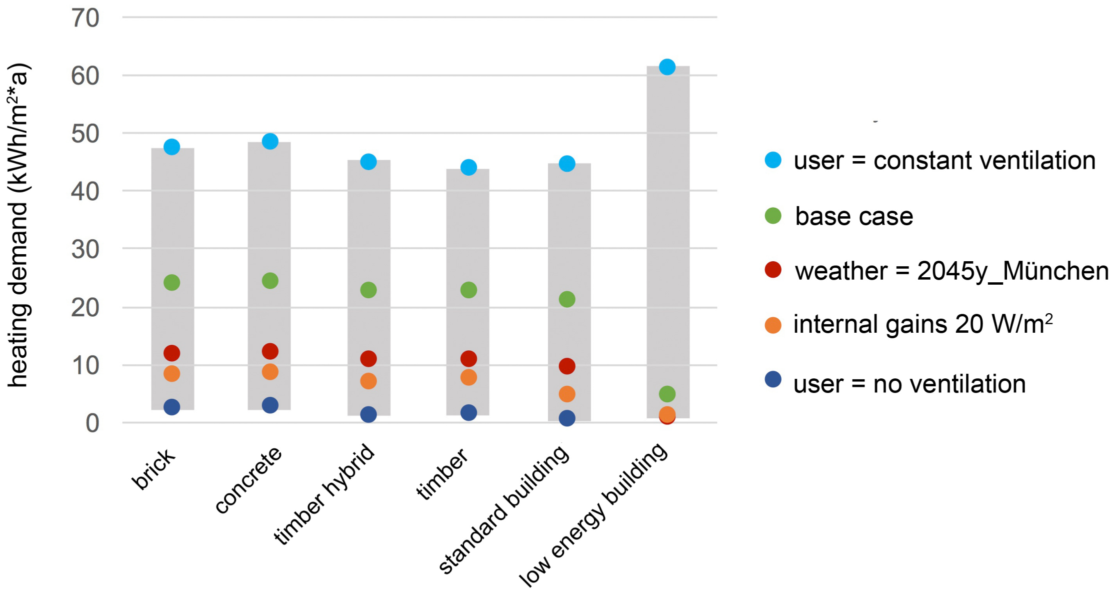


Figure 6: Example of robustness analysis at room level: Result spread for heating demand for a central room with southwest orientation

<u>Investigation at building level</u>

On the basis of the room variants, three typical building forms in multi-storey residential construction were schematically created as a basis for quantity determination and estimation of consumption values:

- solitary, 3 storeys, 704 m2 usable area
- line, 4 storeys, 2.820 m2 usable area
- block edge, 6 storeys, 1,614 m2 usable area

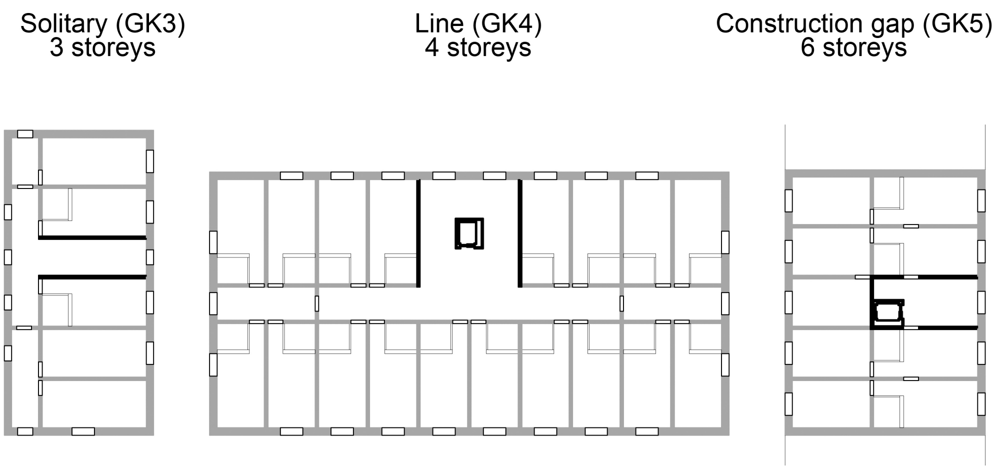


Figure 7: Type floor plans GK 3 (solitary), GK 4 (line), GK 5 (construction gap)

Life cycle and cost analysis

For all room variants, the environmental impact, focused on the global warming potential GWP, and the life cycle costs were calculated and compared. The raw material extraction or production, the operating phase over a period of 100 years and also its disposal were examined.

It turned out that operation clearly dominates production in all variants, both in terms of global warming potential and operating costs. The more compact the design, the smaller the latter. The three Building Simply variants were roughly comparable to the standard and the low-energy house. If, however, the uncertainty in the boundary conditions is taken into account in addition to the static LCA and LCC characteristic values, Building Simply constructions have a significantly lower spread of the heating requirement and thus a more robust system than the more complex standard and low-energy buildings, which are more sensitive in terms of design and operation. This is not only evident in the heating demand, but also in the high demand heating hours, because these fluctuate in a narrower band in "Building Simply" and thus also show a higher robustness both against unforeseen user behaviour and against external influences (global warming), or non-functional subsystems.

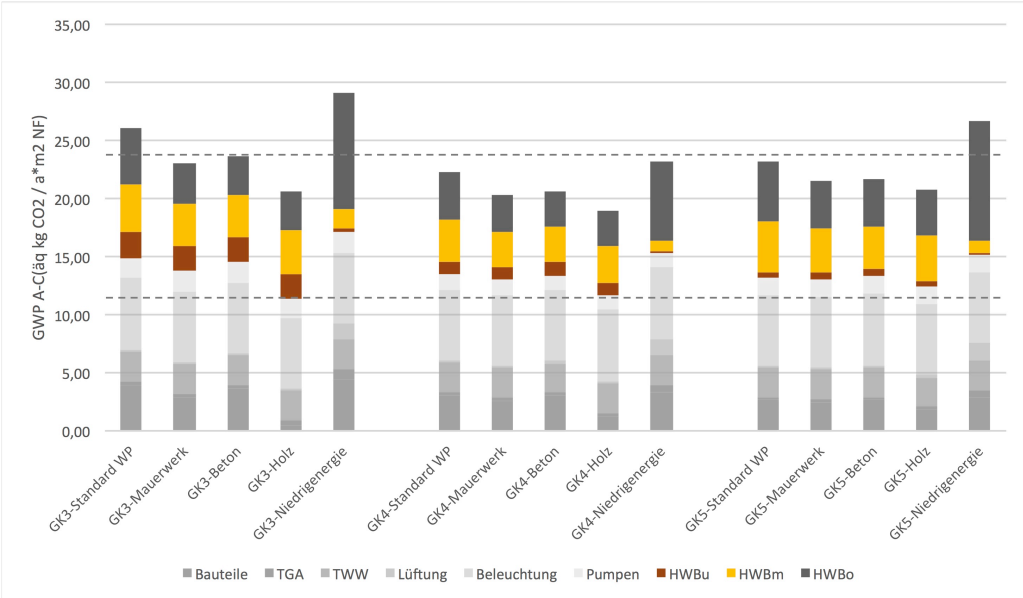


Figure 1: LCA for robustness over the life cycle with minimum, normal or maximum GWP

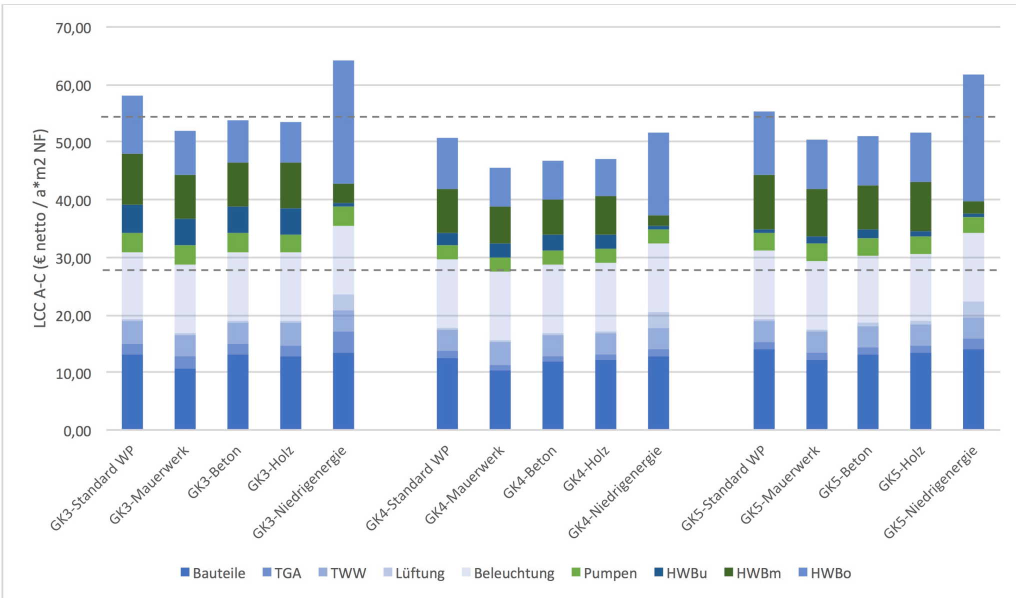
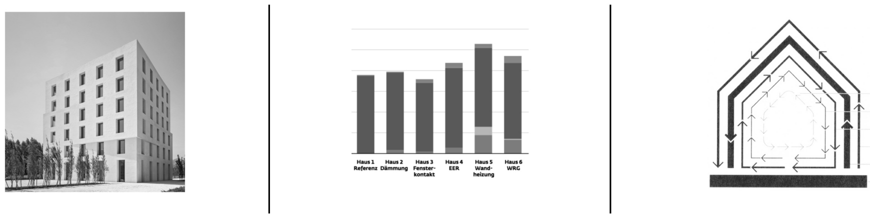


Figure 9: LCC for robustness over the life cycle with minimum, normal or maximum heating demand

Conclusion

Building is too complex to allow a simple formula for how to build "simply". Each construction project has specific boundary conditions that need to be considered (e.g. available energy source, type and orientation of property, etc.). In "Building Simply 2" guidance should be given on how to design a simple house down to the last detail.



Optimise Buildings **Consider the User** **Enable Changes**

Figure 10: Properties of a simple house

Some considerations are generally valid:

<u>The house</u>

The simplicity of a building in terms of low maintenance and energy requirements starts with urban design. Urban designs, i.e. multi-storey and compact, save envelope space and thus energy both in construction and consumption. High density leads to efficiency and synergy in land consumption, development expenditure and traffic volume through construction and use.

The proportion of glass in the building should be moderate enough to create a balanced relationship between daylight penetration, solar penetration and heat loss. This means that additional solar shading or even energetically nonsensical solar shading glass can be dispensed with. Insulation of the building beyond the current standard hardly creates further energy savings in multi-storey, compact buildings and makes no ecological or economic sense.

<u>The human being</u>

Low-energy concepts usually rely on ventilation systems with heat recovery in order to reduce heat losses caused by the necessary fresh air supply to the living space. If these systems are understood and accepted by the residents, there is also a higher probability that the user will behave accordingly, e.g. using window ventilation. The investigations have shown how negative the effects of divergent usage behaviour can be on the energy balance during use. It seems sensible to invest efforts in educating the user and at the same time only use technical systems that are robust enough to achieve the desired results, even where the user behaves otherwise.

<u>Time</u>

Many buildings are preserved for a long time, even if this is rarely considered during the planning phase. In order to be able to use them in the long term, changes should be possible and therefore already considered in the planning process. Flexible floor plan structures enable changes in use. Durable surfaces guarantee the longevity of buildings. The separation of building services and building construction makes it easier to replace obsolete technical systems. As a matter of principle, it is important to ensure that the components can be joined together simply and easily using manual methods. Thus, it is not necessary to consult a specialist company for the renovation and repair of buildings. Even a skilled user can repair damage and replace components themselves - simply build!

Figure 11: Three façade models in thermal insulation masonry, solid wood and lightweight concrete construction