

# Correlation between modular construction and sustainability in the building life cycle

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## Introduction

Modular and prefabricated construction is increasingly regarded as a cost-effective and time-saving alternative to traditional construction methods; and is more than just a trend of the last few years. As it is often described with the characteristics "fast and cheap" it could give the appearance of standing in great contrast to sustainability. However, modular construction and sustainability are stronger correlated than one might think. The notion of sustainability in the life cycle of modular construction will be illustrated in this poster.

The three-pillar model of sustainability, on which common certification systems such as DGNB, LEED or BREEAM are based, addresses the three principles of environmental, economic, and social issues.<sup>1</sup> The aim is to provide future generations an intact living space with an environmental, economic, and social balance. In the construction industry, the pillars of

sustainability are affected in all life cycle phases of buildings.

Component assemblies as basic elements of modular construction offer the possibility of creating new buildings according to one's construction kit. In case current requirements are met no longer, component by component can be removed which makes both site and components available again. Alternatively, additional elements can be added vertically or horizontally. The basic idea of modular construction is to adapt to the current needs and trends without wasting valuable resources. Modules can be various types of prefabricated elements, e.g. component groups such as MEP modules and facade elements, but also large volumetric elements such as bathroom pots, which all differ significantly in terms of the degree of prefabrication and modularisation. The decisive difference to site-built construction methods is frontloading, meaning shifting decisions from the construction phase to the design phases by also reducing time due to the repetition effect.<sup>2</sup>

## Discussion

The design phases are reduced by using standardised component groups according to the degree of modularisation (figure 1) which results in considerable advantages, especially when using volumetric modules. Furthermore, due to the repetition effect, the production costs can be recorded more accurate. With a higher degree of prefabrication, the duration of the construction phase can also be reduced, which, among other things, reduces the general construction site costs. The stationary prefabrication of the modules also achieves a better, homogeneous quality. However, although the modularisation of components simplifies many processes in the construction phase, it restricts requests for changes to a certain extent.<sup>3</sup> From the perspective of users, modular construction does not have a significant advantage for the operation phase. But by contrast it can have an enormous impact for maintenance and repair work depending on the type of measures. Complex measures within the operation and maintenance phase benefit from a higher degree of modularisation. A high degree of modularisation can enable time advantages in the renovation phase, but also creates conditions that limit flexibility. For example, larger component groups may have to be dismantled even though only small parts have to be replaced. Likewise, design limits are set by the existing grid size, which count especially for a high degree of modularisation and larger modules.

A direct link exists between the principles of modular construction and the aspects of sustainability. Reasons for the connection of modular construction to sustainability are especially the serial off-site production, the subsequent shorten assembly time on the construction site, and the recyclability of each individual module. The relocation of the manufacturing process to a weather-protected factory not only means considerable efficiency gains, but also extensive and sustainable alternatives for individual components and processes. Flow-oriented production processes enable the sustainable usage of resources such as materials and labour, both environmentally

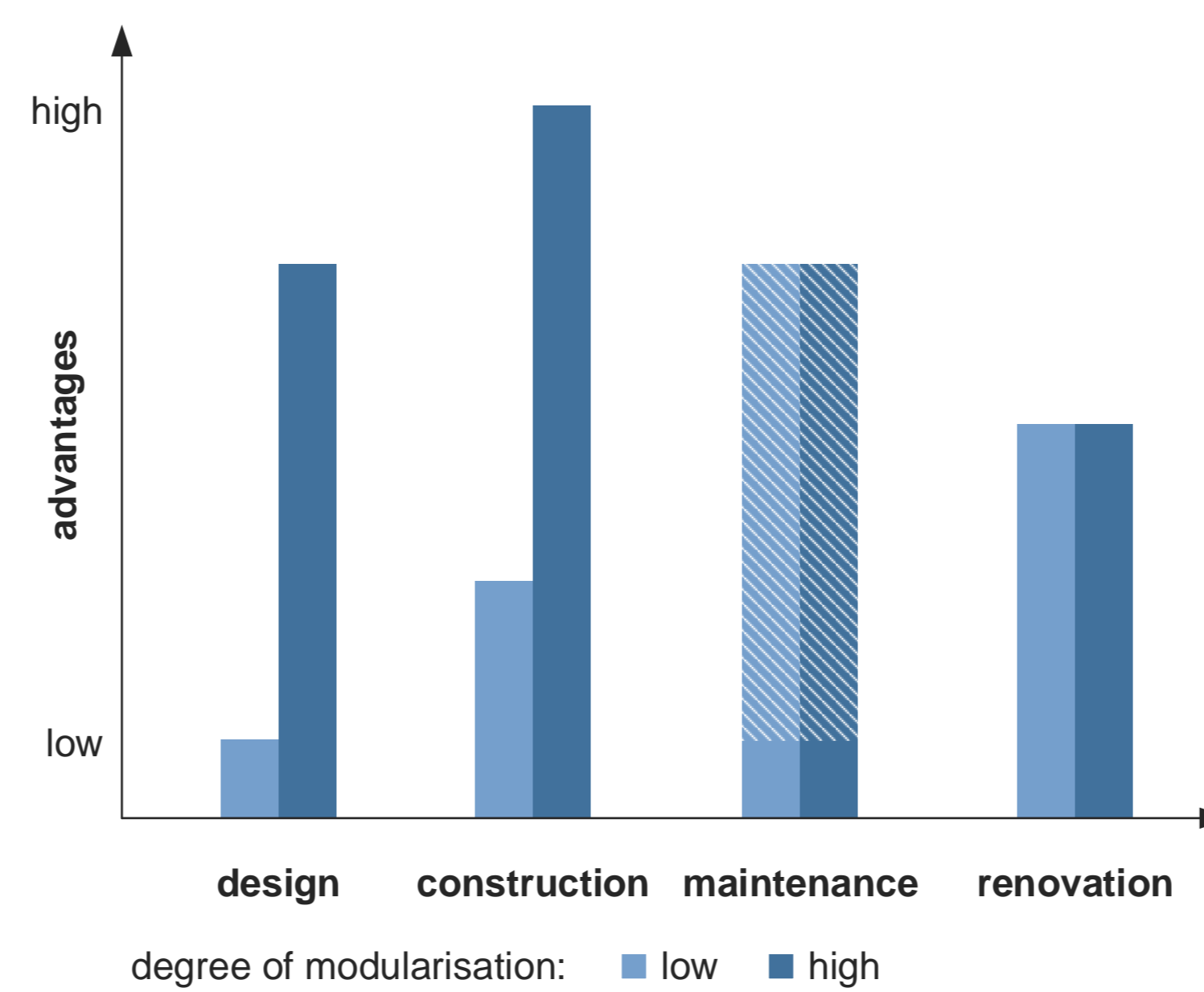


Figure 1: advantages in the building life cycle through modular construction

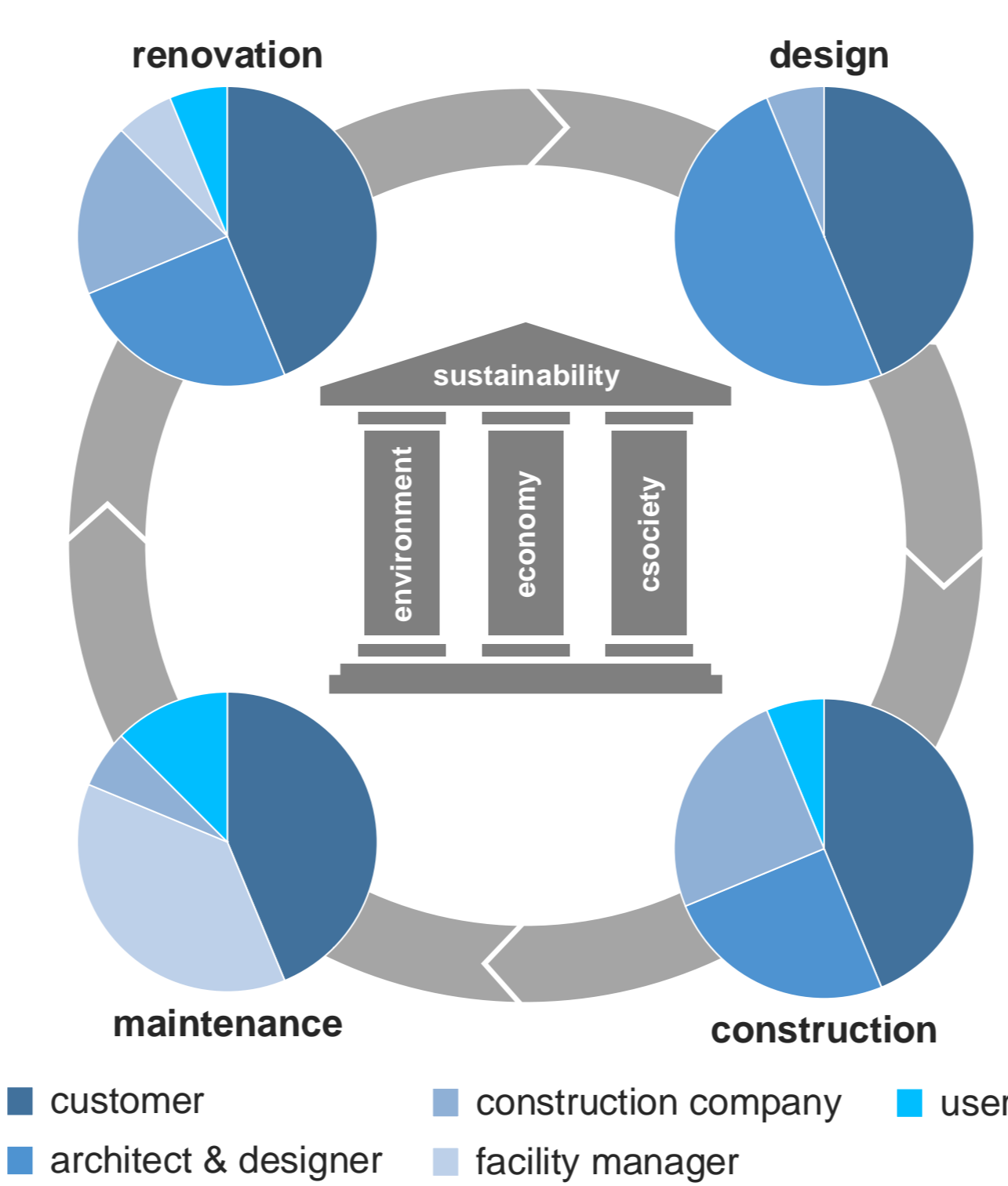


Figure 2: Influence over the building life cycle by each party involved

<sup>1</sup> Hauser/Eßig/Ebert (2010), p. 20 - 87  
<sup>2</sup> Bertram/Fuchs/Mischke/Palmer/Strube/Woetzel (2019), p. 3 - 9  
<sup>3</sup> Subramanya/Kermanshachi/Rouhanizadeh (2020), p. 11 - 19  
<sup>4</sup> Lawson/Ogden (2010), p. 38 - 51  
<sup>5</sup> Kamali/Hewage (2017), p. 3592 - 3606  
<sup>6</sup> Banaitienea/Banaitisa/Kaklauskasa/Zavadskas (2008), p. 429 - 441  
<sup>7</sup> Xue/Zhang/Su/Wu/Yang (2018), p. 290 - 502

and ecologically. Moreover, it improves the social interests of society through improved working conditions. The assembly on the construction site has environmental benefits due to both a significantly shorter and more stable construction process and through a low-waste and low-emission construction site. Economic potentials can be found by the reduced construction time due to the singular assembly of the modules. Finally, the opportunity to exchange single modules, to separate materials by type and to simply deconstruct individual components or entire parts of the building enable the return of used materials and resources to a closed material cycle. This means that these materials and resources can be used as efficiently as possible from an environmental, economic, and social point of view.<sup>4,5</sup>

In the conceptual and detailed design phase, the influence to change to modular construction methods is the highest. In the construction phase, modular alternatives can still be used to some extent for several component groups, whereas during the operating phase there are no possibilities without maintenance measures, as the building has already been completed.<sup>6</sup> In the renovation phase, the possibilities to apply modular construction methods increase again. This clearly demonstrates that stakeholders such as architects and other specialised engineers who are involved in the conceptual and detailed design phase, have a decisive influence on the choice of construction method. In comparison, the influence of executing construction companies is much smaller if alternative construction methods are contractually not possible. Likewise, there are no opportunities for facility managers and users to influence the construction of the building if they were not already involved in the design phases.<sup>7</sup> As the useful life is responsible for a significant proportion of the complete duration of the building's life cycle, maintenance measures are even more important for customers and users of the buildings. Figure 2 illustrates the influence of each party involved for every life cycle phase.

## Conclusion

Advantages and correlations between modular construction and sustainability exist in every life cycle phase. However, as figure 1 shows, the full potential of the subsequent phases can only be exploited when general conditions were already aligned in the design phases. The problem is, as figure 2 shows, that the participants of the design phases are only involved to a limited extent in the further life cycle. In addition, participants in the maintenance phase are not involved in the early phases. To reach environmental, economic, and social goals through modular construction, integrated and holistic project approaches are needed.

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