U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Industrialized Construction – The Case for Modular

Source: NREL

The U.S. Department of Energy launched the Advanced Building Construction (ABC) Initiative in 2019 to modernize and streamline building renovation and construction processes that facilitate the integration of high-performance and low-carbon solutions in the U.S. building stock. The ABC Initiative seeks to increase the usage of Industrialized Construction (IC) processes to drastically increase the speed and scale of high-performance, low-carbon building retrofits and new construction.

IC refers to the streamlining of construction processes including product and system manufacturing, business models, workforce, installation, and more. Modular construction is one IC approach where standardized components are produced off-site and then transported and assembled into the final building on-site. Modular components are typically 3D volumetric "modules" or "pods."

While most of the available data on the benefits of IC is for permanent modular construction (the focus of this document), it should be noted that not all modular construction uses IC approaches or results in low-carbon buildings. The benefits highlighted in this fact sheet apply to modular construction that utilizes industrialized approaches and advanced manufacturing to create high-quality and low-carbon buildings. The benefits are grouped into four categories: affordable, fast, appealing, and low-carbon.

Affordable

Modular construction projects are typically more affordable to producers and consumers than traditional construction methods due to improved productivity, efficient material use, and repeatable processes, though cost savings vary by region in the U.S. Costs can be reduced by leveraging manufacturing and assembly at scale in controlled environments such as offsite factories, thereby avoiding costly delays due to volatile on-site weather and labor conditions [1].

- Total project costs can be reduced by up to 20% in modular construction projects [2]
- 91% of General Contractors (GCs) and Construction Managers (CMs) in a recent survey saw cost reduction in their modular construction projects – 53% of which saw greater than 10% reduction [3]
- Depending on the region, modular homes can cost 10-20% less to consumers than their traditionally stick-built counterparts [4]

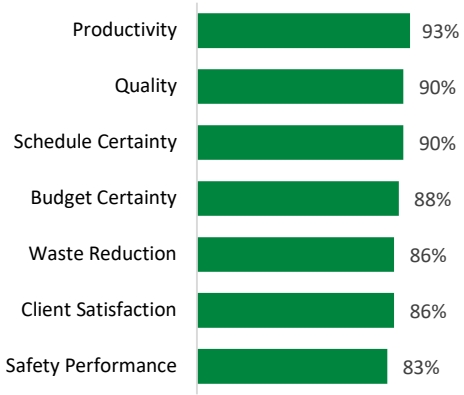
Fast

Modular construction projects are fast due to opportunities for simplified design processes, overlapping construction activities, and reduced delays. Design components can be reused and easily mix-and-matched, meaning the design process does not have to start from square one. In the construction phase, the off-site construction can occur simultaneously, with site preparation and foundation activities – allowing for schedule compression. Delays in construction due to weather and on-site conditions may also be avoided because the components are constructed in an indoor controlled factory environment [1].

- Schedules are compressed by 20-50% in modular construction projects [2]
- 88% of GCs and CMs in a recent survey saw schedule compression in their modular construction projects – 45% of which saw greater than 10% compression [3]

Appealing

Modular construction projects are appealing for several reasons in addition to budget and schedule improvements. A 2020 survey of architects, engineers, GCs, CMs, and trades that use modular construction shows many of the users saw *medium* to *very high* improvements in seven different categories, as shown in the figure below [3].



By shifting work to an offsite, factory-controlled environment, modular construction can result in:

- Better quality control and higher-than-average quality of the buildings [5]
- More predictable and safer work environments which eliminates hazards associated with falls [6]

Low-Carbon

Modular construction allows for reproducible approaches to more easily build low-carbon buildings over traditional construction. Modular construction has the potential to reduce embodied carbon in buildings through reductions in material/resource use and waste as well as increased use of lower-carbon materials such as timber. The nature of modular construction also allows for building components to be deconstructed, reused, and recycled more readily than traditionally constructed buildings. This reduces the demand for raw materials and diverts construction and demolition debris from ending up in landfills.

The precise construction that comes with factory production can create tighter envelopes that lower the energy and cost burden of heating and cooling the space, lowering the operational carbon associated with the building [7]. In addition, modular construction provides the opportunity to incorporate advanced building envelopes at scale without significantly affecting costs [8].

- Modular construction reduces the overall weight of waste generated by up to 83% [10]
- Studies comparing modular construction to traditional saw 30% and 43% reduction in GHG emissions [11] [12]
- Modular homes were found to use 17% less material overall compared to traditionally built homes [11]

Limitations & Next Steps

A lot of the recent research on IC practices, case studies, and resulting data have focused on the benefits of modular construction. The data varies, and the numbers presented in this document are subject to change with more projects and research.

There is a large gap in data pertaining to quantified benefits of other aspects of IC, including renovations, panelized construction, integrated HVAC systems and pods, installation robots, and more. For a more complete picture on the impacts and benefits of IC, further research including case studies and life cycle analyses is required. In addition, more resources are needed to support construction companies and instruct them on how to do modular construction to achieve these benefits outlined in this document.

The market value of modular construction is expected to reach $130 billion in Europe and the U.S. by 2030 [2]. Although modular construction is widely implemented and growing fast, achieving maximal benefits (especially low-carbon benefits) is only possible with industrialized construction methods and a transition to advanced manufacturing, as discussed in the 2021 modular building study by the National Renewable Energy Laboratory [13]. Advanced manufacturing practices include "higher productivity gains, increases in integrated project delivery, data-driven supply-chain optimization, increases in adoption of automation and manufacturing tools, and investment in multiple large manufacturing facilities" [13].

For more information and resources regarding industrialized construction and the ABC Initiative, please visit the ABC Collaborative website at advancedbuildingconstruction.org

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