Bipartisan Policy Center

J. Ronald Terwilliger
CENTER FOR HOUSING POLICY

How Can Construction Innovations Make Housing More Affordable?

AN EXPLAINER

Home prices have risen so quickly that, in 2021, a typical home's value increased by more than the median annual income of a full-time worker. The mismatch between the strong demand for housing and the inadequate supply of homes is the primary driving force behind this striking growth in home values. This trend is amplified by the high cost of new home construction, including the rising cost of all the component pieces of new housing—namely, land acquisition, building materials, and labor.

Innovations in housing construction offer opportunities to significantly reduce some of these key cost drivers. New materials and innovative building processes can help streamline and shorten the production process, improve overall cost and efficiency, and even reduce greenhouse gas emission from the building sector. This explainer details four innovations and how the federal government can better support research and development to further drive down housing costs.

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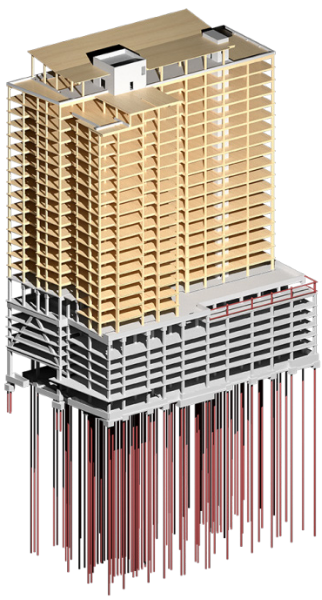
INNOVATION 1: MASS TIMBER AND TALL WOOD

Mass timber products are a building material manufactured in factories from pieces of wood that, when connected with glue, nails, or other materials, are strengthened. Two types of common mass timber products are glue-laminated timber (glulam) and cross-laminated timber (CLT). Glulam is formed from wooden boards pressed together in a parallel direction, connected with glue. CLT is created from wooden boards pressed together in a perpendicular pattern.

Mass timber is often mentioned in conjunction with "tall-wood" buildings. These are multistory buildings—some up to 25 stories—that are built using a preponderance of timber products, including mass timber. To reach their tallest possible size, a mix of steel and concrete may also be incorporated. Mass timber has been used for over 20 years in Europe and, in the Canadian province of British Columbia, all provincial buildings are required to be mass timber.



Ascent, a mixed-use, tall wood development containing 259 apartment units in Milwaukee, WI. Source: Thorton Tomasetti Inc

The benefits of mass timber and using lumber in tall buildings are many.

Cost and efficiency:

- Mass timber is lightweight, yet provides equal or greater weight-bearing capacity than steel or cement, reducing the amount of building material needed for structural support and expediting construction. ThinkWood, a lumber materials education association, estimates that a four-story wood building could cost 30%-40% less than a traditional building using only steel and concrete for load bearing.

- Mass timber lends itself well to the prefabrication of large building segments that can be precisely manufactured in factories, shipped to building sites, and erected quickly using less labor.
- Some products, especially glulam, are considered inherently or aesthetically attractive. Depending on the design, this can eliminate the need for more expensive or labor-intensive finishings, such as drywall or paint.

Sustainability and carbon removal:

- Mass timber and other lumber products are more environmentally sustainable than steel or concrete because these wood products store sequestered carbon dioxide. In contrast, steel or concrete are estimated to provide 13% of global carbon emissions according to the OECD.
- Mass timber ideally uses trees under a 10 inch diameter so that brush cleared to reduce wildfires, which normally could only be used as biofuel, can be used as input for mass timber. Enhancing market demand for so-called waste biomass will help reduce fuel loads in forest—a critical need as the wildfire seasons become longer and more frequent.
- Harvesting and fabrication of mass timber and prefabrication of building segments can provide new sources of rural economic development.

An example of the benefits of using wood construction is a six-and-a-half story, mid-rise apartment building in Sacramento, CA where the developers relied on the cost savings generated to ensure the project was financially feasible. A seven-story, mixed-use affordable housing development in Boise, ID also relied on mixed wood and concrete. In this case, the design and use of lumber and mass timber allowed the builder to incorporate off-site prefabrication, resulting in shorter, more efficient construction schedule.

While mass timber has many benefits, it has not been immune to the increases in lumber prices seen over the past two years. Supply chain issues remain a concern too, as there is limited manufacturing capacity for these new products. As a result, research is being conducted on ways to create mass timber products using weight-bearing plywood. This would be an important development, by helping reduce costs when experiencing fluctuations in lumber prices. Oregon State University and the University of Oregon are partnering on one such pilot project, which involves a building constructed of mass timber plywood.

INNOVATION 2: STRUCTURAL INSULATED PANELS

Structural insulated panels (SIPs) consist of two sides of strand board (a form of high-performance particle board) on either side of an insulated foam core. While research is ongoing to assess SIPs' wind resistance, load-bearing capacity, lifecycle costs, and energy efficiency, they show great promise. These panels can be precision fabricated to fit together like a puzzle on a building site, collectively forming an energy efficient building. SIPs can streamline the production process and therefore lower costs, compared to traditional stick-building. Currently, as lumber prices have skyrocketed, there is some research that SIPs are also proving more cost effective.


The SIPs depicted have two sides of sheathing attached to a foam core.
Source: Shutterstock

Simply put, the amount of detailed framing work that requires skilled carpenters—a profession facing massive labor shortages—is significantly reduced with SIPs, as is the separate step of installing insulation. The amount of detailed knowledge, customization, and time required to install SIPs is also far less.

SIPs typically use high R value insulation (a measure of thermal conductivity in which higher values demonstrate greater insulation ability of a material), which contributes to more efficient heating and cooling. Because most buildings incur their highest operating costs on heating and cooling, this can result in significant savings over the full intended lifecycle of a residential building. An affordable housing development in Grand Junction, CO built using SIPs reduced construction time by at least two months. Moreover, the building's total electricity usage is estimated to be 50% lower than similar buildings in the area.

One downside of using SIPs is the added upfront cost. SIPs can be more expensive than traditional building materials. Yet, the savings on labor costs and construction time can compensate for the difference. For example, using SIPs takes care of waterproofing, adding insulation, and ensuring a tight thermal barrier on the building site, resulting in a shorter construction timetable and lower labor needs. Moreover, when purchasing SIPs at scale for large multifamily projects, bulk purchasing can reduce prices, potentially making the time and all-in cost savings even greater. As the usage of SIPs grows, the corresponding cost may further decline.

INNOVATION 3: PREFABRICATION OR MODULAR BUILDING

Prefabrication in construction is nothing new. In the early 20th century, Sears Craftsmen homes, ordered from a catalog and delivered by rail and truck, were a popular and affordable way families built their homes. Often used interchangeably with the term modular, the process may include entire kit-built, single-family homes to sections of multi-story, multifamily buildings that are assembled on-site like a jigsaw puzzle. Despite the early promise of prefabrication in home construction, the technology waned. Recently, a few factors—including sustainability, advances in manufacturing, and ease of assembly—have caused prefabrication to get a second look.

Prefabrication allows for whole sections of a home, manufactured and constructed offsite, to be brought to the plot and then more quickly assembled.
Source: Shutterstock

Prefabrication can incorporate a variety of building material types, like SIPs and mass timber, as well as metal. Large segments of the building can be assembled on site, expediting construction times and reducing labor costs. Further, prefabrication allows for precision manufacturing, the exact production of the component parts of a product, which results in a tight building envelope that can lower operating costs like heating and cooling.

There are some drawbacks to prefabrication. For one, designs must be fairly homogenized. It would be uneconomical to invest in off-site, manufacturing capabilities if only producing a couple homes or highly customized ones. Further, there are a limited number of facilities capable of mass prefabrication, given that many of the related products and technologies are new. This constraint in manufacturing capacity has led to low supply and increasing prices. Moreover, land-use regulations and building codes often require updating to account modular construction, especially the opportunity to permit factory-site inspection of certain segments, which can slow the construction process. Finally, some argue that modular or prefabricated homes have a lower appreciation value than traditional stick built, though there has been some research to refute this.

INNOVATION 4: 3D PRINTING

3D printing or additive manufacturing involves using robotic extruders and other machines to form building components from concrete. An extruder pours layers of concrete mixture to form foundations and walls. The machines use proprietary, specialty concretes that are a mixture of cement and other additives.

3D printing is not yet widely deployed in residential construction, but early examples of 3D-printed homes show great promise in reducing the time and labor needed to build, thereby lowering the costs of new housing. By one estimate, this technology can reduce the production schedule from seven months to approximately three months. 3D-printed housing is being considered as an option to quickly alleviate housing supply shortages in the United States, China, and Mexico. Organizations are also looking to employ 3D printing to more quickly provide resilient housing in disaster recovery situations.

One of Habitat for Humanity's first 3D-printed homes, located in Virginia, was estimated to have cost 30% less than a traditional house construction. Given this success, Habitat for Humanity is using 3D technology in other states, including Arizona.

One potential downside of 3D-printed homes is the high cost of cement, which can stymie building material cost reductions. However, as the technology of specialized concrete evolves, there are signs this can be overcome. Thomson Reuters estimates that by 2024 the 3D-home-printing industry may grow from $3.5 million globally to $1.5 billion.

Increasing the supply of housing at the rate it is needed will require innovation in the construction industry to keep down costs and shorten construction timelines. Mass timber, SIPs, tall wood, prefabrication, and 3D printing are all promising innovations emerging in the construction industry. Broader dissemination of these materials and technologies will depend on greater awareness and education in all stages of construction, including among building and land use regulators.

A 3D printer pours concrete to ultimately create Habitat for Humanity's first owner-occupied, 3D-printed home—a 1,200 sq. ft house constructed in only 28 hours in Williamsburg, VA. Source: Consociate Media

FEDERAL OPPORTUNITIES TO SUPPORT INNOVATION

As the housing supply crisis becomes more acute, homebuilders are exploring ways to increase production speed and efficiency. As outlined above, mass timber, SIPs, prefabrication, and 3D printing are all emerging innovations that could reduce the cost and time needed to construct new homes. As these technologies emerge, there are opportunities for the federal government to support innovation through R&D, updating building codes, and partnering with the private sector.

Research and Development

The federal government actively supports R&D in housing innovations:

- USDA has a robust program supporting the development and use of mass timber and other new lumber-based products, research focusing on fire and moisture resistance, and the insulation of mass timber products.
- DOE's Building Technologies Office supports research and other tools to promote more energy efficient residential buildings.
- Numerous federal agencies are involved in funding research in 3D printing, especially given its broad appeal. For example, 3D printing and technology company ICON has received funding from or partnered with HUD to research and evaluate best practices, NASA to develop shelters for missions to Mars, and the DOD to build barracks and other military facilities.

Federal R&D funding can be critically important in helping entrepreneurs and innovators finance and test their ideas while developing more sustainable business models and markets for their products.

In addition to federal funding for research, small business development, contracts, and other supports, states and localities are stepping up to support home construction innovations by adjusting their regulatory frameworks and providing economic incentives to foster innovative products and processes. Continuing to partner with the private sector on R&D to further improve home construction technology is critical to meet the shortage in home construction in a cost-effective way.

Some key opportunities to support innovation in home construction include:

1. Performance-Based Building Codes: Traditionally most states and localities require builders to undertake specific measures to achieve certain goals. For example, to promote energy efficiency, some state building codes require the use of specific materials and techniques in a project, often with no proof once in operation that a desired outcome has been met. In contrast, performance-based codes set the outcome, while providing flexibility in the choice of materials and techniques to achieve the stated goals. California, Oregon, and Washington state are leaders in allowing performance-based codes.

The federal government, especially National Institute of Standards and Technology and HUD, also play a vital role in providing evidence-based standards for building materials as well as educating states on best practices in building code development and implementation.

2. Modular Building Units Codes: Some states—such as Idaho, Minnesota, Montana, Nebraska, New Jersey, and South Carolina—allow a third party to certify prefabricated segments in the factory as meeting the building code. Once constructed, these certificates eliminate the need for additional on-site inspection. In addition, many of these same states offer reciprocity so that the state seal is recognized on sites in their jurisdictions. One organization coordinating reciprocity is the Interstate Industrialized Buildings Commission that covers Minnesota, New Jersey, South Dakota, and Rhode Island.

3. Forestry and Mass Timber for Economic Development: Following Canada's aggressive support for the use of mass timber to lower costs and foster rural economic development, states like Oregon, Washington, and Minnesota are developing programs to create linkages between prefabricators and timber products to increase housing supply. The TallWood Design Institute in Oregon is a state-created organization that brings together two state universities to research and develop products and techniques that can encourage innovation and enhance local housing supply.

CONCLUSION

The combination of the housing supply shortage and the escalating cost of home construction are raising the collective awareness of and demand for new construction processes, materials, and other technologies. Because the construction industry has long provided spillover economic benefits, new advances from mass timber to 3D printing also offer new economic opportunities.

Policymakers can better facilitate and scale innovations by continuing to work with the private sector, support new research, and promote a skilled and well-trained workforce. It is equally important to ensure local building codes, product specifications, and inspection requirements adhere to evidence-based outcomes—like protecting health and safety and reducing carbon emissions—while not hindering the adoption of new products and processes that can expedite residential construction.

BPC's J. Ronald Terwilliger Center for Housing Policy will continue to assess policy opportunities to promote innovation in home construction, recognizing its potential to reduce the cost of housing and help address our country's housing supply shortage.

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