Benefits and Opportunities of Off-Site Construction: Analysis of Indiana and Pennsylvania

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ABSTRACT

The paper explores the benefits and opportunities of off-site construction and offers insights from Pennsylvania and Indiana, both known for hosting a significant number of modular home construction facilities in their respective regions. The objective is to highlight the advantages and possibilities inherent in off-site construction.

The paper investigates health and safety benefits for builders, enhanced living conditions for modular home occupants, and the significant cost savings and environmental benefits associated with modular homes. Additionally, the paper assesses the benefits of adopting the International Code Council and Modular Building Institute standards for off-site construction in these states, exploring how adherence to such standards can facilitate the proliferation of off-site constructed homes. Moreover, this paper highlights the opportunity of Inflation Reduction Act funds to incentivize and prioritize off-site construction and investigates the feasibility of awarding tax credits for modular homes through Qualified Allocation Plans to expand off-site construction.

The paper also highlights how builders can seamlessly integrate off-site construction methods, as well as the advantages of local modular home production and workforce development. Finally, we address the stigma attached to modular homes, revealing strategies employed by Pennsylvania and Indiana to debunk prevalent misconceptions. By spotlighting these exemplary states, this paper emphasizes the transformative potential of this innovative housing approach, providing valuable insights for policymakers, builders, investors, and homeowners.

Introduction

Buildings contribute significantly to global greenhouse gas emissions, accounting for 42 percent of annual emissions worldwide (Architecture 2030 2023) and approximately 30 percent in the United States in 2019 (RFF 2024). The urgency to address climate change requires a change in the construction industry, specifically targeting increased energy efficiency and a move toward zero-emission buildings. Off-site construction can help address both the housing

[1] **Acknowledgment:** This material is based upon work supported by the United States (U.S.) Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Building Technologies Office, award number DE-EE0009084.

crisis and the need to reduce greenhouse gas emissions. Off-site construction means "the planning, design, fabrication, and assembly of building elements at a location other than their final point of assembly onsite" (NIBS 2024). The last data gathered in 2020 shows that only about three percent of residential construction in the United States uses off-site construction (NEEP 2021).

This paper begins with an examination of the benefits of off-site construction based on a literature review and then addresses common misconceptions and challenges. A detailed review of the experiences of off-site construction manufacturers in Pennsylvania and Indiana highlights both the advantages and challenges faced in the field. Finally, the paper proposes recommendations to expand the adoption of off-site construction practices through implementing standards and incentives.

The information presented in this paper comes from a review of literature, industry studies, reports, and insights gathered from surveys of professionals and experts in the off-site construction field. This paper provides valuable insights for policymakers, builders, investors, and homeowners as they navigate key challenges and opportunities within the construction industry.

Benefits of Off-Site Construction

Enhanced Community Well-being and Health. Off-site construction significantly diminishes site disruption and enhances overall safety and security by relocating approximately 80 percent of construction activity away from the site and into a factory-controlled environment (Modular Building Institute 2023b). This approach not only accelerates the construction timeline but also minimizes disturbances for nearby residents. Completing a substantial portion of the building away from the site means significantly less cutting, drilling, and use of heavy machinery during on-site assembly. This reduction in noise and activity benefits nearby residents by alleviating stress, improving sleep quality, and mitigating potential health concerns associated with prolonged exposure to construction-related noise and hazards. Moreover, the climate-controlled environment in off-site construction facilities provides a significant advantage in regulating factors such as temperature, humidity, and air quality. Unlike traditional construction methods where building materials are exposed to the elements for extended periods, the storage of materials in off-site facilities minimizes the risk of mold growth, thereby improving indoor air quality and reducing potential health risks associated with mold exposure in the home.

Addressing the Affordable Housing Crisis. Off-site construction can help address the affordable housing crisis by reducing both construction time and costs. The efficiency of modular and prefabricated building techniques allows for mass production and economies of scale, resulting in lower per-unit costs. Faster construction timelines bring housing to market quickly, alleviating shortages and making homes available to low- and middle-income families more rapidly. Using off-site construction speeds up the on-site process, which is especially valuable in dense urban areas because it minimizes disruptions and makes it easier to develop

affordable housing in high-demand locations. Off-site construction offers a rapid, cost-effective solution to expand the housing supply and meet the demand for affordable housing.

Environmental Benefits

Waste Management. The US Environmental Protection Agency reported 600 million tons of construction and demolition waste generated in the United States in 2018 (US EPA 2023). The generation of excessive construction waste poses environmental concerns and significant risks to health and safety, ranging from potential exposure to hazardous materials to the increased likelihood of accidents and injuries on construction sites. Off-site construction processes generate less waste than traditional on-site construction (Waste & Resources Action Programme 2024) and can reduce waste by 83 percent (Loizou et al. 2021). A 2020 Dodge Data & Analytics report found that 86 percent of architects, contractors, and developers noted a significant reduction in construction-generated waste with modular construction. In controlled factory environments, advanced machinery ensures accurate cuts and measurements, minimizing errors that often lead to material waste. Modular structures can be taken apart and moved or renovated for a different purpose, decreasing the use of raw materials and reducing the energy required to adapt a new building for another use.

Lower Carbon Emissions. One of the notable advantages of off-site construction lies in the significant reduction of carbon emissions throughout the entire construction process. A study on the environmental performance of modular fabrication concluded that compared to traditional on-site construction, modular homes exhibit a 25 percent lower carbon footprint (Kouhirostami 2023), showcasing an opportunity to mitigate the environmental impact of the construction industry. The study highlighted that the minimal need for transportation of workers and materials to the site contributes the most to lower carbon emissions, while 67 percent of the emissions in off-site construction come from materials used. Therefore, prioritizing the selection of locally sourced low-emission materials presents an effective strategy to further mitigate the carbon footprint of off-site construction.

Worker Safety

Enhanced Safety Measures. Based on the US Bureau of Labor Statistics report, in 2021, there were 951 fatal injuries (Bureau of Labor Statistics 2023) and 26,900 nonfatal injuries (Bureau of Labor Statistics 2022) in building construction. Stick-built construction is often susceptible to unpredictable weather conditions, presenting challenges that may compromise worker safety[2] in the field. The indoor environment in off-site construction facilities typically has better lighting, limited fall risks, fewer confined workspaces, and less heavy equipment, contributing to a safer, more comfortable setting.

Inclusive Employment Opportunities. Off-site construction offers more accommodating working conditions, making it an attractive option for individuals with disabilities who may face challenges in traditional construction settings (Morrison 2022). For instance, individuals with postural orthostatic hypotension syndrome (POTS), a condition affecting the autonomic nervous system, can struggle when exposed to extreme temperatures and prolonged sun exposure. POTS

[2] A traditional "stick-built" structure involves delivering materials to the job site in multiple loads throughout the project's duration, followed by construction.

is estimated to affect between 500,000 and three million people in the United States alone (Shaw et al. 2019). In addition, seasonal allergies are common chronic health conditions, posing a problem for around 67 million adults in the United States (AAFA 2022). With seasonal allergies, the body's immune system overreacts to outdoor stimulants such as mold spores and pollen. Construction workers face increased exposure due to direct contact from working outside. Off-site construction offers accommodation by providing a climate-controlled workspace, reducing health risks associated with outdoor labor. Moreover, individuals with mobility impairments face obstacles navigating job sites, but off-site facilities feature smooth floors, facilitating easy maneuvering for those using mobility aids (Morrison 2022). The controlled environment of off-site facilities provides a solution for those with specific needs, promoting inclusivity within the workforce.

Cost Benefits

Increased Efficiency and Cost Savings. Studies indicate that teams executing off-site construction projects can complete projects 30 to 50 percent faster than their counterparts using traditional construction methods (Modular Building Institute 2023a). Off-site construction projects generate significantly fewer change orders, as every aspect of the project undergoes digital design and optimization before assembly commences. This proactive approach enables better cost control from the beginning of the project, leading to reduced labor costs per project and fewer on-site resources needed. Relocating labor off-site reduces expenses associated with support facilities like portable toilets. Additionally, the controlled environment of off-site facilities and minimized weather-related delays contribute to project stability, keeping timelines and budgets on track. The centralized manufacturing of modular components in off-site facilities minimizes the need for transporting many construction materials to the construction site. Pre-assembling components in a controlled environment allows for substantially fewer on-site deliveries, more efficient use of resources and overall cost-effectiveness. The economic appeal is further amplified by cleaner job sites, garnering positive feedback from trades, inspectors, neighbors, and customers.

For a clearer illustration of the cost benefits, Figure 1 shows an example of the average overall cost to build a typical 2,000-square-foot house using the two methods, including the labor costs, as provided in October 2023 by Fixr, a company that works with experts in the home improvement industry and provides cost guides, articles, and trends reports (Fixr 2023). The modular home price is significantly lower than the stick built, highlighting significant savings in construction costs.

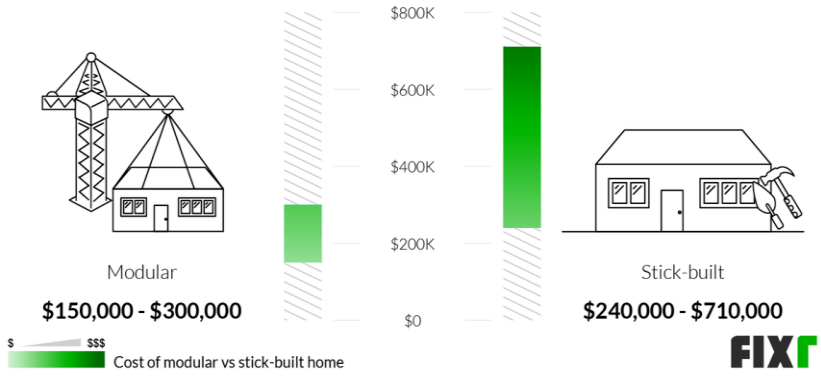

Figure 1. Cost to build a 2,000-square-foot home, modular vs. stick-built, national average. *Source*: Fixr 2023.

In the next section of this paper, we explore the barriers. including resistance to change in the building sector and a lack of familiarity with the off-site construction design potential, highlighting the need for better education.

Misconceptions and Challenges in Off-Site Construction

Despite the numerous benefits of off-site construction, several misconceptions and challenges persist that hinder its widespread acceptance and adoption.

Misconception: Association with Manufactured and Mobile Homes. Many homebuyers confuse modular homes with manufactured and mobile homes. Manufactured or mobile homes, sometimes referred to as "trailers," are built to federal standards known as the Manufactured Home Construction and Safety Standards (HUD Code), which require manufactured homes to be constructed on a permanent chassis.[3] The main difference between manufactured and modular homes is that while manufactured homes are built to the national HUD code, modular homes are built to all applicable state and local building codes, just as traditional site-built homes are constructed**.** Manufactured housing has more stringent zoning regulations that limit their size, design, and placement (US HUD 2021), which is not the case with modular homes.

Misconception: Lack of Customization. One prevalent misconception is the belief that off-site constructed homes lack customization, with some assuming they come in standardized, cookie-cutter designs. However, there are diverse and highly customizable designs that cater to individual preferences and architectural requirements. Homebuyers can choose from a wide range of styles, layouts, and finishes, ensuring that their off-site constructed homes reflect their unique tastes and needs. Architects can also work with off-site construction firms to deliver completely custom homes.

Challenge: Confusing Regulations and Difficulties with Inspection Process. Despite adhering to the same building code requirements as their on-site constructed counterparts, off-site construction projects present unique challenges in the verification of code compliance. In modular projects, the construction may occur in a factory miles away, with fully sealed components arriving at the job site. Thirty-nine states have centralized inspection at the state level, delegating assembly and site-specific responsibilities to local authorities.[4] In jurisdictions without a statewide program, local officials manage the entire review, often facing capacity challenges. To enhance efficiency, many states permit accredited third-party agencies to conduct plan reviews and inspections for off-site components. This approach avoids the need for state officials to visit off-site construction facilities, which might be located far from their home jurisdictions. However, challenges persist in regions lacking standardized practices, statewide programs, or third-party inspections, where local officials are often unable to effectively review off-site projects due to the inability to visit the fabrication facilities. To support local code officials in verifying compliance and monitoring on-site installation, ICC published the *Primer*

[3] Manufactured homes are constructed according to a code administered by the US Department of Housing and Urban Development (HUD Code), which requires manufactured homes to be constructed on a permanent chassis. Modular homes are constructed to the same state, local, or regional building codes as site-built homes. Other types of systems-built homes include panelized wall systems, log homes, structural insulated panels, and insulating concrete forms.

[4] This applies to Indiana and Pennsylvania.

on Off-Site Construction, Codes, Standards and Compliance (ICC 2022), aiding both code officials and the broader building industry with off-site construction inspection processes.

Misconception: Reduced Quality. A common misconception is that off-site construction is of lower quality than traditional on-site construction. This belief stems from outdated stereotypes and limited exposure to modern techniques (NEEP 2022). The off-site construction industry uses stringent quality control measures in controlled environments, ensuring precise and high-quality outcomes. Methods like pre-cut roof trusses, panelized construction, and modular components enhance versatility and energy efficiency. Advanced 3D design software allows for customization, and ongoing innovation improves durability and overall quality.

Examining the Impact and Potential of Off-Site Construction: Insights from Indiana and Pennsylvania

To get more insights from the field, we examined off-site construction manufacturers in Pennsylvania and Indiana. Both states are recognized for their significant number of off-site construction facilities, have facilities focused on modular residential and commercial buildings, and have modular programs to support their off-site construction industries, each with distinct regulatory frameworks. Pennsylvania mandates the display of certification insignias and lists manufacturers and third-party inspection agencies, which has significantly streamlined the process for manufacturers to obtain permits and complete inspections (PA DCED). Indiana requires in-plant inspections by personnel from the Code Enforcement Section or by authorized third-party inspection companies and certification labels with unique serial numbers for quality and safety assurance (IN DHS). Indiana's history with off-site construction dates to the 1940s when National Homes was established, an off-site construction manufacturer that would become the largest producer of manufactured housing in the country (Chicago Tribune 1987). Operating for nearly half a century before closing in the early 1990s, National Homes played a significant role in establishing Indiana as a pioneer in the modular housing industry. In this section, we examine each of these states to understand the benefits and challenges faced by modular building manufacturers, including impacts on quality, efficiency, and regulatory compliance.

Methodology

To achieve our objectives, we utilized surveys with off-site construction manufacturers in Pennsylvania and Indiana as our primary research method. The survey consisted of 15 qualitative questions covering key aspects of off-site construction, such as success factors, advantages, challenges, compliance, and trends. This approach allowed for the collection of qualitative data through open-ended questions, allowing participants to provide detailed insights into their experiences, perspectives, and challenges. It is important to acknowledge the inherent bias that may exist among manufacturers in wanting to promote this approach. Further research is needed to examine perspectives of other stakeholders, such as customers and local or state officials, to gain a comprehensive understanding of off-site construction's impact and potential. Further, our current findings do not provide specific data regarding energy savings or carbon reductions from off-site construction in Pennsylvania and Indiana. We recognize the need for further analysis to demonstrate any achievements in these areas.

The target audience was modular building manufacturers who design and build modular homes in Pennsylvania and Indiana. These manufacturers were chosen based on their specialization in different building types, including single-family homes (both detached and townhomes), multifamily dwellings, and commercial buildings. The survey was distributed to 52 off-site construction manufacturers directly, 33 of which have facilities located in Pennsylvania and/or Indiana, and the rest with a national presence, and to modular home organizations, groups, and collaboratives such as Advanced Building Construction Collaborative, the National Association of Home Builders, particularly the Modular Homes Council, and the Modular Building Institute, which then distributed the survey within their networks. We secured survey responses from nine manufacturers involved in off-site construction, including four from Pennsylvania and Indiana (two from each state).

Receiving responses on the survey proved challenging, eliciting a lower-than-expected response rate, which is not uncommon in qualitative research. However, responses came from residential and commercial manufacturers, providing a diverse and representative sample of the industry. This secured rich qualitative data and a better understanding of off-site construction in Pennsylvania and Indiana and informed recommendations for future action. The key findings below include quotes directly from those off-site construction manufacturers that responded to the survey.

Key Findings

Benefits of Off-Site Construction

Expedited Project Timeline. The four manufacturers that responded to our survey highlighted the speed of off-site construction projects. According to industry experts, modular techniques enable faster completion of buildings as compared to traditional stick-built methods. This expedited timeline translates to quicker occupancy, a significant advantage for both developers and end-users. In urban areas where construction disruptions can significantly impact daily life, fast assembly on site can be particularly valuable in reducing disturbances for residents and businesses.

> "Owners of modular-built hotels and apartment buildings can start occupying the premises much faster compared to stick-built alternatives. The same applies to residential modular homes."
>
> "The ability to occupy the building rapidly not only accelerates revenue generation but also minimizes the disruption to surrounding neighborhoods, making off-site construction an attractive option for urban development projects."

Cost Stability and Affordability. An essential advantage reported by three of the four manufacturers is the stability of costs throughout the construction process. Once contracts are signed, pricing remains consistent, mitigating the risk of budget overruns commonly associated with onsite construction. This financial predictability fosters confidence among stakeholders and enhances overall project feasibility.

> "Price lock/stability once contracts are signed is a significant advantage of off-site construction. It leads to lower construction times and reduces interest on construction loans."
>
> "By providing cost certainty and minimizing the potential for change orders, off-site construction offers greater confidence in project budgeting and financial planning."

Customization Opportunities. Manufacturers emphasize the flexibility and customization options in off-site construction. Two modular building manufacturers reported that they can efficiently accommodate various customization requests, such as floor plan modifications, material choices, and aesthetic features, offering clients greater control over the final product while maintaining cost-effectiveness and construction speed. This ability for customization enhances the appeal of off-site construction across diverse market segments.

> "Modular construction allows for a high degree of customization, offering building owners the flexibility to design according to their unique needs and preferences."
>
> "We don't have any design restraints. Our models are completely customizable."

Environmental Sustainability. Industry experts underscored the environmental benefits of off-site construction, including reduced waste generation, embodied carbon, and operational carbon. One of the manufacturers surveyed has a pilot project underway to demonstrate these benefits. According to the four manufacturers surveyed from our target states, off-site construction can reduce waste by incorporating precise cuts and the potential for material reuse.

> "Off-site construction produces near zero waste."
>
> "We are launching our pilot build this year. It will be building workforce housing with the lowest embodied and operational carbon emissions on the market."

Worker Safety. All of the surveyed manufacturers from Pennsylvania and Indiana emphasize the safety benefits inherent in off-site construction. Their feedback underscores the advantages of operating within controlled environments, which minimize exposure to external elements and standardize processes, consequently reducing the risk of accidents. In both states, workers face cold and snowy winters and hot and humid summers. Operating within a controlled environment helps to ensure their safety and offers a more comfortable work environment year-round, shielding them from the harsh extremes of weather.

> "Building in a controlled environment allows us to keep our workforce out of the elements and standardize processes, reducing the chances of an accident. Working predominantly in the Midwest, our tradespeople are happy to be in a climate-controlled facility and away from the brutal winters we have. Less on-site activities equal less safety hazards than you would typically find on a standard project site."
>
> "Offsite construction is safer due to its intentional onsite assembly and less time on site."

Challenges of Off-Site Construction

Misconceptions and Stigma. The four manufacturers that participated in the survey face challenges related to public misconceptions surrounding modular construction. Despite proven quality and adherence to local building codes, modular homes are often unfairly associated with lower standards or outdated stereotypes. Overcoming these misconceptions requires ongoing education and outreach to promote awareness and dispel myths about off-site construction.

> "People often confuse modular with manufactured homes. They are not the same, but people think they are. There is also confusion that modular is different than stick-built and it is not. They are both built to the same local building codes, it is just a different method of building."
>
> "Most common stigma is the assumption that 'modular' and 'manufactured' homes are the same. We have usually addressed them through physical/virtual walkthroughs of our homes to show the difference."

Market Acceptance and Industry Resistance. Two manufacturers report that off-site construction faces resistance from entrenched interests within the building industry. Traditional builders, subcontractors, and homeowner associations (HOAs) may exhibit reluctance to embrace new methods and technologies, impeding widespread adoption. Overcoming this resistance requires collaboration to demonstrate the viability, quality, and long-term benefits of modular construction.

> "Disadvantage was the local HOAs are very skeptical of "Modular" (Bad Stigma!)."
> "Most traditional builders are very resistant to change, and they often hold the keys to a successful build."

Financial Hurdles and Lack of Incentives. Coupled with misconceptions about off-site construction, financial obstacles, lack of targeted off-site construction incentive programs, and unawareness about available tax credits present significant challenges for all surveyed manufacturers. From securing funding to navigating lending options, manufacturers face hurdles when convincing banks and financial institutions of the viability and value proposition of modular construction.

> "We are not aware of any tax credits or incentive programs."
> "There is a lack of targeted incentive programs. We are looking into the possibility of getting 45L tax credits for a few of our projects."
> "Securing funding for off-site construction projects can be challenging, as not all banks understand or are willing to fund this method of building."
> "Not all banks understand and fund offsite construction"

Localized Production Benefits and Workforce Development

In-State Production Benefits. The manufacturers from Pennsylvania and Indiana have emphasized the advantages of selling modular homes within the states where they are manufactured. These benefits include streamlined regulatory processes, convenient access to manufacturing facilities, and lower transportation costs, contributing to smoother operations and enhanced customer service.

> "State works better with us on approvals than outside manufacturers. Also, dealers/builders can access the plant easier for tours, meetings on projects, etc. Transportation costs are much lower also."
> "Close by for us is much easier to service. Also, the state (Pennsylvania) has a well-oiled modular program, so getting permits and inspections completed is straightforward."

Local Workforce Development. Based on the survey responses from the four manufacturers, off-site construction in Pennsylvania and Indiana has led to increased demand for skilled workers, providing opportunities for workforce development and training programs. This trend supports job growth and creates a skilled labor pool, benefiting both manufacturers and local communities.

> "We have noticed an increased need to hire more workers as the demand increases and the current workforce retires."
> "We have launched our own workforce development program to keep up with the need."
> "We have dealt with the labor shortage as long as we've been in existence, same for our competitors. We're very active in our communities and vocational schools to enlighten our

youth on the benefits of pursuing a career in construction. We're always looking for more talent."

Regulatory Hurdles and Standardization. Three of the surveyed manufacturers sell modular homes beyond their state of operation. Those manufacturers, while reporting on the benefits of selling within the state of operation, reported challenges when selling modular homes beyond state borders, citing regulatory hurdles and lack of standardization, particularly in navigating state-specific building codes and inspection requirements.

"When selling across different states we have experienced a lack of standardization."

"Building codes change per state or even per city. Need consistency nationwide."

"When there are jurisdictional differences between factory location and site location, streamlining and clarifying inspection requirements is needed."

Outlook and Emerging Trends. Two manufacturers surveyed for this study prioritize building affordable housing due to off-site construction's faster completion times and lower labor costs. Younger demographics like Millennials and Gen Z, accept modular technologies more readily than older buyers as this approach aligns with their preference for sustainable, customizable, and technologically advanced housing solutions.

"More and more housing providers, especially in the affordable housing space, are looking at off-site construction. This market is full of non-profits who have limited workforce capacity, and off-site construction lets them 'do more with less'."

"As Gen Z and Millennials tend to accept Modular and Manufactured homes more than older generations, home designs and features are changing to what they prefer compared to older generations."

Technological Advancements and Sustainability Initiatives. Advancements in technology and materials hold promise for enhancing the efficiency and sustainability of off-site construction methods. Manufacturers anticipate breakthroughs in envelope materials technology, enabling the production of lightweight yet energy-efficient modular components. Additionally, a concerted focus on climate regulation and supply chain transparency is driving innovations geared toward achieving both environmental sustainability and economic viability in off-site construction practices.

"With the advancement of Energy Codes and technology, I look for advancements in envelope materials technology that is lightweight but make the modular homes even more efficient and cost-effective."

"Climate regulation is going to push for strategies that are sustainable and economical - modular is well-positioned to do this."

"Increasing adoption of BIM and other digital technologies is streamlining the design, planning, and manufacturing processes in off-site construction. This leads to greater efficiency, reduced errors, and improved collaboration among stakeholders."

Recommendations for Industry Players. Two of the surveyed manufacturers in Pennsylvania and Indiana recommend that other industry players collaborate closely with regulatory bodies, local officials, and educational institutions to address challenges and promote the adoption of off-site construction. By fostering partnerships and investing in educational initiatives, manufacturers can elevate awareness, dispel misconceptions, and cultivate a supportive ecosystem conducive to industry growth.

"Look at what companies that have been in business for a long time do. There are a lot of new companies that come in, think they understand the modular business, they try to change it and are out of business within a few years."
"Review the areas you are going to serve, perhaps meet with local officials to preempt pushback from them. Make sure you coordinate with a good set crew in the field. Get involved with associations and get educated."

Takeaways and Recommendations

In their survey responses, all nine off-site construction manufacturers including the four from the target states mentioned these benefits of off-site construction: faster project timelines, cost stability, extensive customization, environmental sustainability, and improved worker safety. These advantages make off-site construction an attractive option for developers and investors, and a promising solution for the affordable housing crisis. Indiana and Pennsylvania's robust modular programs serve as a model for effective regulation and oversight. With requirements mandating certification and inspection by third-party agencies, these programs ensure adherence to stringent quality standards. This approach fosters consumer confidence and supports the modular construction industry within the state.

However, the industry faces challenges such as public misconceptions, market resistance, financial hurdles, and regulatory inconsistencies. To address these issues and leverage the benefits of off-site construction, we recommend several actions.

Table 1. Recommendations to Address Industry Challenges

Recommendation	Action By	Goal
Demonstrations and Virtual Tours	Manufacturers and industry associations	Showcase the quality and benefits of off-site construction through visual demonstrations and virtual tours
Promote Collaboration	Manufacturers, traditional builders, and industry associations	Facilitate knowledge sharing and the adoption of best practices through collaborative efforts
Education and Outreach Campaigns	Industry associations and educational institutions	Shift public perception, educate mortgage lenders, educate manufacturers about and promote adoption of ICC standards, and increase acceptance of modular homes through targeted campaigns
Invest in Training Programs	Manufacturers and educational institutions	Develop a skilled labor pool to meet the demands of off-site construction through dedicated training programs
Adopt Nationwide Standards	Regulatory bodies and industry associations	Streamline regulatory processes, reduce barriers, and facilitate broader adoption of off-site construction by establishing nationwide standards*
Enhance Awareness of Funding Programs	Industry associations and government agencies	Educate manufacturers about existing funding programs, tax incentives, grants, participation in Energy Star new homes program, and low-interest

		loans available to support off-site construction projects
Advocate for Enhanced Financial Incentives	Industry stakeholders and policymakers	Lobby for targeted government policies that provide increased financial incentives specifically for modular construction, enhancing affordability and promoting sustainability in housing solutions

*In the following section, we will explore off-site construction nationwide standards.

By implementing these recommendations, the potential of off-site construction to provide cost-effective, sustainable, and customizable housing solutions can be fully realized.

Off-Site Construction Standards as Tools for States and Jurisdictions

Prompted by the surge in off-site construction as a strategic response to construction industry challenges, the International Code Council (ICC) and the Modular Building Institute (MBI) collaborated to release two critical standards in September 2021: ICC/MBI 1200-2021 Standard for Off-Site Construction: Planning, Design, Fabrication and Assembly and ICC/MBI 1205-2021 Standard for Off-Site Construction: Inspection and Regulatory Compliance. These standards, which focus on planning, design, fabrication, and regulatory compliance, aim to standardize off-site construction practices, offering a unified framework for inspection and design. These standards pave the way for consistency in inspection processes, especially when off-site construction facilities operate outside the jurisdiction of the final construction site. Moreover, these standards play a crucial role in assisting jurisdictions that are currently grappling with challenges in code enforcement. By facilitating the use of third-party inspectors and enabling remote virtual inspections,[5] these measures address geographical limitations and staff constraints, and enhance the overall efficiency of off-site inspections.

Salt Lake City, Utah was the first jurisdiction to embrace ICC/MBI 1200 and 1205 Standards (Neal 2021). The city's proactive adoption of these standards has addressed housing and infrastructure challenges by facilitating efficient off-site inspections through third-party agents. Virginia recently became the second U.S. jurisdiction to adopt the ICC/MBI standards, setting a precedent for states to embrace the benefits of these standards in expanding the use of off-site construction within their jurisdictions (Campbell 2024). The State Building Codes Office in Virginia is enthusiastic about the prospect of expanding off-site construction within the state, recognizing the benefits these standards bring in standardizing off-site construction (Speed 2022). The potential for this collaboration and regional market transformation becomes even more promising as more states embrace and adopt the newly established standards.

Furthermore, the ICC recently approved 1210-2023 – Standard for Mechanical, Electrical, Plumbing Systems, Energy Efficiency and Water Conservation in Off-site Construction and made it available for adoption by jurisdictions that want to establish criteria for Mechanical, Electrical, and Plumbing (MEP) systems in off-site construction. The standard

[5] Historically, building inspections have been conducted on-site and in-person. New technology and platforms have made it possible to conduct code inspections remotely, either partially or entirely. This practice, referred to as remote virtual inspections (RVI) uses video cameras, still photographs, and video networking software (often in combination) to conduct a home or building inspection remotely rather than conducting it on-site. Learn more at: neep.org/building-energy-codes-and-appliance-standards/prefabricated-construction-and-remote-virtual.

ensures public safety and welfare, and addresses industry challenges, focusing on energy efficiency and water conservation during the planning, design, fabrication, transportation, and assembly of MEP elements in commercial and residential buildings. The standard emphasizes compliance with energy conservation codes and standards and provides further clarity on meeting efficiency and conservation requirements.

Ways to Incentivize Off-Site Construction

The Inflation Reduction Act (IRA) stands as one of the most significant climate investment initiatives, providing hundreds of millions of dollars in rebates and tax credits aimed at promoting environmental justice and energy-efficient building upgrades (The White House 2023). Although it does not explicitly target off-site construction homes, modular builders can leverage IRA funding if they achieve energy and climate benefits. Off-site construction projects that prioritize high energy efficiency in building design and construction can take advantage of these incentives, but there is a need to spread awareness. The survey demonstrated a clear need for educating off-site construction manufacturers about the possibility of benefiting from these funding sources and demonstrating performance.

The National Renewable Energy Laboratory, Oregon State University, Momentum Innovation Group, and the US Department of Energy jointly outlined five key strategies in a 2022 report for modular builders to enhance energy efficiency (NREL 2022). Focusing on envelope thermal control, envelope infiltration control, mechanical, electrical, and plumbing systems, smart controls, and solar-plus-storage services, modular builders can achieve energy efficiency and maximize the advantages offered by the IRA. One key opportunity within the IRA programs for modular home projects is the 179D commercial buildings energy-efficiency tax deduction, crafted to promote energy-efficient construction. Commercial building owners and designers whose projects meet specific energy-efficiency standards are eligible for tax deductions.[6] Another avenue for modular builders is the 45L investment tax credit (ITC), tailored for single-family and multifamily building contractors that meet applicable ENERGY STAR home program or DOE Zero Energy Ready Home (ZERH) program requirements.[7]

States can further support off-site construction by offering tax credits through state-administered Qualified Allocation Plans (QAPs). These plans establish criteria for evaluating projects eligible for tax credit allocations.[8] In Virginia's QAP for Low-Income Housing Tax Credits (LIHTC), tax credits can be awarded to projects incorporating innovative construction methods that reduce both construction time and cost (Fannie Mae 2020). While the QAP does not dictate a specific method, off-site construction aligns with the desired criteria, presenting an ideal fit for tax credit allocations. The recognition of time and cost savings inherent in off-site construction makes it a compelling choice for developers seeking financial support through the LIHTC program. As the need for cost and time-effective energy-efficient homes is increasing, strategic financial support through avenues like IRA funding, federal initiatives, and state-driven tax credit programs creates a positive environment for the broader adoption of off-site homes.

[6] Please review the Department of Energy, Office of Energy Efficiency & Renewable Energy for most up to date information: www.energy.gov/eere/buildings/179d-commercial-buildings-energy-efficiency-tax-deduction.
[7] Please review the Department of Energy, Office of Energy Efficiency & Renewable Energy for most up to date information: www.energy.gov/eere/buildings/section-45l-tax-credits-zero-energy-ready-homes.
[8] The funding for the tax credits is provided through the Low-Income Housing Tax Credits (LIHTC) program.

Conclusion

Off-site construction presents a viable solution for the affordable housing crisis, offering rapid build times, cost stability, and environmental benefits. Constructing energy-efficient homes quickly and affordably can meet the urgent demand for sustainable and affordable housing.

To advance off-site construction, industry stakeholders should prioritize demonstrating its benefits through visual presentations, fostering collaboration among manufacturers, traditional builders, and industry associations to share knowledge and best practices, educating stakeholders about the advantages and standards of modular homes, developing training programs to build a skilled workforce, establishing nationwide standards, simplifying regulatory processes, increasing awareness of funding opportunities, and advocating for targeted financial incentives specific to modular construction.

Implementing these measures will enable stakeholders to leverage off-site construction fully, providing sustainable, efficient, and affordable housing solutions that effectively address the housing crisis.

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