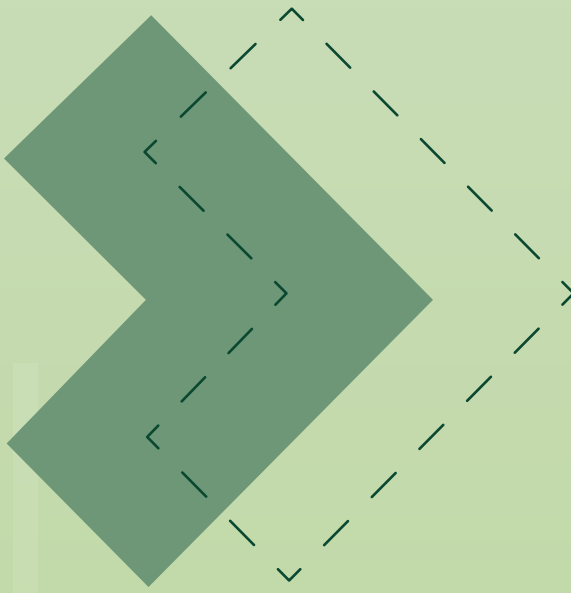


An Exploratory Study of Factory-Built Homes and Their Implications for Affordability

Final Report



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Final Report

Prepared for

U.S. Department of Housing and Urban Development

Office of Policy Development and Research

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2M Research

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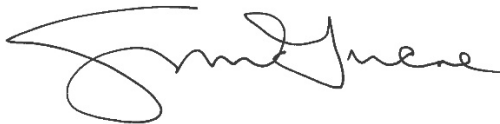
FOREWORD

The U.S. home building industry is facing two major challenges that contribute to the housing affordability crisis: the shortage of skilled construction laborers and the increasing cost of building materials. Both challenges have negatively affected the housing supply chain, which raises prices for consumers. The home building industry, affordable housing advocates, and HUD are exploring strategies that could bend the cost curve for producing new housing units.

Factory-built homes, or homes developed in a factory setting and assembled on-site, are faster and less labor-intensive to build than traditional construction methods. However, homes built off site and in factories have not been widely adopted in the United States, and there is a dearth of policy-oriented research on the factory-built home industry.

This research is based on conversations with factory built industry representatives and experts on the current market strategies to increase the supply and update of factory-built housing. This report discusses innovative manufacturing and construction processes, considers effective market strategies for the industry and consumers, and recommends actions that the U.S. Department of Housing and Urban Development (HUD) could take to facilitate the adoption of factory-built housing in the United States. Marketing strategies include quick reference guides and information briefs for home builders and lenders, as well as resources targeted specifically to factory-built manufacturers. As HUD considers the findings in this report and the development of the factory-built housing industry, we will explore how these innovations could be part of building equitable communities and supporting a thriving workforce.

In May 2022, the Biden-Harris Administration announced its Housing Supply Action Plan, which included significant recent and planned regulatory action around factory-built housing. These actions include increasing the usability of FHA's Title I loan program for manufactured housing, supporting greater securitization of Title I loans through Ginnie Mae's platform, updating the HUD Code to allow manufacturers to modernize and expand their production lines, and helping manufacturers respond to supply chain issues. This report will be a valuable resource for the federal government and its private-sector partners as we work together to implement components of that plan.



Solomon J. Greene
Principal Deputy Assistant Secretary for Policy Development and Research
U.S. Department of Housing and Urban Development

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EXECUTIVE SUMMARY

The purpose of this report is to provide information on current trends in the factory-built home industry related to the manufacturing and construction process, materials, marketing to consumers, and financing—and the implications for housing affordability. The primary emphasis of this study is on the modular industry, with less emphasis given to panelized, precut, and U.S. Department of Housing and Urban Development (HUD)-code manufactured housing technologies. To perform the work, HUD contracted with 2M Research (hereafter referred to as “the Study Team”) to conduct eight case studies of companies operating in the factory-built housing industry, a sector of the building and construction industry that shows significant promise for increasing affordable housing in the United States.

Before the case study data collection, the Study Team developed a Market Research Report that described key aspects of the industry, including the main stakeholders, factory-built production process, use of factory-built construction, and benefits and challenges of factory-built housing. After completing the case studies, the Study Team developed informational briefs that include key information on factory-built housing for multifamily housing builders and developers, financiers of multifamily housing, single-family homebuyers, and factory-built housing manufacturers. The Study Team also engaged an expert panel of key stakeholders in the factory-built housing industry to provide feedback and guidance on the study’s key findings, recommendations, and avenues for future research.

In collaboration with HUD and the Expert Panel, the Study Team developed the following definition: *Factory-built homes* are homes made of components primarily built inside a factory and then assembled on site. Typically, factory-built projects use standardized, repeatable designs, that allow factories to efficiently replicate the same home model from subassemblies, such as panels or modules using uniform—and often proprietary—mass production processes. The structure of the home is largely completed when delivered to the site, unlike site-built homes, which are built from unique designs using materials delivered to a site and totally constructed on the site.

The Study Team worked closely with HUD and the Expert Panel to identify a sample of companies with different market shares, clients or consumers, and production processes. After finalizing the sample, the Study Team conducted semi-structured interviews with representatives of each of the eight selected companies from September through November 2020. In the interviews, the company representatives reported that factory-built housing has significant efficiencies, in terms of both construction cost and time. The case studies’ key findings highlight how (1) factory-built housing produced using standardized, repeatable designs is often more affordable than site-built housing; (2) transportation of factory-built housing incurs significant costs; (3) education on the benefits and quality of factory-built housing is needed to counter negative perceptions; (4) to reduce barriers to financing factory-built housing projects, the finance industry needs more information on the benefits and risks of factory-built housing; and (5) companies reported that efficient production processes, automation, and robotics may

increase the affordability of factory-built housing, but future research is needed to confirm this finding.

Those findings inform four recommendations for HUD:

- 1. Provide education on the benefits of factory-built housing and the strategies to overcome common challenges reported.** The eight companies reported that many potential consumers (for example, single-family homeowners); developers (for example, architects, engineers, and contractors); and other stakeholders (for example, financiers and local code officials) have negative perceptions of factory-built housing and view factory-built homes as being of low quality. Discussions with the Expert Panel and findings in the market research report corroborate this issue; however, the companies also reported that demonstrating the fast construction time, precision, and high quality of factory-built homes helps dispel these negative perceptions. HUD should continue leading educational activities, such as the Innovation in Housing Showcase, to demonstrate the benefits of factory-built housing to support this industry.
- 2. Develop guidance on potential avenues for financing of factory-built housing.** The companies described one common challenge as the difficulty of obtaining financing for factory-built housing. The companies reported that many potential financiers and investors are unfamiliar with the financial risks and are hesitant to accommodate the large upfront costs of factory-built housing projects. Furthermore, projects that use affordable housing subsidies, such as low-income housing tax credits (LIHTCs), are typically structured so that an architect provides the design and a separate company (which usually must have an established work history providing affordable housing for similar projects) provides the construction. Factory-built manufacturers that use standardized, repeatable designs—especially newer companies with limited experience—are usually unable to compete with traditional affordable housing construction companies that use site-built methods for these types of projects. The Expert Panel also noted that factory-built housing manufacturers have difficulty competing for projects that are financed with LIHTCs. The Study Team recommends that HUD develop guidance for both developers and manufacturers on the financing of factory-built housing, including how to compete for projects that use government subsidies. Potential guidance topics could include how to structure payment plans for multifamily projects with large upfront costs, how to work with financiers that are not as familiar with factory-built housing, best practices on risk sharing and how to define each party’s liability during the construction process, and how to apply for and use existing subsidies for affordable housing, such as LIHTC.
- 3. Explore the feasibility of a standardized building code and inspection process for factory-built housing.** The eight companies and the Expert Panel stated that a national building code that facilitates a uniform inspection process for factory-built homes would eliminate the challenge faced by factory-built housing manufacturers that seek to use standardized, repeatable designs to meet various state and local building standards. A potential next step is for HUD to directly engage with factory-built housing manufacturers to understand and develop consensus regarding the specific aspects they agree would be necessary in such a standardized code.

- 4. Develop funding opportunities for affordable factory-built housing.** HUD can continue to support existing funding opportunities, such as the Cooperative Research in Housing Technologies, which encourages more affordable, energy-efficient, resilient, and healthier housing while reducing the cost of construction.¹ HUD can also consider funding additional opportunities for developers interested in developing affordable factory-built housing. This funding could be for additional research projects or seed money for demonstration projects of factory-built housing. HUD attempted a demonstration project, Operation Breakthrough, in the 1960s and 1970s; at that time, however, most demonstration projects were not commercialized. Over the next few decades, the quality, design, and cost effectiveness of factory-built housing has greatly improved. Moreover, if HUD based the funding requirements on key outcomes (such as energy-efficient units, low cost per unit, and the safety of units) rather than specific processes or designs, a wider variety of factory-built companies could qualify.

The main body of the report is organized as follows: First, the report outlines the research conducted, including the design, topics, and companies selected for case studies. Next, the report provides narrative descriptions of each of the case studies, focusing on their manufacturing and construction processes; marketing to consumers; financing; and recommendations for federal, state, or local policies to encourage affordable factory-built housing. The report then details a synthesis of the information in the individual case study narratives as a set of key findings for HUD and the factory-built housing industry in general. Finally, the report concludes with recommendations for HUD based on the key findings and topics for future research.

This study's recommendations represent actionable next steps for HUD as it continues to explore the potential of factory-built housing to increase the availability of affordable housing in the United States. The Study Team acknowledges that the representatives interviewed had an incentive to describe their companies positively, as the findings from their interviews will be published. The Study Team ensured that the recommendations reflect both the findings from semi-structured interviews and the market research report as well as discussion with the Expert Panel. Specifically, the Expert Panel provided valuable feedback on the initial draft of a case study report, which helped the Study Team make revisions and avoid, as much as possible, unsubstantiated findings and recommendations.

¹ The 2020 Notice of Funding Availability for the Cooperative Research in Housing Technologies program is available here: <https://www.huduser.gov/portal/elist/2020-may-26.html>.

CHAPTER 1: INTRODUCTION

In 2021, an improving economy with record-low mortgage interest rates combined with an increase in remote working due to the COVID-19 pandemic spurred housing demand, fueling a residential housing boom. The dramatic increase in the demand for homes resulted in buyers driving up home prices, rapid home sales, and a historically low supply of available homes. On the rental side, the number of vacancies has fallen steadily for apartments priced for moderate- to low-income renters, leading to sharp increases in rents. In 2021, nominal rents increased by 3 percent, whereas earnings for lower income households stagnated after experiencing the brunt of the economic fallout from the pandemic (Joint Center for Housing Studies of Harvard University, 2021). This housing market moment threatens to become an era-defining pandemic phenomenon, especially as the unprecedented event both exposed and amplified the impact of unequal access to decent, affordable housing. A *New York Times* article observed, “The country is running out of affordable places for people to live” (Dougherty and Thrush, 2021).

Even before the pandemic arrived—as recently as 2017—nearly one in three American homeowners were cost burdened, spending more than 30 percent of their income on housing (Galante, Draper-Zivetz, and Stein, 2017). Renters were even more cost burdened than homeowners, and those cost burdens were greatest among lower-income households (Joint Center for Housing Studies of Harvard University, 2021). Furthermore, nearly every county in the United States faces an affordable housing shortage because of limited housing inventory and because the cost of the existing supply of single-family homes is too high for many potential homeowners (Aurand et al., 2019; Olick, 2019). The lack of affordable housing in the United States is compounded by a well-documented construction labor shortage, which has increased the cost of construction and the length of time for materials delivery (Associated General Contractors of America, 2018; Bertram et al., 2019). To a lesser extent, restrictive zoning laws (Glaeser and Gyourko, 2002) and developers’ desire for high profit margins (Harrington, 2016; Hay, 2013; Rogers, 2017) are also driving up the cost of housing.

To address this affordability crisis, HUD is interested in building technologies and construction innovations to increase the amount of affordable housing in the United States. One area HUD identified for further study is the factory-built housing industry. Produced using efficient offsite construction methods and technologies, factory-built homes have the potential to bridge the gaps in affordable housing because they require significantly less construction time and cost (Bertram et al., 2019; Galante, Draper-Zivetz, and Stein, 2017). Despite this potential, however, factory-built homes have not been widely adopted, and knowledge about the factory-built home industry is scant. To advance a common understanding of the factory-built housing industry, HUD seeks new insights into the current state of innovation in factory-built housing.

Defining Factory-Built Housing

Important to note in the literature and colloquially within the industry is that the terms *offsite*, *modular*, *panelized*, and *prefabricated* are often used imprecisely or interchangeably to describe factory-built construction.

Throughout this report, the Study Team uses the term *factory-built* and explicitly define *factory-built housing* as **homes made of components primarily built inside a factory and then assembled on site**. Typically, factory-built projects use “standardized, repeatable designs,” which are designs that allow factories to efficiently replicate the same home model from panels or modules using uniform, and often proprietary, mass production processes.^{2,3} Factory-built housing includes precut, panelized, and modular homes (NAHB Research Center, 1998; Wherry, 2009):

- **Precut homes** are built with components produced in a factory and assembled on site. Precut homes are generally easy to construct on solid foundations; common precut homes include log, kit, and dome housing (NAHB Research Center, 1998; Wherry, 2009).
- **Panelized homes** are made of prefabricated, standardized wall or roof panels that are manufactured in a factory and can be assembled on site or in a factory off site. The two general types of panels are (1) open, which consist solely of framing, and (2) closed,

A Brief History of Factory-Built Housing Post-World War II

During the post-World War II period, a high demand for and severe shortage of housing culminated in a surge of mass construction of homes, including factory-built homes (Galante, Draper-Zivetz, and Stein, 2017). That effort received federal support in 1946 when the U.S. government passed the Veterans’ Emergency Housing Act, which mandated and allocated funding for the construction of 850,000 prefabricated homes within the next 2 years (Smith, 2011).

Federal support of the factory-built housing industry continued in the late 1960s, when the government launched Operation Breakthrough to support the expansion of offsite construction of single-family suburban homes (Galante, Draper-Zivetz, and Stein, 2017). Operation Breakthrough spurred the development of 2,794 factory-built prototype housing units on nine test sites across the United States, followed by 20,000 additional units manufactured by the participating firms, but that number was far lower than the hundreds of thousands of housing units the endeavor was expected to produce (Richardson, 2018).

Although Operation Breakthrough was largely seen as unsuccessful, Richardson (2018) points out the recent marketplace acceptance that factory-built housing “improves construction efficiency, quality, and affordability.” Combined with technological advances in the factory construction of building components that are assembled on site into homes indistinguishable from traditional, site-built homes, the rising acceptance and growth in sales of factory-built housing warrants additional research on the potential of factory-built housings to produce much-needed affordable housing in the United States.

² This contract’s Statement of Work used a definition specifying that the structure of the home when delivered to the location is largely completed (70 percent or more); however, the Expert Panel suggested this alternate definition for factory-built housing. More details appear in the Market Research Report.

³ In February 2020, the Study Team met with an Expert Panel of key stakeholders in the factory-built housing industry. A key theme of the meeting was the importance of a standardized, codified definition of factory-built housing. Panel members noted that past use of incorrect and imprecise terminology raised costs and barriers to the adoption of factory-built homes. The lack of standardized definitions has specific implications for construction budgets and financing, building codes and regulations, and misconceptions among consumers and other stakeholders; each of those challenges reduces the affordability and adoption of factory-built homes.

which include plumbing, insulation, and electrical wiring (Steven Winter Associates, Inc., 2005).

- **Modular homes** comprise volumetric components, also referred to as “modules,” with finished interior and exterior surfaces (Schoenborn, 2012). The modules are built in a factory and assembled on site—stacked, lifted by a crane, and placed on a foundation (Koones, 2019). Unlike site-built homes, which are finished from the outside moving in, modules are finished from the inside moving out, with the frame constructed first, followed by the addition of interior surfaces, electrical, plumbing, mechanical, insulation, exterior sheathing, and cladding (Smith, 2016). Modular homes can be constructed from different materials, including wood, steel, and concrete (Fannie Mae, 2019). Wood modules are typically used for single-family homes and low-rise multifamily buildings with a maximum height of three to four stories. Steel modules are used for buildings that require a more robust structure, such as taller or seismically sound designs and, as a rule of thumb, can be designed to be as tall as 12 stories (Brown, 2014). Module dimensions are largely determined by local and state transportation regulations and are related to the size of what can be transported on the highway (Brown, 2014). Modular, precut, and panelized homes must comply with state and local building codes (NAHB Research Center, 1998).

In addition to the three types of homes described above, factory-built housing also includes manufactured homes:

- **Manufactured homes** (colloquially referred to as “mobile homes”) are portable structures completely constructed in a factory. This type of home is built on a nonremovable steel frame, put on wheels or temporary stands, and transported to its destination, where little or no onsite assembly and very little customization occur (Tracey, 2016). Unlike precut, panelized, and modular homes, manufactured homes must comply with federal HUD regulations: the National Manufactured Housing Construction and Safety Standards Code of 1976 (NAHB Research Center, 1998). Because precut, panelized, and modular homes are also at least partially “manufactured,” meaning built in a factory, the rest of this report refers to manufactured homes as “HUD Code manufactured” homes for clarity.

As noted previously, the primary focus of this study is on the modular industry, with less emphasis given to panelized, precut, and HUD Code manufactured housing technologies.

Objectives and Research Questions

The objective of this study, *An Exploratory Study of Factory-Built Homes and Their Implications for Affordability*, is to examine current trends of innovation in the factory-built housing industry and how factory-built housing may be used to increase the supply of affordable housing in the United States. The results will provide HUD, consumers, contractors, builders, and other industry stakeholders with information on how changes in the production process, industrialization, models used for construction and installation, and efficiencies in the process over the past decade have had significant implications for housing affordability and supply. To advance a common understanding of the factory-built housing industry, HUD contracted 2M

Research (hereafter referred to as “the Study Team”) to conduct the tasks outlined in exhibit 1 with the understanding that the results of this study can improve knowledge of the current state of innovation in factory-built housing (apart from HUD Code manufactured housing).

Exhibit 1 | Exploratory Study Tasks



Source: Study Team illustration of Exploratory Study tasks

This report includes information related to Task 1—Expert Panel and Task 3—Case Studies. The Study Team developed eight case studies of factory-built home manufacturers to document best practices as well as pitfalls experienced as the manufacturers strive to increase the supply and availability of affordable housing. After developing an initial report of case study findings and recommendations, the Study Team presented the results to the Expert Panel, which included key stakeholders in the factory-built housing industry, for feedback. This report incorporates information provided by the Expert Panel and aims to serve as a toolbox for industry stakeholders and producers; provides recommendations for policymakers; and discusses the future of the industry. The study endeavors to spur and inform additional research to further interest and understanding in this topic area.

Organization of the Report

The Study Team organized this report as follows: First, the report outlines the research the Study Team conducted, including the design, topics, and companies selected for case studies. Next, the report provides narrative descriptions of each of the case studies, focusing on their manufacturing and construction processes; marketing to consumers; financing; and recommendations for federal, state, or local policies to encourage affordable factory-built housing. The report then details a synthesis of the information in the individual case study narratives as a set of key findings for HUD and the factory-built housing industry in general. Finally, the report concludes with the Study Team's recommendations for HUD, based on the key findings, and topics for future research.

CHAPTER 2: RESEARCH OUTLINE

This chapter describes the case study research design the Study Team implemented to address the objectives and research questions of the study. The chapter also describes the topics covered during interviews with the eight companies in the factory-built housing space selected as case studies. The Study Team provides summaries of each of the eight companies' consumer base, areas of expertise, and products or services as well as reasons for including them in the study. The chapter concludes with a discussion of the key limitations of the study.

Research Design

The Study Team designed a descriptive multiple-case-study approach to gather in-depth and nuanced information on the best practices and pitfalls companies face within the factory-built housing industry. The case studies are *descriptive* in that their purpose is to describe innovation in the factory-built housing industry in its real-world context. In addition, selecting multiple cases, as opposed to a single-case design, is important to ensure that the Study Team could identify best practices and pitfalls that were replicated across more than one case (Yin, 2014).

To implement the descriptive multiple-case research design, the Study Team conducted semi-structured interviews with representatives of each of the eight companies in the case study sample from September through November 2020. The semi-structured interview format provided interviewers with a standardized outline of topics for each of the interviews as well as the freedom to ask follow-up and probing questions to further investigate lines of inquiry as they arose during the interviews. The interview discussion guide is presented in appendix A. All topics included in the guide are discussed in the next section.

Once the interviews were completed, the Study Team coded the interview transcripts using the computer-assisted qualitative analysis software NVivo. Coders organized the text of the interview transcriptions into the topics of interest that were defined in collaboration with HUD before the interviews were conducted. The Study Team then developed case descriptions for each company. Finally, after completing the case descriptions, the Study Team identified key findings, which include the best practices and pitfalls discussed by the interviewees that were replicated across the case studies. On the basis of those findings, the team developed several recommendations to encourage and incentivize the successful production of affordable, factory-built housing units in the United States.

The development of the case study descriptions and findings was an iterative process. The Study Team submitted drafts of the case studies to HUD for feedback and met with HUD to discuss each case study. On the basis of those discussions, the Study Team refined the case study descriptions. In addition, the Study Team presented the key findings of the case study analysis to an Expert Panel of key stakeholders in the factory-built housing industry. The Expert Panel provided feedback to better ensure that the findings are relevant and beneficial to the factory-built housing industry.

Research Topics

Exhibit 2 shows the research topics the Study Team used to develop the discussion guide for the interviews for each case study. Working closely with HUD, the Study Team identified these topics as those most relevant to HUD’s interests, which also reflect the key aspects of the factory-built housing industry identified in the Market Research Report. The topics identified were designed to facilitate an in-depth description of each of the eight companies selected as case studies.

Exhibit 2 | Descriptions of the Research Topics of Each Case Study

Research Topic	What the Topic Includes
Manufacturing/ Construction Process	<ul style="list-style-type: none"> ▪ Planning and design of factory-built housing and whether the company considers affordability in the planning and design. ▪ Processes and innovations the company uses in factory (offsite) production and if and how they relate to affordability. ▪ Siting of factory-built housing (onsite construction) and related issues, such as transportation, local regulations, and determination of site locations.
Materials^a	<ul style="list-style-type: none"> ▪ Materials each company uses to produce factory-built housing and whether they result in any cost savings that can increase affordability. ▪ Any unique features or novel materials each company uses to produce factory-built housing. ▪ Challenges each company faces regarding the materials it uses.
Marketing to Consumers	<ul style="list-style-type: none"> ▪ Strategies each company uses to market to its consumer base. ▪ Any strategies or partnerships companies use to attract more consumers to factory-built housing. ▪ Whether and how the company markets to affordable housing consumers (both developers and homebuyers).
Financing	<ul style="list-style-type: none"> ▪ How each company approaches financing of factory-built housing (includes successes and challenges). ▪ Each company’s understanding of the financing options available to consumers of affordable housing.
Policy Recommendations^b	<ul style="list-style-type: none"> ▪ Each company’s opinion on policies that the government (federal, state, or local) could implement to increase adoption of factory-built housing and increase its affordability.
Summary of Findings^c	<ul style="list-style-type: none"> ▪ A summary of the successes and challenges of each company.
Industry Outlook	<ul style="list-style-type: none"> ▪ Each company’s thoughts on the future of the factory-built housing industry. ▪ Any initiatives the company is looking to implement in the future.

^aThe Prefab Logic case study description does not include a Materials section because the company does not produce factory-built housing; rather, it provides related factory-built housing services, which are discussed in the case study description.

^bIn the Interview Discussion Guide, the question around Policy Recommendations falls under the Industry Outlook section. The Study Team believed that the information gathered for this section was distinct enough to warrant its own section in the case study descriptions.

^cIn the Interview Discussion Guide, the question around successes and challenges (Summary of Findings) also falls under the Industry Outlook section. As with policy recommendations, the Study Team believed that the information gathered for this section was distinct enough to warrant its own section in the case study descriptions.

Source: Study Team Interview Discussion Guide (see appendix A)

Selected Case Studies

The Study Team followed several steps to identify a diverse sample of case studies that could inform best practices as well as pitfalls faced by companies in the factory-built housing industry. First, the Study Team solicited input from the Expert Panel on companies the panel believed could offer unique insights for the study. Second, the Study Team conducted its own research to identify innovators within the factory-built housing space. The team identified those companies as innovators because each has a unique business model employing interesting approaches in at least one of the following key topics: manufacturing and construction process, materials, financing, or marketing to consumers. In the third step, the Study Team provided a list of 19 companies to HUD for review. HUD helped identify the final list of eight companies listed in exhibit 3. Of the eight companies, six are producers of modular housing; the other two, Prefab Logic and Impresa Modular, provide services related to production of modular and, in the case of Impresa Modular, panelized housing. At the beginning of each case study, a background section provides details on the company's specific business model.

Exhibit 3 | Companies Selected for Case Studies

Company	Primary Location	Consumer Base (National/ Regional)	Area of Expertise	Products or Services Provided	Criteria for Selection				
					Manufacturing and Construction	Materials	Financing	Marketing to Consumers	Recommended by Expert Panel
Prefab Logic	Boise, ID	West Coast	Factory-built product design and project management	Consulting to developers, architects, and general contractors seeking to implement factory-built housing projects	✓		✓		✓
Impresa Modular	Martinsburg, WV	National	Planning and implementation of the modular homebuying process	Connections with modular housing production factories; a website that allows for a completely virtual homebuying experience			✓	✓	✓
Dynamic Homes	Detroit Lakes, MN	Upper Midwest	Modular housing manufacturing, working with tribal communities, and allowing consumer customizations	Single-family, multifamily, ADUs, affordable, luxury, commercial/nonresidential		✓		✓	
Guerdon	Boise, ID	West Coast; Upper Midwest; Alaska	Production of multistory modular homes using innovative technology and rigorous quality assurance procedures	Multifamily, affordable, luxury, commercial/nonresidential	✓		✓		
Clayton Homes	Maryville, TN	National	Production of modular and HUD Code manufactured homes with a vertically integrated supply chain	Single-family, multifamily, HUD Code manufactured, tiny homes, ADUs, affordable, luxury, commercial/nonresidential	✓	✓			✓
Z Modular	Chicago, IL	National	Production of multistory modular homes with	Multifamily, commercial/nonresidential.	✓	✓	✓		✓

An Exploratory Study of Factory-Built Homes and Their Implications for Affordability: Final Report

Company	Primary Location	Consumer Base (National/ Regional)	Area of Expertise	Products or Services Provided	Criteria for Selection				
					Manufacturing and Construction	Materials	Financing	Marketing to Consumers	Recommended by Expert Panel
			innovative technologies and steel frames						
Boxabl	Las Vegas, NV	As of May 2021, operates a prototyping facility in Las Vegas	Production of modular homes using innovative designs and materials that reduce costs as well as innovative marketing strategies using social media	ADUs	✓	✓		✓	
Blokable	Seattle, WA	West Coast/Pacific Northwest	Production of multifamily modular homes with an innovative business model that combines real estate development, manufacturing, and production.	Multifamily, affordable	✓				

ADU = accessory dwelling unit.

Notes: Guerdon and Z Modular also serve markets in Canada. The Study Team did not investigate the Canadian consumer base of these companies because the focus of this research is the United States.

Study Limitations

Two key limitations of this research are important to note. First, the exploratory nature of the study resulted in a diverse case study sample that includes a range of companies with different products (for example, multifamily, single-family, market-rate, nonprofit); backgrounds (for example, architecture, real estate development, manufacturing, construction); and experience levels (for example, startups, established companies). Although the sample diversity ensured findings on a broad range of topics, it also created difficulties in making comparisons between the companies and understanding whether certain findings apply to certain sectors or types of factory-built housing companies. The Study Team was able to identify themes that were consistently discussed across interviews with the eight companies; discussion of those key findings is in chapter 4.

Second, the scope of this research was limited, and the Team was able to interview only one representative from each of the eight companies. Most information presented in the case studies in chapter 3 is based on those interviews, and the Team was not able to independently verify many of the claims the representatives made. As the Expert Panel noted, the companies are engaged in public relations activities and have an incentive to sell themselves as highly successful and innovative. The companies' production processes, especially those for new companies such as Boxabl and Blokable, are largely unproven. With those two limitations noted, the Study Team believes that the case studies provide valuable insights that HUD, companies in the factory-built housing industry, and other stakeholders can learn from.

CHAPTER 3: FACTORY-BUILT HOUSING COMPANY CASE STUDIES

This chapter provides case studies of eight companies that manufacture factory-built homes and provide related services to the factory-built housing industry. The information in the case studies comes from semi-structured interviews with representatives of the companies—one representative from each company—as well as supplemental information obtained from each company’s website.










The Study Team organized the case studies around the primary research topics of the study described in chapter 2. Each case study begins with a brief company background section providing a high-level description of the company and its factory-built products. Next, each case study highlights the various aspects of the company’s business model, including how the company approaches the manufacturing and construction process of factory-built housing, the materials the company uses to develop its products (if applicable), how the company markets to its consumers, and how the company works to finance its products. Each narrative also includes a discussion of the company’s policy recommendations to reduce barriers in the production of factory-built housing. Finally, each case study ends with a summary of the successes and challenges each company representative described during the interview and their perceptions of the outlook of the factory-built housing industry. Throughout the case studies, direct quotations from the company representative—presented in boxes for emphasis—provide further supporting evidence. These case study narratives can serve as standalone documents for the companies and reflect the perspectives of the representatives interviewed.

Case Study 1: Prefab Logic—Boise, Idaho

Company Background

Prefab Logic (Prefab) is a consulting company specializing in product design and project management for modular construction projects. It was established in 2015 and is headquartered in Boise, Idaho. Prefab’s clients are typically developers and occasionally general contractors seeking to execute projects using modular construction. Prefab does not undertake construction but provides consulting services to developers and architects to help execute modular construction projects. The company does business primarily in the western United States and western Canada, with a focus on consulting services for multistory, multifamily modular construction projects, including affordable housing projects, workforce housing projects, and hotels (see exhibit 4). Supporting multifamily housing projects results in Prefab contributing to the production of 1,000 to 1,200 housing units per year.

Exhibit 4 | Projects by Prefab

PROJECTS		
SINGLE-FAMILY HOMES		✗
MULTIFAMILY HOMES		✓
HUD CODE MANUFACTURED HOMES		✗
TINY HOMES		✗
CONTAINER HOMES		✗
ACCESSORY DWELLING UNITS		✗
AFFORDABLE HOUSING		✓
LUXURY HOUSING		✓
COMMERCIAL OR NONRESIDENTIAL BUILDINGS		✓

The owner and cofounder of Prefab is also the owner and cofounder of two other companies in the modular construction industry: Autovol, Inc. (Autovol) and Waypaver International (Waypaver). Autovol is a volumetric modular factory with a high level of automation in its production process, and Waypaver is a consulting firm that helps other companies with building, designing, and operating modular construction plants. During the interview Prefab staff noted that three companies work together collaboratively to help the modular construction industry grow. Due to the relationships between Prefab, Autovol, and Waypaver, the interview provides insight into industry aspects beyond Prefab’s scope of work, such as unit construction and factory operations. This case study focuses only on the aspects of modular construction that Prefab, a consulting company, is directly involved with, such as project design and aspects of project management.

Manufacturing and Construction Process

Planning and Design

For its consulting projects, Prefab typically works closely with architects in the early stages of the project. They are pivotally involved in the planning and design stages to ensure that designs are feasible and efficient for modular construction.

The role of affordability for the consumer is an important consideration in the planning phase of projects. Some modular designs, such as those involving repeatable products, lead to cost savings that can be passed down to the consumer. Currently, Prefab is working with a partner on

multifamily, multistory designs that involve repeatable products. Furthermore, during the interview, the Prefab representative noted repeatedly that building the same product increases efficiency in the production process, which yields many advantages, including faster construction speed, increased consistency, and higher quality products.

In a project’s planning and design phase, Prefab actively engages with municipalities to inform them on how modular construction projects are executed and how they adhere to local building codes and regulations. Prefab usually sends its engineering team with the client to meet municipal officials, including the fire marshal. Such engagements with local officials in a project’s early stages help encourage community awareness and acceptance of modular construction.

Moving modules from the factory to the onsite destination requires advanced planning, which Prefab helps coordinate with the general contractors and developers to ensure the construction project’s smooth transition from factory to site. Depending on the area, manufacturers must account for delays caused by traffic, trucks’ turning radii, and the number of units that can be assembled per day. The use of a crane must also be considered when planning onsite assembly because of limitations in height and movement. The manufacturer must consider the time needed to move a crane from one location on the site to another location. Such complex logistics are generally handled by a consulting firm such as Prefab.

Marketing to Consumers

Prefab’s clients are primarily developers undertaking multistory construction projects. Occasionally, general contractors will consult with Prefab when looking for a way to execute projects using modular construction. Prefab’s typical portfolio contains projects in communities with a high demand for affordable housing and high building costs (see exhibit 5 for an example project). The Prefab representative noted that for multistory buildings in these

So, it’s an introduction to the city to help them understand, ‘Okay. This project is modular. This is what it looks like. Here’s what your expectations can be.’

—Prefab Representative

The coordination level . . . it takes to actually transport and then stage products prior to craning [is considerable], again because for multifamily, multistory projects, you have anywhere from 80 to 300 modules going out to a job site.

—Prefab Representative

Exhibit 5 | Chamonix Complex in Vail, Colorado. Affordable Housing Project by Prefab



Source: Prefab Logic. n.d. “About Prefab Logic: Featured Project.” <https://prefablogic.com/about/>

communities, modular construction offers definite cost savings compared with traditional, site-built construction.

The challenge to educate the general public on the benefits of modular construction remains, however. The Prefab representative reported encountering negative perceptions associated with modular construction projects. Those negative ideas stem from perceptions of HUD Code manufactured housing and pre-HUD Code (that is, pre-1976) mobile homes, wherein people believe that nontraditional building methods are of low quality and less value. Many older mobile homes continue to shape such perceptions, and people do not understand the difference. From Prefab's point of view, the most important factor for communities to accept modular housing is for them to observe the high speed of construction and the high quality of the finished product. To spread positive awareness of modular housing, Prefab uses opportunities such as industry shows, which provide a chance to explain building speed and cost efficiency—which can, in turn, trigger powerful word-of-mouth advertisement.

The Prefab representative noted that, in the past, modular construction was considered a risky investment by developers and financial institutions because of the public perception that modular construction is lower quality. In recent years, however, the company has observed that financial institutions and developers now perceive traditional, site-built construction methods as high risk due to cost overruns, time delays, and vulnerability to lawsuits and litigations that can occur during the construction process.

Construction in modular manufacturing plants combats such risks because prices and delivery times are fixed and do not change over time. Prefab believes that education and increased public awareness will ensure that the modular—and, more generally, factory-built housing—industry will continue to grow. The Prefab representative stated that they have already seen a rise in popularity compared with when they first started in the industry in 2015.

Well, it really came down to people being able to witness the power of modular construction. From our first project on, people would have again a stigma. And then all of a sudden, they would see this building rise out of nowhere in a matter of weeks and finished off. And people started to accept it.

—Prefab Representative

Financing

Prefab consults with clients (developers) after most funding has been acquired. Unlike conventional site-built construction, modular construction requires substantial funding at the beginning of the project because all materials must be present inside the factory before construction starts. Traditional, site-built construction differs because materials are purchased and brought on site as needed.

Prefab reported that this frontloaded funding requirement can be challenging when financial institutions are unfamiliar with modular construction methods. In other words, modular construction's significant upfront costs can appear risky to lenders. Helping financial and other institutions better understand factory-built projects can alleviate some of the perceived risk. For example, Prefab has encouraged those institutions to send inspectors to the factory in the same way they would tour a traditional construction site to physically see the materials (for example, wood, tools) set aside for the specific project and to witness the progress over time.

Policy Recommendations

Government regulations and building codes vary across municipalities throughout the country. The Prefab representative noted that these variations in regulations yield additional, unnecessary costs to production, such as a reduced ability to streamline tasks and decreased efficiency in the production line. For example, regulations for accessibility and plumbing can vary between municipalities, necessitating extensive research before Prefab works in a particular area, leading to higher costs for consumers in new areas. The Prefab representative suggested that standardizing building codes would increase efficiency in the factory and cited HUD Code manufactured housing as an example. HUD Code manufactured housing is standardized to a national-level code for manufactured housing, which allows manufacturers to take an order and immediately begin the construction process without the need for further research.

The cashflow on one of these projects is considerably faster on the front side because the manufacturing facility—one, they have to buy the materials out[right] earlier. But two, the manufacturer sets the pace with respect to traditional construction that it basically takes down a large percentage of the financing at a quicker pace.

—Prefab Representative

[With manufactured HUD homes 'mobile homes'], as long as you were building with the HUD Code, it didn't make a difference what manufacturer you were, what region you were in. You could take an order immediately and start building it because you had all the code references for those standards.

—Prefab Representative

We have 50 states, and everyone is different . . . even municipalities. Imagine the efficiency if you could standardize [codes and regulations]?

—Prefab Representative

Summary of Findings

- **Combating stigmas associated with modular homes and factory-built construction generally is an ongoing challenge for manufacturers and consultants in the factory-built industry.** Although progress has been made in recent years regarding public perception of factory-built homes, including modular homes, ongoing education is still needed. Witnessing the speed and quality of modular construction firsthand can also significantly help mitigate negative perceptions of modular construction.
- **Securing funding for multistory factory-built construction projects can be a challenge because of the large upfront funding requirement.** Factory-built construction projects often require the purchase of materials at the beginning of a project, in contrast to traditional, site-built construction methods that allow for the purchase-as-you-go method. Financial institutions may perceive the need for upfront funding as risky because they must trust that the work will be completed on schedule as agreed upon with the developers and manufacturers. To alleviate this uncertainty, Prefab encourages financial institution representatives to tour the factory in the same way they would a site-built construction project.
- **Substantial variations in building codes and regulations across the country decrease the efficiency of the production line.** The variation in building codes across municipalities leads to increased costs and decreased efficiencies in the production process because factories must adapt their product to satisfy building codes specific to each municipality. The Prefab representative noted the importance of meeting with municipal officials early in the planning and design of projects to ensure that designs meet local codes and regulations. Prefab works with architects in the planning and design of projects to use standardized and repeatable designs to produce cost savings; however, a uniform building code for factory-built construction would eliminate variation in local building codes and allow for much more efficient and affordable factory-built housing.

Industry Outlook

According to Prefab, standardizing codes and regulations and spreading awareness about the benefits of modular construction are the two most effective ways to increase the growth of modular construction. Prefab believes attitudes toward modular housing will continue to improve as the public witnesses the speed of construction and the high quality of the final product.

Lessons Learned from Prefab Logic

This case study of Prefab Logic demonstrates the challenges a factory-built company can face, including perceptions of factory-built housing as low quality, difficulties financing multifamily factory-built housing projects because of high upfront costs, and variations in state and local building codes that can increase production cost. The other seven companies included in this study also discussed these issues and, as a result, chapter 5 includes increasing education on the benefits of factory-built housing, developing guidance for financing factory-built housing, and investigating the potential for a standardized regulation of factory-built housing in recommendations to HUD.

Case Study 2: Impresa Modular—Martinsburg, West Virginia










Company Background

Impresa Modular (Impresa) is an offsite custom modular homebuilder. The company plans and implements the whole lifecycle of the homebuying process and function as an intermediary between the factory and the consumer. One of Impresa’s biggest assets is the network of factories it works with, which helps ensure that Impresa can provide its services nationwide. Its unique strength is that consumers can access the Impresa website to have a complete virtual homebuying experience. Impresa plans the scope of design work and connects the homebuyer with a local modular home consultant who identifies the appropriate factory, local contractors, and financing options.

The company does not directly manufacture homes in a factory but instead works with approximately 25 factories across the nation to help clients build modular homes. Per Impresa’s website, the size of its network allows it to be the only national builder of residential custom homes, providing consumers with the option to select and purchase their home online in any state through the website.⁴ The company has the capacity to execute a wide variety of roles in a modular construction project, including consulting in the design process, managing the home delivery schedule, assisting with financing, and providing project and technical support. In addition to having individual customers who purchase single-family homes, Impresa works with developers and owners of multifamily housing projects, including student housing and commercial projects such as banks, municipal buildings, and restaurants.

In 2019, Impresa franchised its business model, offering the opportunity to educate the industry about the modular construction process and correct common misunderstandings about the modular construction process, especially in the multifamily housing sector.⁵ Its website offers franchising opportunities tailored to a variety of backgrounds in the homebuilding profession, such as entrepreneurs, architects, developers, real estate agents, and commercial builders. Access to Impresa’s business support systems (for example, marketing, payroll, customer communications) is included in the franchise offerings, alongside trainings for the modular design process, business and accounting, and marketing and sales. Interested parties can navigate Impresa’s website to view the seven steps of the franchise awarding process, which starts with a

Exhibit 6 | Projects by Impresa

PROJECTS		
SINGLE-FAMILY HOMES		✓
MULTIFAMILY HOMES		✓
HUD CODE MANUFACTURED HOMES		✗
TINY HOMES		✗
CONTAINER HOMES		✗
ACCESSORY DWELLING UNITS		✗
AFFORDABLE HOUSING		✗
LUXURY HOUSING		✗
COMMERCIAL OR NONRESIDENTIAL BUILDINGS		✓

⁴ For more information, see the Impresa Modular website: <https://impresamodular.com>.

⁵ “Franchising” is a technique of distributing products or services involving a contractual relationship between a franchisor—a company that has established a brand name and a business system—and a franchisee that pays a royalty for the right to do business under the franchisor’s name and system.

request for information and ends with final approval and creation of a franchise agreement. At the time of the interview, the COVID-19 pandemic was affecting the rollout of the franchise program, but Impresa was hopeful that its model will grow in the coming years.

Manufacturing and Construction Process

Planning and Design

The Impresa representative described the planning and design of projects for Impresa’s two primary customer groups: individual consumers and developers. An individual consumer who is looking to build a single-family residence can choose from two methods for floor plan development. In the first approach, the customer brings ideas or a set of plans for Impresa’s team to “Modularize™.” The team develops plans or adjusts existing plans to fit modular construction production specifications, while trying to keep the original architectural characteristics intact. For example, the customer plans may include certain openings or opening sizes that would increase the cost of modular construction, so the team works to adjust the plans to bring down those opening-related costs.

For the second method of floor plan development, the single-family home consumer can select from a preexisting base plan that Impresa provides. Impresa then works with the consumer to incorporate any requested modifications to the existing plan. For both methods, Impresa works with the consumer so that they understand repeatable designs have faster production and installation rates, and aesthetic customizations add time and cost to their project.

When working with developers, the main consideration in the planning and design stage is to create an aesthetically appealing product at a reasonable price. Because a great deal of time and strategy are invested in the home design process, Impresa carefully considers ways to reduce the cost and production time for both factory and onsite processes (the Impresa representative said, “Every dime counts, and every dollar counts [such] that if it’s not going into something useful, it’s wasted”). This careful approach in the design stage of developer projects keeps costs low, especially if the project uses a limited number of repeatable designs. To clearly communicate project costs, Impresa staff use spreadsheets and related costing mechanisms to build an estimate for the developer.

Fewer [uses of the crane] and less work on site, less transportation costs, less finish cost, because time is money. The more work they have to finish on site, the more expensive it becomes. Honestly, when you’re talking design, it’s really the most important factor when it comes to the cost effectiveness as far as with that actual building portion.

—Impresa Representative

Transportation is an essential factor in the planning phase of both single-family and multifamily projects. In discussing their experience with crossing state lines, the Impresa representative noted that the size of modules is limited by transport regulations regarding oversized loads and

superloads. An oversized load is approximately 14 feet wide, whereas a superload is approximately 16 feet wide (Oversize.io, 2021). Size load regulations and permit fees vary from state to state and can affect the cost of a project. Among the services provided to the consumer are cost and planning for module delivery to the site.

Impresa gave several examples about how transportation considerations are important in the planning and design phase of a project (exhibit 7 provides an example of module transportation). For a recent project in New Jersey requiring superload transportation, Impresa mapped out the route from the factory to the construction site through Delaware due to certain superload regulations in New Jersey. This resulted in an additional transportation cost, as Delaware regulations require a \$500 fee to obtain a superload permit. In another recent project with more than 250 units, transport fees totaled more than \$80,000 because Ohio required a State Police escort because the route included bridges that were too low. In this instance, the transport team had to navigate around the bridges by use of highway entrance and exit ramps. Impresa knows firsthand that transportation regulations can dramatically increase the cost of a project. The Impresa website explains that obstacles and limitations to transporting modules that most people do not think of may arise, such as narrow roads, narrow bridges, power lines, trees and hills, mountain tops, and water view sites. In most cases of hard-to-access sites, Impresa’s transport team can deliver modules with the help of engineering ingenuity, preparation, and access to the proper tools and equipment upon transport.

Exhibit 7 | Module Transportation



Source: Impresa Modular

People always asked us what determines the size of your modules. People think it's the factory, it's a limitation, it's a It's not. It's transportation.

—Impresa Representative

Impresa helps the consumer think through instances of local municipalities’ requirements that may affect the overall design of the home. They discuss any additional code requirements with the customer during comprehensive interviews in the early stages of the project. In addition, the factories Impresa works with have their own inspection and quality assurance systems to ensure that units are constructed to the relevant area and state building code.

Offsite Activities

Once a design is finalized, Impresa provides the specifications to a factory in its nationwide network and places an order. The company strategically selects factories to ensure that at least three are available to partner within any given region. With multiple factory options, Impresa chooses a factory for a specific project on the basis of indicators of the factory’s capabilities, such as price, production time, and technical capabilities within a given area. The company noted that 85 percent of capabilities are similar across the factories; the other 15 percent are specialties within each factory, such as the ability to create vaulted roofs, low-cost construction methods, and absence of material backlogs that affect production time. Among all Impresa partner factories, quality assurance is built into the assembly line to ensure that homes are built to the proper state and local code requirements where the home will be sited.

In working with different factories, Impresa staff have learned about the efficient processes employed by each factory. The company sees itself as uniquely positioned as a repository of knowledge of best practices in the industry; because the modular construction industry is very competitive, companies do not share proprietary methods with each other.

Onsite Construction Activities

Although Impresa does not construct factory-built housing, the company develops designs that incorporate multiple build systems, such as modular and panelized construction, through its Advanced Modular Off-Site Solution® (AMOSS) tool. Impresa’s website states that the AMOSS approach “involves the utilization of multiple build systems to complete a home, a project, a building, or a community with the dominant system being modular construction.” The website also provides an example of a project that combined modular construction with

panelized construction and notes that this combination can be very cost effective when “building high” (multiple stories). For example, first-floor home modules (installed on a pier foundation; top right square in exhibit 8) can be set in the early morning, the panelized roof and second-floor walls set by mid-afternoon (bottom left and right squares in exhibit 8), and the roof shingling by evening (top left square in exhibit 8).

Materials (Inputs)

Most factories Impresa works with have jigs and other tools that improve the efficiency of the assembly line. Regarding the use of highly automated tools, the representative stated, “Factories aren’t nearly as robotic as a lot of people think.” Typically, the process involves modules being moved to various lines for workers to make individual contributions to the module unit.

Exhibit 8 | AMOSS® with Impresa Modular



Source: Impresa Modular

Impresa also provided insight about the impact of materials on final product affordability. The representative noted that buying in bulk is one way to incorporate savings into the final product. Also important is to look at every aspect of the production process for ways to reduce time, materials, and labor costs. Impresa stressed the value of using materials that serve multiple purposes; for example, using a vapor barrier paint successfully combines two steps into one (installation and paint application).⁶ Impresa highlighted the fact that small cost savings can add up quickly and have an impact on the overall cost of the project.

And if I can save one thing, one butt joint in the factory, I can save 15 minutes of process time, I can save all that material three coats, I can save all the labor . . . I just saved a lot of money per house. And if I can save \$100 a house, \$200 a house, \$300 a house by doing things like that, all of a sudden, now I can sell it for less money to the builder who hopefully will pass that along to the consumer.

—Impresa Representative

Marketing to Consumers

Impresa refers to itself as the *customer* of the factory, with homeowners, contractors, and developers as the *end users*. For single-family homes, Impresa works with clients on modular designs in person or through their website. They estimate that 20 percent of their single-family-home consumers request partially completed projects and provide their own plumbing, electricians, and other handyman work. For those consumers, Impresa provides modules that are mostly completed in the factory (65 to 85 percent), and then the consumer or designated subcontractor completes the remaining tasks on site after home installation. For the other 80 percent of single-family projects, Impresa works directly with a contractor or builder and provides 100 percent-complete modules.

As a nationwide builder, Impresa includes detailed information on modular building on its website, which is easy to find. The website provides interested parties (consumers, developers, and contractors) access to a Getting Started Guide that “will help you plan your project, save money, and avoid many pitfalls.” The website allows customers to connect to a modular home consultant in their area, choosing from sales representatives in Impresa’s nationwide network. The consultant then helps the consumer think through the design of the home and selects a manufacturer that best suits the needs for the project.

Impresa developed its current network of 25 factories over several years. Selection of the geographic locations of their factories is driven by a sales perspective: Most factories can support a consumer base within a 5-hour transportation radius.

⁶ A vapor barrier is a material, typically a plastic or foil sheet, used to prevent water vapor from diffusing into the wall, ceiling, or floor of a unit (for more information, see CertainTeed, n.d.; IKO Commercial, n.d.).

The general public, as well as construction stakeholders such as realtors and appraisers, may be confused about the difference between modular and HUD Code manufactured housing. Impresa employs a marketing strategy that aims to clearly highlight the difference between modular and HUD Code manufactured homes. The Impresa representative stated that they prefer the term “*modular* to be classified as an industrialized building systems methodology.” They believe that moving away from the term *modular* and instead using the term *industrialized* for education and marketing purposes will reduce confusion on the difference between HUD Code manufactured and modular housing.

Impresa is part of a joint effort with the Modular Home Builders Association (MHBA) to promote awareness about the modular construction industry. The MHBA runs a consumer awareness program (CAP) to educate homebuyers about the benefits of modular construction through various channels, including ads on social media and radio spots.⁷ A key message of CAP is the strength and resilience of modular construction compared with traditional, site-built construction. In addition to promoting the modular industry through CAP, MHBA focuses on advancing the legislative interests of the modular industry in the United States.

When you look at a hurricane or a tornado that hits [a region], [a] modular home is the one that stays together because it's like taking Legos and assembling and locking them together. And that segment or that modularization actually builds an inherent strength into the house.

—Impresa Representative

Impresa’s website also highlights an article about the 1992 FEMA study, *Building Performance: Hurricane Andrew in Florida*, which found that “modular homes weathered the storm better than their site-built counterparts.” Impresa emphasized there is a need for the modular industry to coordinate and systematically educate various stakeholders—including building inspectors, appraisers, and realtors—about the benefits of modular construction.

Financing

The Impresa representative discussed different processes for financing single-family housing and multistory buildings. Consumers typically finance their single-family homes through a construction loan.⁸ In Impresa’s experience, factories generally require an initial 10-percent down payment and the remaining balance upon delivery of the home module on site.

⁷ For more information, see the Modular Builders Association website at https://www.modularhousing.com/HtmlPage.aspx?name=member_list.

⁸ The Impresa website describes a construction loan as one in which periodic draw payments are made to contractors, subcontractors, and suppliers on the basis of work completed. Monthly interest payments are billed to the borrower.

Financing larger projects such as multifamily or multistory buildings is challenging because lenders who understand the modular construction process are hard to find. In a traditional, site-built construction project, payments are made in installments as work is completed on the construction site. In modular construction, modules are built off site in the factory. From the lenders' perspective, they do not see any work completed on site and thus are hesitant to provide payments.

When modules come offline, they're sitting in the yard but they're not at the job site. They're not installed. So, it's not really construction in a lender's mind.

—Impresa Representative

The Impresa representative described how details of financing vary from project to project for multifamily or multistory projects, and the lack of a standardized process can make securing financing harder. Sometimes payments are made on the basis of the number of modules completed or the percentage of work completed. At other times, a down payment is made when the order is placed, an additional percentage is paid for ordering materials, and so on.

Differences in factories' finance methods and preferences (for example, providing a down payment versus payment upon module completion) sometimes result in increased effort to secure financing on the consumer's behalf. The Impresa representative suggested that government-sponsored enterprises such as Freddie Mac and Fannie Mae could help if they worked with lenders to develop a standardized procedure for financing multistory modular construction projects. Such procedures should clearly establish which party is bearing risk at each point of the production process. The people at Impresa believe that standardizing those procedures would help answer questions such as whether the builder's insurance policy covers modules while they are stored off site.

It all comes down to risk, and define what is it? Could it just be modules coming off of the factory and they are stored off site, so in the event there is a bankruptcy, a fire at the factory—is it an insurable risk? [Is the risk associated with] the lender or the developer, just like we have a builder's risk insurance policy? Does the builder's risk policy reach out to not just items on site? Does it cover completed and paid-for modules in a yard or maybe [at] a third-party site for storage, until they are actually installed on site?

—Impresa Representative

Lenders are beginning to better understand the modular construction process and recognize its advantages over traditional, site-built construction (such as faster construction), and they are becoming more willing to finance modular construction. The Impresa representative thinks that the speedy construction of modular multistory buildings is particularly attractive to lenders and developers, as it enables them to generate revenue faster.

Policy Recommendations

The Impresa representative provided insights about policy changes that would likely increase the adoption of modular construction. The modular construction industry deals with wide variations in modular building codes across states, which drive up construction costs. As an example, Massachusetts requires a double layer of drywall on the ceiling that must be fastened with screws. That state-specific regulation slows down the efficiency of the production line in the factory and drives up costs for modular housing, as it requires an additional step in the production process for modules that are to be installed in Massachusetts. Having a single national building code for modular construction would help streamline the production process and reduce costs.

My hope for the future would be we would get to some type of international regulation somewhere to the HUD Code, where all of the homes across all of the United States could be uniformly built, and that would reduce a tremendous amount of cost.

—Impresa Representative

In some instances, the modular construction industry is subject to restrictions that are not applied to site-built construction. The representative cited the example of Maryland's 2012 sprinkler law, whereby all residential structures in Maryland are required to have a sprinkler system (for more information, see Garrett County Government, 2012; National Fire Protection Association, n.d.). According to Impresa, site-built construction was given a year and a half to implement the change, whereas modular construction was required to implement the change almost immediately; the underlying assumption was that those protocols were easy to implement in a factory setting. The sprinkler requirement added a \$4,000 to \$6,000 premium to the cost of modular homes; the Impresa representative noted, "These little things happen a lot. The MHBA lobbies [in] a lot of instances to remove the impediments that hurt modular off-site construction."

Summary of Findings

- **Modular housing companies can capitalize on aspects of production and materials that can add up to big savings for consumers.** The Impresa representative noted the benefits to being able to buy in bulk and purchase materials with multiple uses to drive down costs. Because modular construction, unlike onsite construction, typically produces multiple units using standardized processes, those small changes can lead to big savings.
- **A systematic training program is needed for stakeholders such as realtors, appraisers, and building code inspectors to educate them about modular construction.** Impresa's affiliation with MHBA's CAP facilitates the promotion of modular construction. CAP strives to educate the general public and key stakeholders, such as realtors and appraisers, as there seems to be a widespread lack of understanding about modular construction among those groups. CAP also uses various channels such as social media and radio spots to educate homebuyers about the benefits of modular construction. The Impresa representative expressed that further education and promotion of the differences and advantages of modular construction are critical to combat antiquated negative stereotypes.

- **Impresa successfully increases the visibility of modular housing construction and provides easy access for consumers interested in purchasing single-family modular homes through its well-designed website and nationwide network.** Interested consumers can go to the Impresa website to select and purchase a home that can be delivered to locations in all 50 states. Moreover, Impresa has a network of local modular home consultants across the country who can work with consumers in person. The website provides an easy process for consumers, as they are prompted to think through all aspects of the modular design process. The consumer selects or customizes plans for the home, and Impresa helps manage the project by assisting with budgeting, financing, delivery, and connecting the consumer to a regional manufacturer.
- **Variation in state regulations drives up the cost of modular construction.** State-specific regulations slow down the efficiency of the production line, for example, when additional steps may be required to meet regulations and, in turn, drive up costs. The Impresa representative suggested that having a single national building code for modular construction—similar to how the Manufactured Home Construction and Safety Standards regulate HUD Code manufactured homes—could help streamline the production process and reduce costs.
- **Although lenders are becoming more open to funding modular construction, challenges still exist in the financing process, especially for multistory or multifamily projects.** The details of financing agreements can vary widely from project to project and lender to lender. A more standardized process for financing multistory or multifamily modular construction projects would help lenders better understand how to manage and mitigate potential risks. For example, if modules stored off site are damaged, are those units the lender's or the builder's responsibility? Clearly written contracts that spell out such details can help lenders more fully understand the risk associated with investment.

Industry Outlook

Impresa strongly believes in the quality of modular construction and is eager to see the industry grow. The company is working to expand its business in several different directions—residential single-family homes, multifamily construction, and commercial projects, as well as franchising. They believe that simplifying and streamlining building codes and other regulations will make modular housing even more affordable.

Lessons Learned from Impresa Modular

Like Prefab Logic, Impresa noted challenges related to variations in local regulations, financing, and negative perceptions of factory-built housing. Impresa's website increases the visibility of factory-built housing and may help overcome negative perceptions by offering single-family home designs and pictures demonstrating the quality of factory-built homes. Another important finding from the Impresa case study is that contracts that clearly define liability and risk can help with obtaining financing for multistory or multifamily factory-built housing projects. That key finding is highlighted in the recommendation to HUD suggesting a need for more guidance around the financing of factory-built housing.

Case Study 3: Dynamic Homes—Detroit Lakes, Minnesota

Company Background

Dynamic Homes (Dynamic) manufactures modular housing and has been serving a variety of consumers throughout the Midwest for the past 50 years. Dynamic produces several types of modular structures, including single-family and multifamily homes; accessory dwelling units (ADUs); tiny homes; affordable and luxury housing; and some small commercial buildings, such as veterinary clinics and chiropractic offices (exhibit 9). The specific types of homes produced (single-family homes, multifamily structures) vary by year, but Dynamic produces about 150 homes per year.

A unique aspect of Dynamic is its emphasis on marketing to tribal communities. Since 2000, Dynamic has been majority owned by Ho Chunk, Inc., the economic development corporation of the Winnebago Tribe of Nebraska (For more information, see Abourezk, 2019; U.S. Department of the Interior, Indian Affairs. n.d.; and the Dynamic Homes website).










The company produces primarily single-family homes; however, in times of economic downturn, such as during the 1980s and the 2008 housing market recession, Dynamic shifted toward commercial, multifamily, and tribal housing projects. Most of Dynamic’s sales are single-family homes sold and marketed through Dynamic’s dealer network, with more than 30 dealer locations across the Midwest.⁹

Manufacturing and Construction Process

Planning and Design

The steps involved in the planning and design phase of each project depend on the type of structure being produced. Individual homebuyer projects begin with Dynamic’s Plan Book, located on their website. The Plan Book shows an array of modular housing options with customizable floor plans and room dimensions, as well as contact information for local, authorized dealers. Using a local dealer or retail outlet means the homebuyer works directly with those representatives before Dynamic is involved in the specifications, design, and pricing processes. The dealer talks to the

Exhibit 9 | Projects by Dynamic

PROJECTS		
SINGLE-FAMILY HOMES		✓
MULTIFAMILY HOMES		✓
HUD CODE MANUFACTURED HOMES		✗
TINY HOMES		✓
CONTAINER HOMES		✗
ACCESSORY DWELLING UNITS		✓
AFFORDABLE HOUSING		✓
LUXURY HOUSING		✓
COMMERCIAL OR NONRESIDENTIAL BUILDINGS		✓

When it comes to a commercial multifamily [project], normally the developer or general contractor, landowner, [whoever is] initiating this is coming to us. Maybe it’s an architect. And we’re working with them directly.

—Dynamic Representative

⁹ Locations were counted using the Dynamic website’s authorized dealer locator function.

customer about the budget, which allows affordability to play a significant role in the overall design. Dynamic and the dealer work together to incorporate designs that satisfy the customer's preferences and fit their budget. For larger projects such as multifamily and commercial projects, developers or contractors typically reach out directly to Dynamic for a quote.

Regarding the design of homes, Dynamic's products can be customized in a variety of ways. The Dynamic representative estimated that about 80 percent of their projects are customized by the customer, including various woodwork elements such as cabinetry, trim, flooring, and siding. The representative interviewed described Dynamic as a "highly customizable high-end modular company" but noted that it also offers standard plans to provide less complex, more affordable options for consumers. Even with the standard plans, customers are still able to customize certain aspects of the home, such as the materials for countertops. Dynamic's standard homes are inexpensive and can be easily produced because they require minimal customization.

Offsite Activities

After the customer finalizes plans, factory production of individual home components begins. Dynamic builds all modules in a 120,000-square-foot factory. Although the elements of each home may vary by type of housing (that is, single-family or multifamily) and specifications, all homes must be built in compliance with appropriate state and local codes; therefore, every module must undergo inspection. In-factory inspection procedures are a critical step in the production process. Modular manufacturers undergo inspections in the factory in accordance with the state codes where the home will be sited. Dynamic's internal Quality Control Department ensures code compliance and consists of three specific people in the factory and a representative from Minnesota's Department of Labor. The state inspector approves plans before production and physically inspects the components in the factory. These rigorous inspection procedures vary by type of housing. In terms of time and expense, inspections and approvals for single-family homes are less burdensome than those required for multifamily homes.

Volumetric construction will be a larger part of Dynamic's business in the future.¹⁰ The company plan to use repeatable modules on a large scale to positively affect production for both single-family and multifamily housing projects. By incorporating more repetition in the design and execution of modules, Dynamic will gain greater efficiencies than it would in designing highly customized projects. For example, they have partnered with a developer to produce workforce housing, which may consist of one or two large apartment projects per year with repeatable modules.

¹⁰ Volumetric construction involves the offsite prefabrication of individual three-dimensional units of enclosed space that are then connected on site to form a single building.

Onsite Construction Activities

After completion of the factory production portions of the project, activities related to onsite construction begin. The components produced in the factory are ready to be sited onto the foundation using cranes. The process of siting involves meticulous planning, especially in terms of logistics. In the final stages of the project, Dynamic is responsible for obtaining transportation permits, delivering the modules, and setting the modules on the foundation using cranes (see exhibit 10). The onsite construction process for factory-built

housing differs depending on the type of housing being constructed, especially with respect to the duration of Dynamic's involvement. In the case of single-family homes, preparations of the homeowner's lot, including the foundation, are carried out by an authorized independent builder. Dynamic then delivers the modules and sets them on the foundation. Once the modules are set on the foundation, Dynamic's involvement ends, and responsibility for the project transfers to the dealer. For multifamily or commercial properties, Dynamic conducts extensive planning to review each project in collaboration with developers, subcontractors, architects, engineers, and a local building inspector. For larger projects such as multifamily structures, Dynamic finds a piece of land near the construction site to be used as a staging area for storing multiple modules. The crane is an expensive element of onsite activities, so the short distance between the project site and staging area expedites the siting process, which reduces the project's overall construction burden and cost.

Transportation represents a major component of the cost because housing components are oversized, requiring special transportation vehicles and permits. The distance traveled also plays a key role in transportation costs. To keep transportation costs lower, Dynamic serves customers in states within approximately 400 miles of its factory, including Minnesota, North Dakota, South Dakota, Wisconsin, Northern Iowa, and parts of Nebraska.

Exhibit 10 | Onsite Installation of Commercial Project



Source: Dynamic Homes

Dynamic elaborated on the advantages of factory-built structures in contrast to traditional, site-built construction. One advantage is that temperature-controlled factory production reduces the deterioration of construction materials that occurs when they are exposed to unpredictable weather conditions. Furthermore, producing units indoors allows Dynamic to operate in all weather conditions, unlike traditional, site-built construction. The factory system also offers financial advantages due to the speed at which multifamily units are installed. For example, for a 36-unit apartment building in Minnesota, Dynamic set modules in late September and made modules available for renters in early January. The company representative also explained that the financial gain resulting from an accelerated installation timeline is an important selling point for developers and investors.

Labor

The skill set required for building a home in a factory differs from skills needed when building a house on site. For example, traditional, site-built construction may require workers to be proficient in multiple skills, such as roofing, flooring, and plumbing. By contrast, factory labor can rely on workers who are proficient in one skill rather than multiple. This single-skill distinction can be advantageous because it widens the selection pool for recruiting while reducing and streamlining employee training for *one* specific skill.

Although the factory-built production process does not require workers with multiple skill proficiencies, finding workers to fill positions is nevertheless challenging. For example, the Dynamic representative noted that the factory uses “tables, jigs, overhead cranes, etc.” to increase company efficiency and consistency, but using those tools requires a basic skill set that many younger workers lack. To address such skills gaps, the company now provides more rigorous and extensive training than was previously needed. The Dynamic representative suggested that offering basic training to build skills in high schools or other educational institutions could help address the labor shortage.

Worker retention has always been an important part of Dynamic’s business model. Employees typically stay with the company long term (30 to 45 years). The representative noted that if an employee stays 3 to 4 years, then they are more likely to stay long term. High levels of worker retention are important for companies’ realization of production efficiencies. The Dynamic representative noted that many of their lifelong employees who have helped realize the efficiencies described are retiring. Replacing those workers has been a major challenge.

But the advantage of modular is speed and quality The last apartment we built [was] a 36 unit in Cloquet, Minnesota. We set our modules in September 22nd Took 2 weeks to set all the boxes. And so, then you start your stitch-up process . . . we were renting out that apartment the first week in January.

—Dynamic Representative

[In contrast to a site-build] I can have a guy [in a factory] and all he does is build walls, all day long. And that’s what a lot of these guys do. Some guys like to move around; some guys, for 45 years they’ll do one thing.

—Dynamic Representative

Investing in employees from the beginning by providing training in the factory is crucial to the continued success and efficiency of the business.

Materials (Inputs)

Dynamic uses traditional equipment in the building process, such as tables, jigs, and cranes, which rarely wear out and can be used for decades; however, the true innovation in their production process comes in the form of materials used, particularly engineered woods. Dynamic has been able to increase spans through the use of Microllam® Laminated Veneer Lumber (LVL) beams, allowing structures as long as 64 feet (APA—The Engineered Wood Association, n.d.; Martel, 2019; Weyerhaeuser, n.d.).¹¹ LVL requires less labor because workers no longer have to build up materials by placing multiple dimensional lumber sheathings together. Instead, they buy LVL made to order, which results in a high-quality, structurally stronger home. Using LVL is more expensive, but the Dynamic representative noted that the product is of superior quality, and the reduction in labor justifies the higher price of the material.

Another significant technological innovation for production process materials that Dynamic implements is shrink-wrapping housing units in the factory as opposed to manually wrapping them. Wrapping protects modular homes from weather damage when being stored or transported (for more information, see Dr. Shrink, n.d.). In the shrink-wrapping technique, typically the entire module is covered in a shrink-wrap film. Heat is then applied to the wrapping so that it shrinks to fit the module (Rhino Shrink Wrap, n.d.). Dynamic adopted shrink-wrapping nearly 10 years ago, and it has become an important part of reducing cost and labor during production.

Marketing to Consumers

As mentioned previously, modular housing must meet the same building code standards as units built on site (HUD, 2016). The Dynamic representative reported that although their construction adheres to the same standards as traditional, site-built construction, the perception that factory-built housing is of lesser quality presents a challenge when they work in new communities. The representative observed that consumers often confuse modular homes with HUD Code manufactured homes.

Negative/stereotypical narrative from site builders and architects has not helped. We get lumped in with manufactured housing. People assume we build trailer houses. Education is the only way to fight this misconception.

—Dynamic Representative

¹¹ LVL is a type of engineered wood product that consists of many thin (less than one-fourth inch) wood veneers adhered with high-strength adhesives and is typically available in lengths far beyond conventional lumber lengths. Wood veneers are essentially very thin slices of wood.

Exhibit 11 | Marketing Brochure



Source: Dynamic Homes

When asked about strategies used to attract more consumers to factory-built housing, the Dynamic representative reported engaging in typical marketing trends used in site-built construction, such as brochures and other marketing materials and attending housing conventions. In addition, the company reaches out directly to developers, architects, and tribal entities to form new relationships and grow their customer network.

As a tribal-owned company, Dynamic underscores not only the importance of tribal housing as a staple of the company but also the importance of providing opportunities to work with tribal communities during what the representative called “lean housing years.” For example, during the recession in 2008, the federal government incentivized tribal housing development. Dynamic cited a 4- to 5-year period during the recession when 40 to 60 percent of their work was in tribal communities. Those numbers contrast with a

normal production year, during which only 10 to 12 percent of projects are tribal housing. Using marketing brochures such as the one shown in exhibit 11, Dynamic reaches out to specific communities through visualizations and descriptions of the options available.

When the single-family housing market is soft, or when we're in a recession, tribal housing is a larger percentage because it seems like then the federal government is pumping more money into that.

—Dynamic Representative

Financing

Dynamic’s consumer base consists of individual homebuyers who purchase single-family homes through the dealer network and developers that employ the company for multifamily and commercial properties. The company’s factory-built homes are financed using the same options and processes used for site-built homes. Single-family homes are sold through its dealer network,

All the financing is traditional, that the homeowner will go through their local bank and do what . . . a normal 30-year mortgage, or 15, whatever they're doing.

—Dynamic Representative

and the homeowner obtains financing through traditional means, such as a mortgage from a local bank. Although Dynamic does not provide financing for the homeowner, they have relationships with mortgage lenders that the homeowners can use.

Policy Recommendations

The Dynamic representative offered several thoughts on policies to encourage the adoption of modular housing. Challenges in securing permits and funding from local governments, along with the public perception of factory-built housing, can hinder Dynamic's ability to secure a project site. Currently, the company is focused on entering B markets that have a need for housing, but rents are not high enough to attract competition from larger developers.¹² The representative noted, however, that certain subsidies such as tax abatement or tax increment financing (TIF) are needed for them to profitably enter B markets.¹³ One of the biggest roadblocks to entering these smaller markets is determining whether the local governments are willing to provide any kind of subsidy. Currently, Dynamic can spend months working with local governments doing site studies and paying third-party analysts to conduct tests determining the need for TIF, only to have their project rejected at the end of the process. The federal and state governments could help address this problem by developing a working database of communities with accommodating regulatory policies or subsidies for factory-built housing providers, which would (1) provide an option to combat the area's housing shortage and (2) incentivize housing providers because they would no longer need to negotiate with local governments to convince them of the need for factory-built housing.

The Dynamic representative reported that incentives from the federal or state government for factory-built housing providers to work directly with communities would benefit the market. The company believes that federal, state, or local intervention in the form of standardized subsidies and production incentives would reduce the costs of searching for funding sources such as TIF districts, tax abatements, or other tax credits. Further, standardized building codes and permit processes would reduce the time required to complete each project.

The representative suggested several other policies that federal and state governments could implement to encourage the adoption of factory-built housing. The state government could provide property tax relief to modular housing factories, thereby making modular housing more affordable. The federal or state government could promote awareness about modular housing by undertaking a marketing program and educating state, county, and local inspectors about modular housing. If inspectors have a clearer understanding of

Quite honestly, not much has been done. Getting all state/county/local inspectors educated on our product would help. Pilot programs, incentives to build using modular, property tax relief to modular factories. Statewide marketing program using the modular factories in Minnesota. Anything would be a plus.

—Dynamic Representative

¹² B markets refers to growing cities that are outside larger, more well-known areas. B markets have a growing economy, but the housing markets are less competitive than housing in larger markets.

¹³ TIF is a tool used by local governments to finance real estate development costs. The additional property taxes paid as a result of development in a district are used to pay for the development cost.

modular construction, then the inspection approval processes could be more streamlined. To address the housing shortage, the Dynamic representative cited the need for pilot programs, which can help “jump start” modular construction in areas with a need for affordable housing.

Summary of Findings

- **Engineered wood, such as LVL, reduces labor costs while improving the overall quality of the build.** New innovations in materials, such as LVL, reduce the labor required during construction by allowing Dynamic to source the appropriate material rather than create it. By ordering the exact wood specifications needed for a project, the company can reduce the cost and time burden in the factory and provide higher quality materials at a lower cost.
- **Developing housing within tribal communities provides company stability during lean economic periods.** Dynamic uses incentives for and opportunities within tribal communities during economic downturns, such as the housing crisis of 2008. Government incentives allow the company to continue operations at relatively normal levels when others may scale down due to economic downturns affecting their customers.
- **Skilled labor shortages require Dynamic to increase time spent on initial training.** Building a home in a factory does not require workers to have a multitude of skills, unlike with traditional, site-built construction. Nevertheless, the Dynamic representative reported that in recent years finding workers with even the basic skills needed to fill positions has been a challenge. As a result, the company must spend money and time training new workers. Furthermore, the representative observed that retaining trained workers is key to maintaining efficiencies.
- **Limited code standardization and knowledge of factory-built homes hinders Dynamic’s ability to efficiently work with local governments to obtain necessary approvals and subsidies.** Misconceptions and lack of overall knowledge about the processes required for factory-built homes can cause challenges in obtaining necessary approvals and small subsidies from local governments. Often, Dynamic must spend months working with local inspectors and councils to convince them of factory-built housing’s benefit in addressing housing shortages in the community.

Industry Outlook

When asked about the future of the factory-built housing industry, the Dynamic representative offered several thoughts about why they believe the industry will gain market share over traditional, site-built construction. To address the expansion of affordable housing to consumers, they believe that the industry must shift to incorporating more automation, which will drive higher efficiency and lower costs. As part of their company goals for the next decade, Dynamic plans to continue working with Minnesota communities in need of workforce or affordable housing. The company anticipates meeting housing supply demands with larger projects that will further increase modular construction visibility.

We are trying to work with communities in Minnesota that need workforce/affordable . . . housing. I hope within the next 2 to 5 years we will have built enough of these [units] in Minnesota to hopefully spark more interest in modular construction—it is one of the tools that will help solve this housing crisis we are facing.

—Dynamic Representative

Lessons Learned from Dynamic Homes

In contrast to the previous two case studies (Prefab Logic and Impresa Modular), Dynamic Homes manufactures factory-built homes. As a result, the case study offers insight into how factory-built companies can use special materials—in Dynamic’s case, LVL beams—to increase the quality of the homes they produce. The Z Modular and Boxabl case studies, later in this report, also include information on specialized materials that factory-built companies use to increase quality. Finally, a unique aspect of the Dynamic Homes case study is that the company markets to tribal communities. This strategy benefits the company because it can capitalize on government incentives and continue production of housing even in periods of economic downturn, when its other products may be less in demand. Representatives of the other companies in this report did not discuss strategies for overcoming periods of economic downturn; thus, Dynamic Homes stands out in this respect.

Case Study 4: Guerdon—Boise, Idaho










Company Background

Guerdon, a modular construction company in Boise, Idaho, has 15 years of experience producing multistory modular buildings. The company offers unique insights into the best practices of producing modular buildings, including collaboration with the architect from the early stages of the project and continuous and rigorous quality assurance (QA) of both the manufacturing process and product. In addition, the company’s use of technologies such as subassemblies and a 3D drafting program highlights innovations implemented to efficiently produce high-quality modular buildings.

Established more than 50 years ago, Guerdon is a producer of multifamily and commercial projects.¹⁴ Initially, Guerdon built HUD Code manufactured housing but transitioned to building single-family modular housing in 2001. The company found it difficult to operate in both single-family and multifamily markets because of the differences in marketing strategy, design of the structures, delivery methods, and consumers or buyers. Around 2005, Guerdon decided to exclusively produce multistory modular buildings, including multifamily homes, affordable housing, luxury housing, and commercial projects (exhibit 12).

Guerdon primarily produces buildings for projects on the west coast of the United States and Canada. The company serves a large area and has shipped its products as far east as Oklahoma in the United States and as far north as Saskatchewan in Canada. They build approximately 8 to 15 projects each year, ranging from a hotel with 40 modules or 80 suites to multifamily projects with hundreds of living units and hundreds of modules. In the past 3 to 4 years, Guerdon has built 20 to 25 hotels.

Exhibit 12 | Projects by Guerdon

PROJECTS		
SINGLE-FAMILY HOMES		✗
MULTIFAMILY HOMES		✓
HUD CODE MANUFACTURED HOMES		✗
TINY HOMES		✗
CONTAINER HOMES		✗
ACCESSORY DWELLING UNITS		✗
AFFORDABLE HOUSING		✓
LUXURY HOUSING		✓
COMMERCIAL OR NONRESIDENTIAL BUILDINGS		✓

Some plants produce [both single-family and multifamily housing]. We choose to dedicate ourselves to the multistory sector and the multifamily hospitality sector. I don’t think any other factory in the country has been dedicated to that for the last 15 years like we have.

—Guerdon Representative

¹⁴ For more information, see Guerdon’s website: <https://www.guerdonmodularbuildings.com/>

Manufacturing and Construction Process

Planning and Design

Guerdon actively participates in the planning and design phases of the construction projects for which they manufacture modular pieces. An in-house design and engineering team regularly communicates with project architects starting in the early stages of a project. This early engagement ensures that the building plans are compatible with modular construction methods and the structure can be built with minimal waste.

We'll engage with the developer and their architect as early as schematic phase and make sure that the footprint of the building and the unit plans are going to be efficient for a modular solution.

—Guerdon Representative

Guerdon has an extremely collaborative relationship with project architects. In their experience, for most multistory projects that use modular construction, the modular components account for about one-half of the project's construction, while the other half of the project consists of site-built components such as parking garages and community spaces. Typically, Guerdon designs the project's modular components, which are reviewed by engineers and subconsultants working for the project architect ultimately responsible for the overall project design. Guerdon's design team uses a 3D drafting program,¹⁵ allowing both their team and the architect to work collaboratively from one shared basic design instead of trying to integrate components that were designed separately.

Offsite Activities

Guerdon's factory production line has more than 30 stations and includes all necessary equipment and scaffolding. The factory setup also provides flexibility to customize products as needed. Guerdon also has a variety of proprietary subassemblies (exhibit 13), which are separately assembled units

Exhibit 13 | Guerdon Subassemblies in the Factory



Source: Guerdon

designed to be incorporated with other units into a larger product. These subassemblies allow the company to tackle challenges specific to modular construction, such as ensuring secure ceiling-to-floor connections and secure wall-to-wall connections between apartments. The Guerdon representative noted that these proprietary subassemblies have been tested rigorously by third parties to ensure that the subassemblies can be safely used in a building. According to Guerdon's website, the workflow of the manufacturing system allows a higher production rate than onsite construction, as they are able to produce 20 assembled units per week.

Products built efficiently and to a high-quality standard in the factory are likely to have fewer defects. Fewer defects mean less need for late-stage repairs, which leads to cost savings. Moreover, maintenance costs are lower for high-quality products, making the product more

¹⁵ Guerdon uses the 3D building information modeling via Revit throughout its building process.

affordable for both the unit occupant and the developer renting out the unit. A well-executed QA process thus facilitates indirect cost savings.

According to the Guerdon, the factory has in place three steps for inspection procedures. The first step is conducted by the internal QA team within the factory to ensure that modules meet state requirements. Next, supervisors and skilled craftsmen undertake inspections at the line level. Finally, a state-certified third party inspects both the products and the production process. The representative stated that this QA process with a team that consistently inspects production processes and products in the factory setting is more rigorous than that of traditional, site-built construction.

We have full-time QA people in the plant every day, whenever we're building, and we have a third party that's coming in and they're actually inspecting our process more than they are the product to make sure that we're actually following the process.

—Guerdon Representative

The Guerdon representative noted that a major benefit of modular construction in a factory is the reduction of waste and energy usage. Traditional, site-built construction produces more waste, such as truck pollution and disposal of wrapping materials and other debris. By contrast, a factory setting allows parts to be reused and uses larger packing materials, generating less waste on site. In fact, the representative reported that Guerdon's waste-minimizing processes during production allow them to construct buildings with a platinum Leadership in Energy and Environmental Design (LEED) certification, the highest level of LEED rating.¹⁶

We just have a much lower waste stream in our process because we're building in a factory, where we can see the [parts] get reused as a subcomponent, where[as] [on] a site, you typically don't have the ability to hold that material and reuse it somewhere else.

—Guerdon Representative

¹⁶ LEED is a rating system that expresses how efficiently a building is designed and operated. Ratings and rankings of buildings are calculated on the basis of a number of points given to each structure based on its environmental impact. (LD Products Inc., n.d.)

Onsite Construction Activities

Guerdon faces challenges related to transporting modules and materials to the site. Because every state has its own Department of Transportation (DOT) requirements, Guerdon’s transporters must know the DOT regulations for each state to plan an efficient route. They must also take into consideration varying road conditions as part of the delivery process. Furthermore, the Guerdon representative expressed that one of their most significant challenges related to projects in urban areas is obtaining secure storage space within a reasonable distance to house the modules before installation.

When it gets to the site itself, the biggest problem on inner city work, which we do a lot of, is having storage space within reasonable distance of the actual site because you have to store modules ahead of time.

—Guerdon Representative

Guerdon coordinates the transportation of modules from the factory to the construction site. The representative noted that some modular companies deliver modules only partway to the site, which requires the developer to take over during final delivery. By contrast, Guerdon coordinates delivery until the product reaches the site. Once modules arrive on site, the building is assembled quickly by a separate skilled crew using a crane to place units onto the foundation. Depending on the project, Guerdon may be responsible for crane management; at other times, the crane is the responsibility of the general contractor.

Other work on the site, such as finishing the units and making utility connections, is completed by the general contractor and its subcontractors. Guerdon typically has staff on site during the module installation to aid the general contractor. Because the plumbing, water, and HVAC components are completed at the factory, subcontractors can be used on site to finalize the connections for occupancy use. Developers’ use of subcontractors, who are potentially more flexible and less costly, helps reduce costs at project end.

The Guerdon representative described several benefits of modular construction compared with traditional, site-built construction. For a modular project, minimal staff are required on site, and the construction timeline is faster (“weeks, not months”). Furthermore, in the case of site-built construction, traffic around the construction site is affected for months by the ebb and flow of trucks, materials, and equipment transportation, as well as the challenge of adequate construction crew parking. Because modular construction work is performed so quickly on site, city traffic flow disruption is not a significant challenge for urban projects.

Exhibit 14 | Onsite Installation and Construction



Source: Guerdon

Labor

Guerdon has training programs in place to prepare its employees for factory work and to ensure that they have the skills to excel in their positions. Guerdon also invests in helping develop employees' relevant skills. For instance, the company offers a certification program that enables employees to obtain licensing or certifications in the plumbing, electrical, and mechanical trades and also offers an employee apprenticeship program.

Marketing to Clients

Guerdon markets its products primarily to developers of multistory residential and commercial building projects. Its main customers are developers or general contractors, but on rare occasion the company directly serves a municipality developing a project as a principal owner/developer. Guerdon has also produced several buildings for the hospitality sector, including for hotel chains such as Marriott, Hilton, and Hyatt. In the residential sector, Guerdon provides products for specific industries in need of an affordable component. The company produces housing that is affordable to middle-income workers and produces resource housing in remote locations for the workforce of industries such as oil (see exhibit 15).

Exhibit 15 | Workforce Housing by Guerdon in North Dakota



Source: Guerdon

Guerdon representatives believe that the quality of the website plays an important role in generating inquiries from developers. The website features articles describing the benefits of the modular system to promote awareness and combat the stereotypes of factory-built housing being of lesser quality. The website also describes Guerdon’s services in depth, which provides consumers information about different aspects of a project’s lifecycle (such as design and engineering, manufacturing, transportation, and onsite supervision and coordination). The representative explained that the sales team constantly follows up on inquiries and reaches out to potential clients through emails and phone calls. In addition, Guerdon representatives attend trade shows to promote their product.

Because our website is so robust and our experience level is so robust, we get leads, phone calls, emails on a daily basis, and that’s actually maintained pretty steady in the [past] 6 years.

—Guerdon Representative

The Guerdon representative acknowledges that the public has negative perceptions of modular housing, such as (1) that modular housing and HUD Code manufactured housing are the same and (2) that HUD Code manufactured homes are low quality. In the representative’s opinion, developers seek out their services as a solution to problems that cannot be addressed through traditional, site-built construction methods and in response to the rising costs of traditional, site-built construction.

Financing

The Guerdon representative believes that banks and financial intuitions may also carry negative perceptions about modular housing. They believe the finance industry views modular construction as posing a higher risk compared with traditional, site-built housing. This perception of increased risk stems from certain ideas about modular construction, such as (1) modular products require significant upfront funding compared with traditional, site-built products, which require small funding increments over time; (2) modular products are low quality; and (3) resale value may be affected by the perception of modular products as low quality. These ideas foster resistance to financing modular construction projects, which, according to Guerdon, is the most significant challenge facing the modular construction industry.

To mitigate those negative perceptions, Guerdon actively educates banks and construction lending groups on the benefits of modular construction—specifically, how modular construction is faster than site-built construction without compromising quality. The representative interviewed stated that they make efforts to “make sure that we educate the construction lending group[s], how the project is going to be improved and their risk is going to be mitigated by using a modular solution on appropriate projects.” The Guerdon representative reported emphasizing to bank professionals that the shorter timeline for construction makes modular projects less risky investments that can start generating revenue faster than traditional, site-built construction projects. The company provides banks with examples of how modular construction can streamline production and installation, such as how onsite activities such as laying the foundation can be executed simultaneously with the construction of modules in the factory. Moreover, several rounds of QA in the factory ensure that the product is of high quality.

Policy Recommendations

The Guerdon representative believes that the modular construction industry would benefit immensely if HUD attempted to increase awareness about modular construction among banks and other institutions that finance construction projects. The representative also suggested that HUD implement its own modular construction projects (or HUD-subsidized projects) to help reduce banker biases against modular construction. Further, HUD can promote the use of modular construction by offering incentives to developers for undertaking modular construction projects. That kind of support for and promotion of modular construction from a federal agency would, in the Guerdon representative's view, help mitigate negative perceptions of modular construction not only among banks but also among the general public.

Summary of Findings

- **Guerdon's use of a 3D drafting program in the planning and design phases ensures that the project's modular and nonmodular components are well integrated.** Guerdon uses a 3D drafting program that allows its team and the architect to work from the same basic design instead of trying to integrate components that were designed separately.
- **Guerdon's proprietary subassemblies ensure efficient and high-quality modular construction.** Guerdon has a variety of proprietary subassemblies that help solve problems specific to modular construction, such as ensuring secure floor-to-ceiling connections and secure wall-to-wall connections between apartments.
- **Negative perceptions and lack of information about modular construction among banks and other financing sources pose a significant challenge for the modular construction industry.** In Guerdon's experience, the finance industry considers modular construction projects to be riskier investments than site-built construction projects. Guerdon actively communicates to banks the benefits of modular construction, including shorter construction time and higher-quality housing units.

Industry Outlook

Guerdon's 4-year plan is to expand construction activities and serve projects "coast to coast" in North America. As for criteria considerations in selecting new factory locations, the Guerdon representative explained that they "don't really live off a particular local community" because their maximum shipping radius allows them to serve customers 300 to 500 miles in any direction of the factory. Rather, they are driven to have new factories close to areas with higher population density while also aiming to "stay out of the high-cost areas, where labor is in short supply and the price is exorbitant." The representative noted that four to six factory locations across the nation would serve the vast majority of the multifamily market. Regarding their market interest, Guerdon believes that affordable housing and housing for the homeless will be in high demand and would like to specifically expand their involvement in those sectors. The company believes that modular construction has immense potential as a cost-effective way to make housing affordable.

Lessons Learned from Guerdon

A key lesson from the Guerdon case study is the importance of collaboration between manufacturers and architects during the planning and design of factory-built construction. The Guerdon representative discussed their innovative 3D drafting program, which helps the company achieve this goal. Collaboration with the architect is one way that factory-built companies can encourage affordability and successfully implement standardized, repeatable designs. The representative also discussed Guerdon's proprietary subassemblies and how they increase the efficiency and quality of its products. The Z Modular and Blokable case studies (later in this report) also describe proprietary methods the companies use. Chapters 4 and 5 note that the relationship of innovative production methods to affordability is a potential area for future research. As stated in the limitations section of chapter 2, the authors were not able to verify the claims of Guerdon and other companies interviewed that their innovative production processes increase the affordability of factory-built housing.










Case Study 5: Clayton Homes—Maryville, Tennessee

Company Background

Clayton Homes (Clayton), headquartered in Maryville, Tennessee, is one of the largest manufacturers of factory-built housing in the United States and owns 40 building facilities.¹⁷ Clayton was acquired by the multinational conglomerate Berkshire Hathaway in 2003. A majority of the 50,000 homes Clayton builds annually are constructed as HUD Code manufactured housing. Approximately 10 percent of their housing portfolio consists of modular housing, including tiny homes and commercial properties (exhibit 16). After many years of experience with meeting HUD Code’s extensive quality control (QC) and inspection requirements,¹⁸ Clayton has developed an innovative infrastructure to carry out rigorous inspections in an efficient manner. This infrastructure helps the company ensure that it meets the varied code requirements of modular construction.

Clayton is a large company with a vertically integrated structure,¹⁹ with its own mortgage,²⁰ insurance,²¹ and distributor companies. The company also manages and operates its own transportation business, Clayton Connect, delivering homes to the final site for installation; in some locations they have their own installation crew to help set up the home on site. The vertically integrated nature of Clayton’s operations protects the company from the adverse effects of volatilities in the supply chain. Unlike many other factory-built housing companies, Clayton did not experience supply shortages during the COVID-19 pandemic because its subsidiaries build many of their components.

Exhibit 16 | Projects by Clayton

PROJECTS		
SINGLE-FAMILY HOMES		✓
MULTIFAMILY HOMES		✓
HUD-CODE MANUFACTURED HOMES		✓
TINY HOMES		✓
CONTAINER HOMES		✗
ACCESSORY DWELLING UNITS		✓
AFFORDABLE HOUSING		✓
LUXURY HOUSING		✓
COMMERCIAL OR NONRESIDENTIAL BUILDINGS		✓

¹⁷ See the Clayton Homes website: <https://www.claytonhomes.com/>.

¹⁸ Requirements for HUD Code manufactured homes are available at https://www.hud.gov/program_offices/housing/rmra/mhs/mhshome.

¹⁹ A vertically integrated company is one that controls two or more stages of production typically operated by separate companies (Dongoski, 2019).

²⁰ Vanderbilt Mortgage and Finance and 21st Century Corporation are listed on Clayton’s website as its subsidiaries that provide financing.

²¹ HomeFirst Agency is listed on Clayton’s website as its subsidiary that provides insurance.

We're also the distributor, not [in] all cases, but in a lot of cases, we're the distributor. Again, retailer, financier, and insurance as well. So [we're] pretty vested in the industry, certainly vertically integrated.

—Clayton Representative

Manufacturing and Construction Process

Planning and Design

Clayton's in-house design department comprises three architects and five interior designers. The design process for the company's products varies depending upon the type of home being built. For HUD Code manufactured homes, Clayton has fixed number of floor plans, and the representative interviewed said that they allow only minimal consumer customization: "[We] take literally thousands of floor plans and try to develop those into just a few." Minimizing customization allows them to produce high-quality homes at affordable prices. "They [the floor plans] just don't have all the different options that we were doing before. Those options will drive the cost up."

For modular homes, Clayton offers brochures with designs, but often customers customize their chosen design to suit their needs. Customers sometimes choose a floor plan from Clayton's HUD Code manufactured home product line, and the company builds the design as a modular home. Finally, some designers or builders already have a floor plan but would like to use cost-effective modular construction rather than traditional onsite construction.

Whereas HUD Code manufactured homes must meet a single, national standard, modular homes must meet code requirements that vary from state to state. To systematically navigate state-specific building code variations, Clayton consolidated and digitized the state-level codes into six manuals; each manual can be used to build modular homes in multiple states. In the Clayton representative's words, "When they go to North Carolina, different pages will pop up, but the rest of the manual will be exactly the same We just plug things in and out as necessary for the different states." The company also tracks any changes to state-level building codes and implements training in its facilities to ensure that modular units meet any new code requirements. That process has made it easier for an individual factory to ensure that modular units meet all code requirements for the area for which they are being built.

Offsite Activities

Clayton has 40 factories nationwide producing homes in a climate-controlled indoor environment. Those factories can source components, such as windows and doors, from Clayton-owned subsidiaries any supplier in the market. The competition ensures that Clayton-owned suppliers have quick response time and produce high-quality products at affordable prices.

Clayton's HUD Code manufactured and modular housing are on the same assembly line in the factory. This production process allows various workers, such as plumbers, to work on multiple homes in a day. The assembly line production system is efficient, as repetition enables workers to become proficient at their tasks. Industrial engineers observe the assembly lines, track timings

with stopwatches, and provide recommendations for improvements. Clayton has also begun producing houses with smaller floor plans, which allows them to build houses that are of high quality but also affordable.

Where we try to save money is with our buying power and our vertical integration, certainly with our assembly line process. There are opportunities there, and also with the floor plan. Floor plans have gotten smaller. Where we were building bigger two-story Cape Cods, most of our product now is much smaller and more affordable. Not all, but that is the trend. It's smaller, more affordable, but better quality.

—Clayton Representative

Clayton believes its experience building HUD Code manufactured homes has given it an advantage in modular construction. Currently not all Clayton factories build modular homes, but the facilities that do so also build HUD Code manufactured housing. HUD Code manufactured homes have extensive quality control and inspection requirements. As a result, the factories have a well-established infrastructure in place to carry out rigorous inspections and quality assurance (QA) procedures. For both HUD Code manufactured and modular homes, a factory-specific, internal QA department inspects the products and the production processes. Clayton maintains a database of flaws detected in the products or production process during internal inspections. The internal QA team then systematically discusses any problems found in the production process and how to address them. In the case of modular homes, state representatives (state inspectors or third-party agencies) also inspect the products.

In addition to the standard QA process, Clayton has two internal systems—the boss system and the gateway system—to ensure that final products are high quality. Under the boss system, each department inspects the quality of its products before transferring them to the next department. The next department also inspects and approves the product before using it. For instance, the floor department first inspects the flooring before sending it to the wall department, which has to approve the floor before using it. If the wall department finds that the floor does not meet certain quality standards, then the wall department sends the product back to the floor department to be fixed. This system has multiple levels of quality checks because the product moves from department to department as it proceeds through the assembly line. Under the gateway system, the completed home is inspected in a walk-through to ensure high quality of the final product.

Labor

Clayton does most hiring and retaining of workers at the factory level, but it had encountered challenges at the time of the interview due to skilled labor shortages. Clayton engages in various kinds of outreach to address the labor shortage, including attending job fairs to promote awareness of the modular and HUD Code manufactured housing industry as an opportunity for young high school graduates to earn higher wages than they might earn elsewhere. The company also tries to partner with trade schools and local high schools to ensure that students are taught

the construction skills needed to succeed in the factory-built housing industry. Clayton also provides formal training in its factories. The company makes efforts to retain workers by investing significantly in making their factories a safe, clean, and attractive workplace environment.

In the next few years, Clayton plans to increase automation in its factories. They believe that the industry's focus is shifting toward automation due to labor shortages. Clayton has already begun investing in systems to automate production processes and will most likely invest further in robots and machines to automate home assembly.

Materials (Inputs)

As a vertically integrated company, Clayton's business model is based on an efficient supply chain that includes its own subsidiaries and partner companies to provide some smaller parts necessary to construct the house (Daly, 2020). For example, Clayton has its own subsidiaries to supply windows, molding, cabinetry, and doors. This structure offers Clayton the flexibility to seamlessly incorporate quality improvements in products at no cost to the consumer. For instance, they now use higher-quality furnaces and locks in their homes than were used previously. They can offset any cost increase in materials by buying in bulk at lower prices from their subsidiaries.

Marketing to Clients

Clayton recognizes that the general public has a negative perception of HUD Code manufactured housing. This negative perception stems from the belief that HUD Code manufactured housing is low quality or lower value. People have the same negative perceptions about modular housing, believing that modular housing is the same as HUD Code manufactured housing. To disassociate their current products from this negative perception, Clayton prefers to refer to the houses they produce as factory-built rather than specifying whether the houses are modular or

HUD Code manufactured. In Clayton's experience, the negative perceptions dissipate when consumers and developers view the homes and recognize that modular and HUD Code manufactured homes look almost identical to site-built homes.

Financing

The Clayton representative reported that single-family modular homes are financed the same as traditional site-built homes: When a consumer wants to purchase a modular home, they can use Clayton's mortgage subsidiaries or approach a local bank for a home loan. The modular home is appraised in the same process as a traditional, site-built home, and the same lending methods are applicable. On the other hand, potential buyers of HUD Code manufactured homes often face difficulty in obtaining financing. The representative noted, "You go into your local bank and

We couldn't tell the difference between our home and the site-built. They look exactly the same. You really can't tell, and that was manufactured housing. Mod is even more so. You just can't tell the difference. So, most of that stigma goes away when people actually see it.

—Clayton Representative

want financing for a manufactured house or HUD Code manufactured, they're not going to know what to do about it.”

In most cases, a HUD Code manufactured home is not titled as real property and, as a result, can be financed only through a chattel or personal property loan.²² Chattel loans generally have higher interest rates than comparable mortgage loans.²³ The Clayton representative noted that Freddie Mac and Fannie Mae have programs aimed at mitigating barriers to financing HUD Code manufactured homes, including CHOICEHome® (Freddie Mac) and MH Advantage (Fannie Mae), both of which offer affordable financing options for HUD Code manufactured homes that have features typical of traditional, site-built homes.^{24,25} To increase the possibility of mortgage financing for their HUD Code manufactured homes, Clayton developed CrossMod™, a line of HUD Code manufactured housing that qualifies for mortgage financing under Freddie Mac's CHOICEHome® initiative²⁶ and Fannie Mae's MH Advantage program.²⁷ According to the Clayton representative, however, only a few banks and financial institutions are aware of the those programs. As a result, banks often treat CrossMod™ homes as eligible only for a chattel or personal property loan.

Exhibit 17 | Clayton's CrossMod™ Homes



Source: Clayton Homes

Policy Recommendations

Clayton strongly believes that factory-built housing has the potential to combat the affordable housing shortage in the United States. The company believes that the federal government could enact policies that would help make housing more affordable and expand the adoption of factory built as an alternative housing option.

First, many manufactured homes were built in the 1960s and 1970s, before the establishment of the federal standard or HUD Code established in 1976.²⁸ Typically, those older houses have thin

²² *Chattel* is the legal term for personal property, as opposed to *real property*, which typically includes land and the structures on it (for more information, see National Consumer Law Center, 2014).

²³ For more information, see CFPD, 2014.

²⁴ For more information, see Freddie Mac, n.d.

²⁵ For more information, see Fannie Mae, 2021.

²⁶ CHOICEHome® is Freddie Mac's affordable mortgage initiative, which offers traditional, site-built financing for factory-built homes that meet certain prescribed specifications of a site-built home.

²⁷ For more information, see Clayton Homes Website.

²⁸ For more information, see HUD, n.d.

walls and lack proper insulation, resulting in houses that are not energy efficient. The subsequent high energy bills reduce the affordability of the home; thus, newer, relatively more energy-efficient HUD Code manufactured homes are more affordable in the long term than manufactured homes that predate the 1976 code. A federal program that provides financial incentives to owners who wish to trade in their old, manufactured homes for newer, more energy-efficient HUD Code manufactured homes could benefit those who currently reside in the older manufactured homes.

Second, the Clayton representative suggested allowing smaller homes to be exempt from meeting certain energy-related code requirements, which can increase build costs. For example, California's requirement of solar panels on the home²⁹ is not very costly in relation to the overall cost for larger homes, but the representative interviewed pointed out that for smaller homes, that requirement "may be the difference between [a consumer] being able to get a new home or not." Moreover, the representative argued that smaller homes use less total energy and thus "shouldn't have to meet all the same code requirements [as] a larger home."

Finally, a single national standard of building codes for modular construction, rather than codes that vary from state to state or state to local level, would greatly increase the efficiency of the modular production process. The Clayton representative explained that significant time and effort are required to ensure that their modular products meet the building codes in the state or local area where they are shipped.

Summary of Findings

- **Vertical integration protects Clayton from supply chain volatilities and may provide the consumer with cost savings.** Through its subsidiaries and partners, Clayton has access to its own suppliers for windows, molding, cabinetry, and doors, as well as its own transportation company and installation crew to deliver and install modular homes on site. Clayton also has its own mortgage, insurance, and distributor companies that complete the vertically integrated nature of its operations. The Clayton representative argued that the vertically integrated structure provides protection from volatilities in the supply chain and gives them the flexibility to easily incorporate new, higher-quality products at no to low cost to the consumer.
- **Clayton developed a systematic organization to streamline the navigation of modular state building codes.** Building codes for modular construction vary greatly from state to state. Clayton consolidated and digitized the state-level codes into six manuals that can be used to build modular homes in multiple states. The company tracks any changes to state-level building codes and implements training in its facilities to ensure that modular units meet any new code requirements. Consolidating state-level codes and systematically tracking changes to codes enables the factory to more easily ensure that modular units meet all code requirements for each state.
- **Federal programs aimed at easing financing barriers for HUD Code manufactured homes have not been effective.** Typically, HUD Code manufactured homes, including

²⁹ For more information, see Chappell, 2018.

Clayton's CrossMod™ homes, are financed through chattel or personal property loans, which have higher interest rates than comparable mortgage loans. Freddie Mac and Fannie Mae have programs aimed at easing the barriers to financing these homes: CHOICEHome® and MH Advantage, respectively. The programs are not as effective as they could be, however, because only a few banks and financial institutions are aware of the programs. The Clayton representative suggested increasing awareness by “educat[ing] the lenders” and expanding the number of banks that participate in these two programs.

- **Hiring and retaining workers is a challenge.** Clayton has engaged in various kinds of outreach to address the labor shortage, such as attending job fairs and partnering with trade schools and local high schools. The company actively promotes awareness of the factory-built housing industry to ensure that students are taught the construction skills needed and have an opportunity to earn a higher wage than they might earn elsewhere. To rely less on hiring workers, Clayton plans to invest in more automation in its factories.

Industry Outlook

Clayton believes that increased automation is the future of the construction industry. The company plans to invest in more in robots and machines to automate home assembly, increase the accuracy and efficiency of the production process, and make workers' jobs safer.

Lessons Learned from Clayton Homes

As one of the largest manufacturers of factory-built housing in the United States, Clayton Homes has a vertically integrated supply chain that helps it continue to produce affordable homes. Unlike some of the other companies in this report, as a large company, Clayton also has the resources to document variations in state and local building codes across its markets. Both of those aspects of the company represent solutions that increase the ability of factory-built companies to provide standardized, repeatable designs that improve the affordability of housing. Clayton's integrated supply chain allows the company to bulk buy materials and increase standardization of its products. Its building code manuals allow the company to ensure that its designs comply with various regulations in its markets and avoid potential delays that increase costs. Like the representatives from the other companies, the Clayton representative discussed challenges with financing factory-built homes. Unlike the representatives from other companies, however, the Clayton representative noted challenges with financing HUD Code manufactured homes and expressed the opinion that many financiers are unaware of the federal programs meant to encourage financing of these homes. Finally, the Clayton Homes case study includes information on challenges with hiring and retaining factory labor. Other established manufacturers in these case studies also raised this issue, including Dynamic Homes and Guerdon.

Case Study 6: Z Modular—Chicago, Illinois










Company Background

Z Modular is based in Chicago, Illinois. It offers a complete factory solution—including design, fabrication, and building assembly—to provide fully finished modular buildings to its customers.³⁰ Unlike some companies in the modular construction industry, Z Modular does not have roots in HUD Code manufactured housing. Z Modular is a division of Zekelman Industries, North America’s largest independent producer of steel pipe and tube products (for more information, see Rucker, 2016; Zekelman Industries, n.d.). Given this background in steel manufacturing, the company builds multistory modular buildings with steel frames and bases its housing modules around its proprietary building connection system, called VectorBloc®.

The VectorBloc® system is the structural support base of the company’s modular units. According to the Z Modular representative, the VectorBloc® system is revolutionary because it allows for constructing taller modular buildings than previously possible using standard modular construction (for more information, see Rosario, 2019; Z Modular, 2018). On Z Modular’s website, the VectorBloc® system is an important component of what they call the *Z Modular Building Ecosystem*, as it integrates the production process, technology, and workers to ensure that projects are completed in compliance with the timeline, budget, and specifications. The Building Ecosystem operates with an affiliate program that helps other companies build their own modular construction using the Building Ecosystem.

As of summer 2020, Z Modular had four factories, with plans to expand. They also have multiple affiliate facilities across the United States and Canada that use their Building Ecosystem. Currently, the company has multiple large multifamily development projects in the United States and Canada. Their main focus is buildings for the hospitality industry and multifamily housing, including student housing and senior housing (exhibit 18). In the future, Z Modular has plans in place to expand to multifamily workforce and affordable housing.

Exhibit 18 | Projects by Z Modular

PROJECTS		
SINGLE-FAMILY HOMES		✗
MULTIFAMILY HOMES		✓
HUD-CODE MANUFACTURED HOMES		✗
TINY HOMES		✗
CONTAINER HOMES		✗
ACCESSORY DWELLING UNITS		✗
AFFORDABLE HOUSING		✗
LUXURY HOUSING		✗
COMMERCIAL OR NONRESIDENTIAL BUILDINGS		✓

³⁰ See the Z Modular website at <https://www.z-modular.com>.

Multifamily is booming . . . especially workforce and affordable housing. The needs are enormous.

—Z Modular Representative

Manufacturing and Construction Process

Planning and Design

Z Modular offers a variety of services related to the design phase of construction projects, including ready-to-build plans, schematic conversions of traditional onsite projects, and complete design. They believe in having strong involvement in projects early in the planning and design stages. The company representative elaborated on their reasoning for early involvement, noting a project designed as traditional, site-built construction would typically require a significant redesign to fit modular construction; therefore, designing a project for modular construction “can’t be the afterthought.”

The company’s architects and engineers work closely with external architects under a system called “design assist” (Gregory, 2019). Under the design assist system, the construction team (often including key subcontractors) collaborates with the design professional to optimize the building design for modular construction and reduce the time and cost of construction. The company representative noted, “[Architecture firms are] talking to clients every day. We want them to be educated, be able to talk about the system, have a full understanding of it, and be able to design and engineer with it.”

The Z Modular representative emphasized that designing multistory housing to have limited design variation across units is key to increasing production efficiency and lowering the cost of modular construction. In one of their previous multistory housing projects, they incorporated more than 60 different unit types. The significant variation between unit types was challenging because it reduced the efficiency of the production line and increased costs. They learned that the optimal amount of variation for a multistory project is about 12 to 14 different unit types.

Furthermore, involving local officials as key stakeholders in a project’s early stages is crucial to smooth execution of the project. Once a high-level schematic drawing is finalized, the Z Modular team, the architect, the developer, and the general contractor meet with local officials to help them understand the process for executing the project, as well as the project timeline. In addition, invitations are sent to local officials to visit the factory. The purpose of those invitations is to educate officials about the modular construction process and to keep in touch with them throughout the project through periodic check-ins. For example, when components are being moved from the factory to the construction site, “stacking events” are held during which local officials—such as the inspectors, the fire marshal, and the mayor—are invited to watch the building’s assembly on site. The company representative noted, “Some of [these officials] have seen [the construction process] in the factory, but they may have not seen the Legos come together on site. It’s pretty exciting [for them].”

Offsite Activities

As previously mentioned, Z Modular’s entry into the modular construction industry is different from other companies in the industry because its origins lie in the highly automated steel industry. The company representative stated, “We didn’t rise up from manufactured housing; we rose up from steel production.” The representative asserted that in the steel rolling mills of their parent company, Zekelman

Exhibit 19 | Automation in the Factory



Source: Z Modular

Industries, the production process is highly automated, and they have built their modular factory processes on the same principles as industrialized steel operations. Leveraging Zekelman Industries’ experience in lean manufacturing and operations, Z Modular builds homes using a highly automated process that incorporates robotics as much as possible. Their production line includes welding robots, material placement robots, and stud framing machines. They also use fully automated Computer Numerical Control (CNC)³¹ machines that allow the operator to predrill and cut the steel materials with precision, according to desired specifications. To develop specifications, CNC machines use software to visualize and simulate the product design. This process saves the production team significant time and materials because precision cutting ensures that the individual pieces fit together perfectly.

Compared with traditional, site-built construction methods, Z Modular’s construction methods are less labor intensive because they are highly automated. The automated processes provide a solution to the onsite labor shortage by completing most of the work in factories and completing projects with 10 percent fewer workers (see the Z Modular website). Use of the VectorBloc® system allows teams to build structures to any scale with predesigned standard steel-framed modules. Further, building modules with computerized efficiency and design limits wastage of materials.

Once the modules are built in the factory, flatbeds or drop deck trailers transport them to the site. Hayes Construction, Z Modular’s construction partner, undertakes building installation and is responsible for delivery of modules, module stacking, site coordination, and management and finishing of the building.

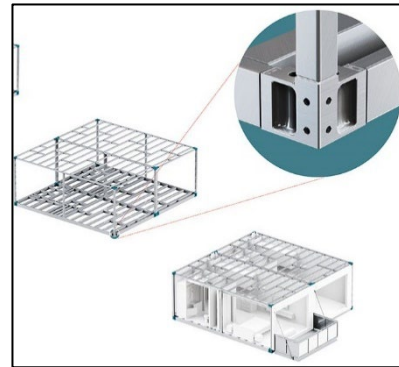
Materials (Inputs)

Z Modular incorporates steel products manufactured by its parent company, Zekelman Industries, into its homes. Sourcing several steel components, such as coil, from its parent company gives the company a supply chain advantage and secures access to inputs needed to produce homes.

³¹ CNC machining is a manufacturing process in which preprogrammed computer software dictates the movement of factory tools and machinery. The process can be used to control a range of complex machinery, from grinders and lathes to mills and routers.

The Z Modular representative described the VectorBloc® system (exhibit 20) as an innovation unique to their company. Under the VectorBloc® system, modules are built with hollow structural sections³² (HSS) and cast steel connectors and are joined together with bolts. HSS are essentially high-strength hollow steel tubes, and according to the company representative, they “form the backbones of the modules [we] build.” As shown in exhibit 20, HSS are connected using VectorBloc® connectors that form steel frames to provide the structural support needed to form the base of the home. According to the Z Modular website, the VectorBloc® system creates modules that are highly standardized.³³

Exhibit 20 | The VectorBloc® System



Note: The zoomed-in portion highlights the VectorBloc® connector.

Source: Z Modular

Marketing to Clients

The company representative reported that they use word-of-mouth advertising among developer groups to gain new business by leveraging recommendations from Z Modular’s previous and current clients to showcase work to potential consumers. They also promote their work through social media and trade shows.

Z Modular’s market area extends to an approximately 500- to 700-mile radius around each of their facilities. In their experience, transportation costs are typically too high for sites that are farther than 1,000 miles from a factory, although there can be exceptions. For example, the company is competitive in the Bay Area in California, which is about 1,200 miles from their nearest factory.

The Z Modular representative noted that modular housing is a “paradigm shift” from traditional, site-built processes to offsite construction: “We’re talking about breaking 100 years or thousands of years of doing [construction] the same way.” In addition, the representative mentioned a negative perception or “stigma that modular construction is manufactured housing.” Z Modular considers education key to changing the public’s negative or indifferent perception to a positive one. In their experience, giving the public insight into the modular construction process facilitates people’s understanding of how housing can be created by way of an industrialized production process.

The Z Modular representative stated that recently, hospitality industries have shown increased interest in modular construction. In the past 5 years, Marriott has established initiatives to use modular construction in its North American hotels (Marriott International, 2017). In one of its

³² HSS are high-strength, welded steel tubes that are used as structural elements in buildings (Steel Tube Institute, n.d.)

³³ Z Modular’s website provides a brochure that describes how use of the VectorBloc® system enables users to construct 30 stories or more. As of July 2021, the tallest module constructed by Z Modular is 6 stories.

most recent initiatives in 2019, Marriott created the tallest modular-built hotel in the world (Marriott International, 2019).

The Z modular representative noted that large architectural firms and general contractors are now also increasingly focused on modular construction. These firms recognize the growing demand for modular construction from their developers and are moving toward having departments that focus on modular construction.

Financing

According to that Z Modular representative, financial institutions do not yet understand modular construction, resulting in a hesitancy to back modular projects. Most developers and financial firms are familiar with the traditional, site-built construction process, which invoices in a piecemeal manner and differs from the modular construction model. In modular construction, a substantial percentage of funds are needed up front to procure materials for production. Z Modular aims to ease financial institutions' hesitancy to finance modular construction by adopting an approach to financing multistory modular construction projects that mimics the financing process for traditional, site-built multistory construction projects.

To appeal to financial institutions largely accustomed to traditional, site-built construction financing, Z Modular approaches funding in a two-phase process. In phase one, the design and engineering phase, the design and engineering team engage with the client (the developer or financial institution) to delineate a payment plan, which is often segmented into 30-, 60- and 90-day periods that correspond to the arrival of different materials to the factory. To invoice for payments,

[The phases are] a highly compressed schedule, but at least it looks similar to what they would see on the conventional construction side. It's just that it's highly compressed. So, we're a little different. A lot of people don't do it the way we do it.

—Z Modular Representative

Z Modular confirms to the client via pictures or videos that materials have arrived in the factory. The client may also send an inspector to the factory to confirm that the materials are in place. Phase two, the construction and execution phase, consists of factory production, transportation, and installation. The purpose of the two-phase process is to mimic site-built construction processes so the client is comfortable making payments. The Z Modular representative noted that their clients are frequently impressed at the speed at which the modules are erected. The representative also noted that an important buy-in feature for financial institutions is observing how quickly large buildings can be completed using modular construction.

The company representative noted that the most important tool to change the financing landscape for modular construction is educating financial institutions about their production process. Starting in 2015, the Marriott hotel chain’s growing interest in modular construction has resulted in its hosting financial forums with industry stakeholders. One major objective of those forums is to educate developers and other financial institutions about the modular industry.

[Marriott] viewed it as critically important to have a forum sponsored by them, to bring these people and educate them and train them, and to include a factory visit. So, they could see it, touch it, feel it, understand it. They all see the speed at which it moves, and it helps them, helps the industry, really helps the financial firms get a better handle on it.

—Z Modular Representative

Policy Recommendations

According to Z Modular, modular construction constitutes only 5 percent of the U.S. construction industry, but it is used more widely in Europe and Asia. The company believes that government adoption of modular construction can help educate the general public about its benefits. For example, the company representative noted that if the government incorporates modular construction in affordable housing projects and undertakes studies to better understand modular construction, those actions will boost the growth of the industry. Furthermore, multifamily housing will have a much more significant impact on combating the affordable housing shortage than will single-family housing, especially in urban areas and semi-urban environments. The Z Modular representative emphasized the need to standardize the designs and layouts of affordable multifamily modular housing to improve production efficiency and decrease production costs.

The company believes that modular construction has great potential for use in affordable housing construction. According to Z Modular, if designs are standardized, modular construction can be used to efficiently produce high-quality, affordable housing. They believe that the modular construction industry lacks understanding about the requirements of affordable housing programs and the use of government incentives such as low-income housing tax credits. The representative suggested that the government educate the modular construction industry further on issues surrounding subsidies and tax credits to encourage modular construction firms to enter the affordable housing sphere.

The Z Modular representative suggested that implementing a national building code for modular construction would greatly benefit the industry. Currently, similar to traditional, site-built construction, building codes for modular construction vary from state to state. The representative noted that, typically, states have licensed third parties to review the products according to state standards. According to the Z Modular representative, a consistent, national building code would improve efficiency and further decrease production cost.

Summary of Findings

- **Z Modular works closely with architects under “design assist” to educate them about the optimal way to design modular buildings.** Under the design assist system, the construction team, often including key subcontractors, collaborates with the design

professional to optimize the building design for modular construction and reduce the time and cost of construction.

- **Z Modular’s proprietary VectorBloc® system enables the stacking of modules taller than what has been possible in modular construction.** Using the VectorBloc® system, modules are built with steel tubes known as HSS and cast steel connectors and are joined with bolts. According to the Z Modular representative, under the VectorBloc® system, modules are highly standardized and built with such precision that they can be stacked higher than previously possible.
- **Z Modular approaches the financing of modular construction projects through a two-phase process that mimics the financing of traditional, site-built construction.** In the first phase of the funding process, Z Modular clearly delineates a payment plan and provides visual confirmation (photos or video) when materials have arrived in the factory, to correspond with invoice payments. The second phase includes factory production, transportation, and installation. According to the Z Modular representative, this approach to financing makes financial institutions that are unfamiliar with modular construction more comfortable with the process.
- **Negative perceptions about modular construction are a challenge for the modular construction industry.** Z Modular considers education the key to changing the public’s negative or indifferent perception to a positive one. In Z Modular’s experience, giving the public insight into their production process allows people to comprehend how housing can indeed be created using an industrialized production process.
- **Incorporating variation in unit designs in multistory housing drives up costs.** The Z Modular representative stressed that designing multistory housing with limited design variation across units is key to increasing production efficiency and keeping down costs of modular construction. Although clients may prefer variation in unit types, incorporating too many variations drives up costs.

Industry Outlook

Z Modular’s work includes multifamily residences, commercial and nonresidential buildings (such as hotels), senior living residences, and student housing. When asked about the future of their company, the Z Modular representative expressed that a major objective is to continue creating efficiencies and standardization in its factory production process. They have chosen project work that allows them to consistently build similar modules, which helps them achieve that objective. The representative noted developers’ positive reactions to its latest models, as they meet state housing requirements and are cost effective. Z Modular plans on expanding into other markets by incorporating workforce and affordable housing into their repertoire.

Lessons Learned from Z Modular

The Z Modular case study mirrors many findings from the Guerdon case study, including the need for manufacturers to collaborate with architects in the planning and design of factory-built housing and the potential of proprietary production processes to increase quality and affordability. The Z Modular representative also described the challenge of negative perceptions of factory-built housing, as mentioned in most of the other case studies. The Z Modular case

study particularly stands out in its discussion of financing solutions for multifamily factory-built housing. The representative provided examples of payment plans the company has used in the past to increase the comfort level of financiers—a good example of a solution a factory-built housing manufacturer can implement to overcome barriers to financing its projects.

Case Study 7: Boxabl—Las Vegas, Nevada

Company Background

Based in Las Vegas, Nevada, Boxabl was founded in 2017 with a mission to develop a building system compatible with factory mass production. At the time of this case study, Boxabl has a prototyping warehouse in Las Vegas and is setting up a factory for its production process that incorporates new building materials and manufacturing methods.³⁴ Their first product is the “Casita,” a \$49,500 studio-style accessory dwelling unit (ADU). The Boxabl representative stated that the Casita has an “8.5-foot shipping footprint [compatible with normal highway load] that unfolds on site in about an hour into a 20-foot [by 20-foot] room.”³⁵ At the time of the interview in November 2020, Boxabl had received 50,000 preorders and planned to ship the first Casita within a year. As of March 2022, Boxabl is still accepting preorders for the Casita.

In the future, Boxabl plans to build other products, such as affordable, tiny, single-family, and multifamily homes. This report focuses on Boxabl’s Casita product and, where possible, highlights their plans for the future.

Manufacturing and Construction Process

Planning and Design

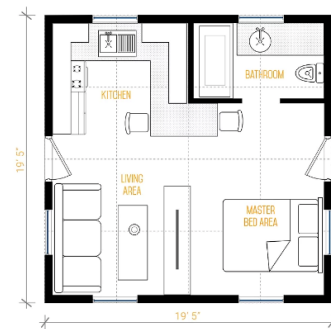
Upon completion of its factory, Boxabl will mass-produce standardized and repeatable building products with no customizations done during the design and production process, at least for the Casita. Their current product has an open floor plan that includes a kitchen with full-sized appliances, a bathroom, a bedroom, a living area, and 9.5-foot ceilings (see layout in exhibit 22). The external appearance of the Casita can be changed once on site to meet a wide range of design requirements, including the color of the home, decks, architectural finishings, and different roof pitches.

Exhibit 21 | Projects by Boxabl

PROJECTS		
SINGLE-FAMILY HOME		✗
MULTIFAMILY HOME		✗
HUD-CODE MANUFACTURED HOME		✗
TINY HOMES		✗
CONTAINER HOMES		✗
ACCESSORY DWELLING UNITS		✓
AFFORDABLE HOUSING		✗
LUXURY HOUSING		✗
COMMERCIAL OR NONRESIDENTIAL BUILDINGS		✗

Note: Boxabl did not complete this exhibit during their pre-interview.

Exhibit 22 | Casita’s Layout



Source: Boxabl

³⁴ Unlike companies in the other case studies, Boxabl is in the preliminary stages of setting up its mass production process. As they implement the plans, their business model may change.

³⁵ See the Boxabl website at <https://www.boxabl.com>.

In the future, Boxabl plans to produce different size room modules (or Boxes) with different interior configurations, such as a kitchen box, a master bedroom box, a two-bedroom box, and a staircase box (a living room with a staircase). The company envisions designing these individual room modules so they can be stacked or connected in different configurations on site to construct single-family or multifamily housing. For example, at the time of the interview in November 2020, the company was undertaking in-house testing and expected the modules to satisfy the fire rating requirements for connecting them together.

. . . maybe we'll have one Box that's a kitchen only, one that's a bedroom only, one that's a living room only, maybe in a few different sizes.

–Boxabl Representative

The Casita was designed to be folded to fit as a highway-legal load, which is typically 8.5 feet wide, so transportation does not require the permits associated with oversized loads and saves on permitting fees, especially when crossing state lines. Moreover, although the Casita is folded during transport, the design allows for unfolded space for the kitchen and bathroom attachments (such as sinks) that are finished in the factory.

Offsite Activities

Since the time of the interview, Boxabl has hired several new factory staff and continues to grow. Boxabl plans for the factory to produce between 3,000 and 5,000 units per year. The new factory will incorporate an assembly line production process with a high level of automation, including the use of computer-controlled cutting equipment (see Materials section for more details).

Exhibit 23 | Casita Module



Source: YouTube, 2020

Onsite Construction Activities

Boxabl will deliver Casitas using trucks, shipping containers, or trains. The module can be shipped anywhere as long as the consumer pays for shipping. It can be moved from the delivery truck to the foundation site without any heavy equipment, such as a crane. For example, the driver could unload and move the module with an oversize forklift to the foundation site because the Casita is equipped with forklift pockets.

According to Boxabl's website, when they start shipping their product, future plans include connecting the consumer with a nearby Boxabl-certified and state-licensed installer. Once delivered on site, the certified installer can use a jack and caster system to drag the module from the truck bed onto the foundation.³⁶ The floor of the modules can be bolted to any type of

³⁶ A caster is a tool that includes both a wheel and bracket. Casters are mounted to an object, which allows the object to move. A jack is a tool used for lifting heavy objects with a minimal amount of exertion by the operator.

foundation using connector plates. The Casita can then be unfolded using a unique bracketing system. The Boxabl representative interviewed said the Casita will “self-seal like a car door.”

Materials (Inputs)

Boxabl uses materials that differ from traditional site-built construction. Site-built homes largely employ wood lumber framing, which the Boxabl representative noted is “incompatible for factory mass production.” Lumber is subject to water degradation and does not guarantee uniform production due to slight variations in individual pieces of wood. Instead, Boxabl plans to use sealed composite panels to build the wall structures in their products, which the Boxabl representative

called a “laminated panel solution.” To form these wall panels, galvanized steel sheets are cut, laminated with Expanded Polystyrene foam for insulation, and merged with other steel sheets. In lieu of sheetrock, the interior part of the wall consists of ceramic boards, which are highly resistant to mold and mildew. The materials used are compatible with computer-controlled cutting equipment. The representative interviewed said that each wall also has a PVC pipe perimeter “that serves as a hinge, a gasket, and an end cap.” The Boxabl representative stressed the durability of the panels, which outperform lumber frames “on water resistance, fire resistance, [and] wind resistance.” In addition, the panels are well suited for the robot arms and other automated equipment Boxabl plans to incorporate in its new factory. The high level of precision helps ensure that each unit can spring into place and click together when unfolded.

Because of the materials Boxabl uses to engineer its current product, the Casita meets the most stringent state building codes. For example, the Boxabl representative said that the Casita will pass the tests for high winds in Florida (due to hurricanes) and earthquakes in California. A third party is testing the safety and durability of the Casita at the time of writing this case study.

Exhibit 24 | Boxabl’s Laminated Panel



Source: Boxabl

So, we're outperforming those lumber frame buildings on water resistance, fire resistance, wind resistance, everything. So, our thought is if we can engineer one product that works everywhere in the whole world versus what they do now, which is engineer a specific house for specific local environmental needs, it's like, okay, maybe there's earthquakes in California, so you build the house one way or high winds in Florida, so you build the house another way. No, we're just building one thing that works everywhere. And because this laminated panel technology is so strong and weather resistant, it's very flexible.

—*Boxabl Representative*

Marketing to Consumers

Boxabl markets its initial product as an ADU or backyard housing because it is an emerging market in California due to law changes that allow backyard houses for most types of existing homes (Sisson, 2019). This product has received nationwide interest, which the company attributed to the popularity of tiny homes in the media (such as TV shows and social media groups). Social media is an integral part of Boxabl's marketing strategy. Initially, the company posted videos online of the Casita unfolding, which received thousands of views. Boxabl followed this marketing strategy with additional videos and other promotional content on social media. They also showcased the Casita at industry shows, such as the International Builders Show 2020.

[When people] actually come in person, they like it [the Casita] even more. And I think that's due to the high ceilings, which are hard to see online.

—*Boxabl Representative*

The Boxabl representative reported that the Casita could be used for purposes other than an ADU, such as for workforce housing, vacation homes, or rentals. For example, the representative stated that one of their first shipments will be for housing on a military base for the U.S. Navy. Boxabl plans to expand its product line eventually, but the representative said “the demand we've seen for our product alone, this small Casita initial product, is incredibly massive. Just this year alone, over a billion dollars in preorders from people who want them.”

Financing

Because the Casita is an ADU, the Boxabl representative speculates that homeowners will likely be able to finance the purchase similar to other ADUs, through a mortgage refinance or a home renovation loan.^{37,38} For new constructions, financing can come from a new construction loan for

³⁷ A cash-out refinance is one way to finance an ADU on an existing home. It is very similar to a traditional refinance, but instead of refinancing for the exact amount of the current mortgage, a homeowner would refinance for a higher amount. The additional funds would then be used to pay off the existing loan and provide additional resources for the ADU (GreatBuildz, n.d.).

³⁸ The Boxabl representative mentioned that Fannie Mae has a program under which the property will be reassessed as if the improvements have been made, and loans will be provided up to that new value (Fannie Mae, n.d.).

the main home and Casita as an ADU. Boxabl believes that once its products are on the market, mortgage and insurance companies will perceive them as low risk due to the wind ratings and water resistance of their products and thus will be willing to offer favorable terms and rates.

I think that the risk from an insurance perspective and of course secondary is a mortgage perspective, they don't want to lose their collateral, they're going to say, "Oh, these houses are water resistant. Oh, that makes it a little safer for us to insure. Oh, these have better wind ratings. Oh, that makes it safer for us to insure. Oh, if a flying projectile hits the wall, it doesn't smash a hole in it." All that stuff I think is going to contribute to less risk for the insurer, that mortgage company as well, once we're up and running and proving.

—*Boxabl Representative*

Policy Recommendations

The Boxabl representative noted that because they can ship the Casita as a highway-legal load, the company does not face the transportation permit fees typically associated with oversized loads. The representative stated that they plan to ship the Casita to locations other companies may consider too far away due to cost increases arising from transportation restrictions such as “extra permitting fees, travel route restrictions, and time restrictions and all the other reasons why that doesn’t work.” As Boxabl expands the geographic area served, however, the company will need to ensure that its products satisfy the building codes in various states. The Boxabl representative also noted that some zoning restrictions specify whether a homeowner may place an ADU in a certain neighborhood. Boxabl is working with Permits.com (Permits.com, n.d.), a company that makes the permitting process easier by collating information from building departments across the country and helping customers obtain the required permits. For example, they help potential customers determine whether local building codes and zoning restrictions allow them to situate an ADU on their property and then obtain the necessary permits.

According to the Boxabl representative, ensuring that its products satisfy building codes in various states is an expensive exercise. Further, even after the product is approved at the state level, the company anticipates its customers will face challenges in obtaining approval at the local government level because the product is new. The representative suggested that a single universal building code for modular housing, in the style of the HUD’s *Manufactured Home Construction and Safety Standards*, would minimize those hurdles (HUD, n.d.).

Summary of Findings

- **Boxabl designed the Casita to be transported as a highway-legal load.** As a result, transporting the Casita does not require the permits associated with oversized loads and saves on permitting fees. As a result, they can ship the Casita to locations other companies may consider too far away from the production facility.

- **Boxabl has successfully used social media to generate an interest in its product.** Boxabl initially posted videos online of the Casita unfolding, which went viral, so they followed this marketing strategy with additional videos and promotional content on social media. The company believes that online videos have been important for attracting people to its product.
- **The Boxabl representative noted that ensuring that its product satisfies building codes in various states requires significant effort.** Even after its product is approved at the state level, the company predicts that its customers may face pushback from local governments because their product is new. The Boxabl representative suggested the establishment of a single, universal building code for modular housing, in the style of HUD's *Manufactured Home Construction and Safety Standards*.

Industry Outlook

The Boxabl representative said that the Casita is well suited to workforce and emergency housing because it uses highly durable materials; leaves the factory 90 percent complete (washer/dryer, bathroom, kitchen appliances); and is easily installed on site. The Boxabl representative suggested that government agencies could potentially use the Casita for disaster relief: "We can send out a thousand of them to a field. They can be set up same day in the field and provide immediate shelter. Later, they can be brought back to the demolished building site and used to rebuild a house that, by the way, is probably going to withstand the next disaster better than the original one did."

Boxabl plans to diversify and grow its product line for new consumers by developing standardized room modules with a few different sizes that onsite installers can stack and join in various configurations. The company aims to develop its building system to be compatible for factory mass production and anticipate using the modules to help alleviate the housing crisis by building affordable single- and multifamily homes.

Lessons Learned from Boxabl










Unlike the previous case studies, Boxabl, at the time the authors interviewed the company's representative, was a new, startup company in the factory-built housing space. As a result, much of the information discussed during the interview was about Boxabl's plans rather than its current operations. One promising finding that future research can verify is Boxabl's unique solution to the issue of transportation costs with its Casita product.

Case Study 8: Blokable—Seattle, Washington

Company Background

Based in Seattle, Washington, Blokable is a real estate development company specializing in multifamily modular construction.³⁹ Founded in 2016, the company aims to create equity in communities by removing intermediaries in the complex traditional housing development process and providing a vertically integrated modular solution. Specifically, they do not sell their modules to third-party developers or builders but develop their own multifamily housing projects. Furthermore, they have integrated real estate development, modular construction, and manufacturing processes to build market-rate and not-for-profit (affordable) multifamily infill housing.⁴⁰ As a real estate developer, they create equity through appreciation of the land and building development. The Blokable representative noted that they can then use the equity to invest in research and development for new methods to further reduce the cost of their standardized repeatable product. Blokable creates high-quality, low-cost multifamily housing developments through their proprietary *Blokable Building System*. The Blokable representative interviewed stated that this innovative system helps design 95-percent factory-complete products and leverages repeatable processes, ensures quality control, accelerates government regulatory approval processes, and creates certainty in cost and timing. The system also provides accurate cost estimates so that Blokable can determine before starting a project if it is economically feasible to develop on a particular site. The Blokable representative reported that this system helps cut down the build time to 2 months during the development phase. At the time of the interview, Blokable has a 60,000-square-foot prototyping factory in Seattle, Washington, and plans to expand its operations to the Sacramento, California, area.

Exhibit 25 | Projects by Blokable

PROJECTS		
SINGLE-FAMILY HOMES		✗
MULTIFAMILY HOMES		✓
HUD-CODE MANUFACTURED HOMES		✗
TINY HOMES		✗
CONTAINER HOMES		✗
ACCESSORY DWELLING UNITS		✗
AFFORDABLE HOUSING		✓
LUXURY HOUSING		✗
COMMERCIAL OR NONRESIDENTIAL BUILDINGS		✗

Manufacturing and Construction Process

Blokable has two components: The first is its real estate team, who are on the ground working to acquire sites in the markets they serve, obtaining financing for their developments, and undertaking other development-related activities, such as site entitlement and obtaining of

³⁹ For more information, see the company's website at <https://blokable.com/>.

⁴⁰ Infill housing is the use of land in an urban area environment, usually open space, for new construction. In Blokable's context, this means being part of a community redevelopment strategy to renew neighborhoods and connect them with more prosperous communities.

predevelopment authorizations. The second is the product team, which includes the research and development,⁴¹ systems,⁴² and production teams. The next two subsections explain the function of each team.

As shown in exhibit 26, Blokable’s proprietary development platform, *BlokSense Development Platform*, helps the company implement its vertically integrated modular solution for a project from design, planning, engineering, financing, permitting, purchasing, modular manufacturing, building, logistics, transportation, onsite delivery, onsite installation, and onsite construction to the processes in place to ensure that every project is implemented according to schedule. The Blokable representative described *BlokSense* as “a set of software tools the team uses that brings together the 3D engineering and architecture of the building with the enterprise resource planning (ERP) systems and supply chain that represent everything that’s in that building.” The platform allows Blokable to develop accurate project cost estimates to inform decisions about whether to proceed, based on the projected return on investment.

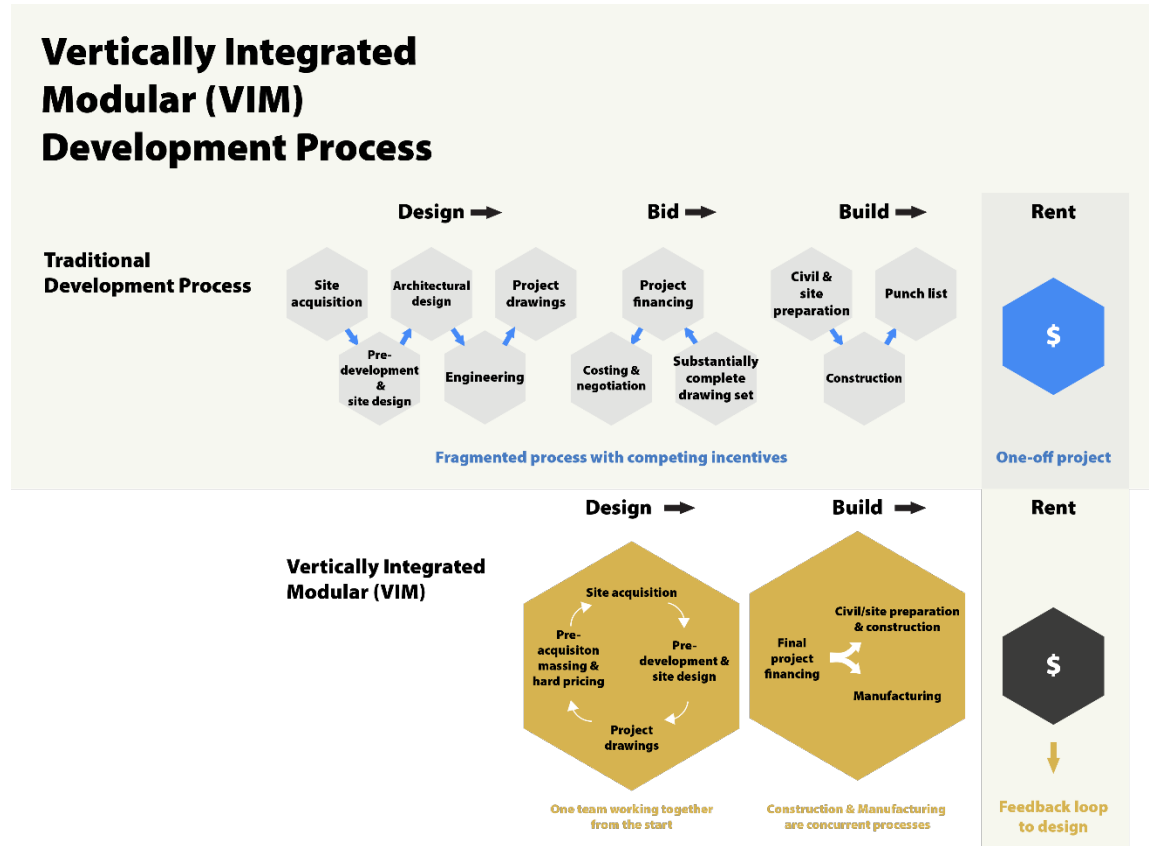
Put that whole building together and then we’re not just looking at a 3D model of it, we’re also saying, “Now here’s everything that’s in there, here’s every beam, every bolt, every sink,” like everything that’s in there is through our supply chain partners, and is costed, so I can say, “Here’s how much that building costs to make,” and then into productions say, “Now let’s order all this stuff that we’ve got to order to build these.”

—Blokable Representative

⁴¹ Blokable’s research and development team includes, but is not limited to, architects, product designers, and mechanical engineers. The current head architect used to work for a city planning department.

⁴² Blokable’s systems team includes a mechanical/electrical/plumbing systems designer as well as software engineers.

Exhibit 26 | Vertically Integrated Modular System Compared with the Traditional Development Process



Note: The Study Team recreated this image from the source noted below.
Source: McManus, 2020.

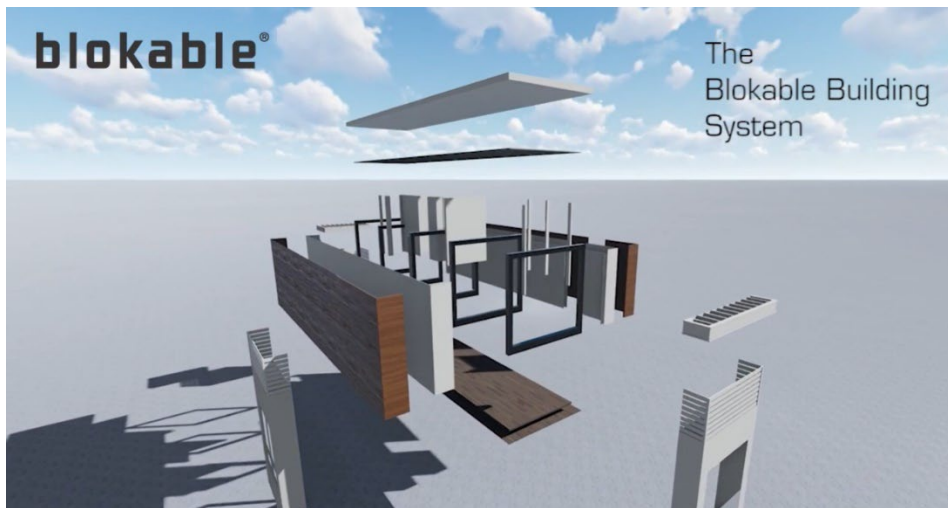
This platform creates a positive feedback loop in which the product team receives design recommendations for product improvements to be implemented in future projects. In addition, Blokable reinvests any equity created by a project in research and development to constantly improve the capabilities and performance of its building system and to lower the cost of building, saving money and thus creating additional equity. According to the Blokable representative, the product development team is “constantly doing research and development to improve the capabilities and to lower the cost of the Blokable building system.”

Planning and Design

Being vertically integrated enables Blokable to be engaged throughout the entire process, from site acquisition and architecture to planning and development of its multifamily housing units. While evaluating a site for development during the initial planning meetings, Blokable is able to develop 3D engineering and architectural drawings of the building using its *Blokable Building System*, which is housed in its *BlokSense Development Platform*. This process helps Blokable determine if a site is worth developing.

The research and development team uses this comprehensive system to design, engineer, and manufacture a “Blok”—a standardized, factory-built modular housing component that can be stacked, combined, and connected to create up to eight-story multifamily housing (see exhibit 27). Blokable can add to each Blok unit a wide range of cladding features, such as decks, railings, stairs, architectural features, and a variety of roof types to create unique designs that match the site requirements. The individual Blok meets the local regulatory requirements across the markets in the four states the company currently serves—California, Idaho, Oregon, and Washington—which helps Blokable build a more replicable product that will pass stringent requirements for single-story multifamily homes in these markets. Currently, the company is focused on ensuring that its stacked product will meet the requirements for eight-floor multifamily housing.

Exhibit 27 | Blokable Building System’s 3D Design and Engineering System



Source: <https://proptechzone.com/startups/blokable/>.

Blokable uses its production team for projects but can enhance capacity by working with its network of local architects, engineers, and contractors, all of whom are trained on the company’s *Blokable Building System*. This system is designed to be a canvas for their architects and network architect partners and offers them flexibility and creativity in design.

We’re not building anybody’s drawings. We have a product, that product is the same every time; no architect would understand how the product works in the first place. So, we wouldn’t work with any architects, because they don’t know how to work with our system—we have our own network of architects who work on every project that we do. Because all the engineering, all the structural, all mechanical, all electrical, everything in our building is already engineered.

—Blokable Representative

The *BlokSense Development Platform* helps coordinate the cloud-based 3D design and engineering system across multiple resources, such as the company’s ERP, supply chain management, and prefabrication machining software to provide an overview of the entire process (schedules, costs, logistics, and so on). For example, this platform ensures that the production team knows which tools, machines, and specific materials are needed to build a given project.

The Blokable systems team works on updating the building information management system that underlies their *BlokSense Development Platform* to ensure that all the systems are coordinating and functioning properly.

And then we have an entire department that just works on BIM, so Building Information Management and so those systems that are underneath it All the 3D models, all the metadata, everything that connects our building system together so that we can kind of put together, pull it apart, create subsystems, create subassemblies, order things from outside, stuff like that.

—Blokable Representative

Offsite and Onsite Activities

Bloks can be assembled to build up to five floors from the ground up or eight floors over a podium.⁴³ The Blokable representative noted that these 95-percent-complete modules are currently constructed in Blokable’s prototyping factory and can be transported to the site “to snap together to create apartment buildings,” as shown in exhibit 27. The Bloks are standardized but can be configured in a variety of ways, from standalone homes to multiunit developments with retail and community spaces on the ground floor. According to their website, the Blokable structural steel frame and shear-wall building system allow the creation of open spaces for studio and one-, two-, and three-bedroom apartment homes.

For factory labor, Blokable does not see the traditional, site-built construction crew as a good fit for their in-factory positions, as they need workers with assembly line skills and with high-degree precision manufacturing skills. The Blokable representative noted that workers from the commercial building industry usually have the skills they need. For a recent project in Auburn, Washington, the company used contract labor to complete the onsite construction. Specifically, the representative mentioned the need to use contract labor to put in the foundation and connect the building product to the foundation.

⁴³ Podium construction (also known as pedestal or platform construction) typically includes a concrete “foot,” pedestal, or base of a structure that supports multiple stories sitting atop.

Most of it comes to the factory, some of it will be finished on site. So, you've got that mix, and then we're going to have to get trucks that are coming in and pulling the buildings and moving them over there. And we're going to have to book a general contractor to go and do the civil work and to dig trenches and to put in foundation.

—***Blokable Representative***

The Blokable representative noted that the company works with several supply chain providers to obtain all materials needed for building, as “the building system is built to accommodate an extensive variety of materials and finishes, giving a choice in aesthetics” for each project.

Marketing to Consumers

As a real estate developer, Blokable does not have “customers” in the traditional sense. They look for potential markets in the four states they serve—California, Idaho, Oregon, and Washington—where prevailing rents are high and build cost is low, to give them an advantage as a developer. The Blokable representative noted that they consider two criteria: areas with “low-cost land” or sites to acquire and build on, as well as an abundance of potential renters. They then identify multiple sites and submarket areas within the market that are “friendly to modular construction” and could potentially support a 200,000- to 300,000-square-foot factory size. For example, at the time of the interview, Blokable’s real estate team was in Sacramento, California, looking to acquire sites and raise funds for development through their investors.

Are we sure that in the submarkets where the economics work that we are not going to run into big issues with entitlements or the ability to build, we are not going to get shut down because of a design review, we are not going to get shut down because somebody doesn't like modular, we are not going to get shut down for any arbitrary reasons? And there's a ton of arbitrary reasons in real estate development.

—***Blokable Representative***

The Blokable representative also noted that they avoid markets with strong labor unions that may have concerns that factory-built construction may reduce the number of traditional, site-built construction jobs. The Blokable representative stated that opposition from labor unions can mean, “Projects get shut down and slowed down and don't happen because the folks at the city [government] can do that. They can slow projects down, they can make them move very slowly.”

Financing

Blokable creates a pipeline of projects before investing in a particular market. After the pipeline is developed, the on-the-ground real estate team raises acquisition financing through investors

for each site they potentially want to develop. After acquiring the site, they also raise capital for development through the same investors, ensuring that the company has sufficient collateral to finance the setup and operations of their modular manufacturing plant and the materials needed for building Bloks to develop the real estate.

As we create the pipeline, as long as we can finance our site acquisition, which we can do through investors, and we can finance our real estate development, which we can bring in investors to finance the real estate, then that establishes that we have pipeline of demand. It means that the finances to purchase the Bloks as we build them will be there. If we can establish the financing pipeline and the project pipeline, that means then that we have the collateral basically to finance the manufacturing, because one of the hardest hits that you take when you're doing this is you go into a new market and you want to lease 200,000 square feet, and the landlord is going to ask you for \$2 million security.

—Blokable Representative

Blokable's greatest single cost is often the security deposit usually required on their lease for a 200,000- to 300,000-square-foot factory space when they enter a new market.⁴⁴ As landlords consider their new business model to be risky, they can potentially ask for a security deposit of up to \$2 million.

Policy Recommendations

With the assistance of Low-Income Housing Tax Credits (LIHTC)⁴⁵ and other public and private funding vehicles to increase the supply of affordable housing, Blokable believes that creating additional incentives will encourage modular construction on a larger scale; however, too many administrative requirements may create additional barriers to market entry. For example, as the representative observed, “You have to have a certain number of projects under your belt. You have to have certain affordable [housing] development experience, then you need to have an outside architect, you need to have an outside manufacturer, and you need to have an outside general contractor; those are the rules to just be able to *apply* for that money.”

Referring to the success of its recent project in Auburn, Washington (see exhibit 28), in which a state senator appropriated funds specifically for the project, the Blokable representative suggested that the federal, state, or local government work to provide a separate source of funds and, at the local level, parcels of land to support affordable housing development by modular companies. Rather than setting prescriptive requirements that restrict how affordable housing

⁴⁴ The Blokable representative **said**, “Due to economies of volumetric shipping, modular [construction] shipping tends to work for about 500 miles.” As a result, Blokable plans to potentially open a factory in every new, geographically distant market.

⁴⁵ The LIHTC program, created by the Tax Reform Act of 1986, gives state and local LIHTC-allocating agencies approximately \$8 billion to issue tax credits for the acquisition, rehabilitation, or new construction of affordable housing targeted to low-income households.

gets built, the Blokable representative recommended that the government set specific “performance criteria,” such as net zero energy buildings, all-electric buildings, and so on, and leave it up to the modular housing company to figure out how to build.^{46,47}

The Blokable representative noted that projects do not need to be fully financed by the government: “We’ll put in some money, we’ll leverage the [government] financing. It doesn’t have to be 100 percent financed, it just means put some money into it to put some skin in the game, open up some sites that can be developed, and make the requirements based on cost and performance.” This form of housing support lends itself to public-private ventures in which the state or local government invests money in housing innovation instead of subsidizing housing to make it affordable.

Exhibit 28 | Twelve Permanent Units of Blokable’s Phoenix Rising Project in Auburn, Washington



Source: Blokable

Summary of Findings

- **As a real estate developer, Blokable has full control over how its modular housing gets built.** The company can maximize the cost benefits of a standardized, repeatable design. Moreover, the equity that results from developing the land is returned to Blokable. It does not lose any profit to an external developer.
- **Blokable’s building system is approved through several regulatory processes within four states.** Blokable’s building prototype, Blok, is approved through several states and local authorities’ regulatory requirements. Those approvals enable Blokable to build a readily replicable product that will pass stringent requirements for one-floor multifamily homes in the markets they serve. Currently, the company is focused on ensuring that their product meets the requirements for up to eight-floor multifamily buildings by stacking the Bloks.
- **Sometimes local governments prevent or limit acceptance of modular construction.** In some high-potential markets where Blokable would like to build affordable housing, the current local government may not be welcoming to modular construction. The representative suggested that some local area governments and organized labor unions seem to view modular housing as a threat to onsite construction.

⁴⁶ A net zero energy building means that the total annual amount of the energy used by the building is equal to the amount of renewable energy created on the site of the building (or sometimes at a separate site) using technologies such as solar panels.

⁴⁷ Since November 2019, Blokable has been a part of the Wells Fargo Innovation Incubator (IN²), a technology incubator and platform funded by the Wells Fargo Foundation and coadministered by the U.S. Department of Energy’s National Renewable Energy Laboratory. This grant is to validate and enhance the energy performance of Blokable’s prefabricated building system against industry standards. Blokable is also working with IN² to develop metrics for zero energy readiness and the full lifecycle impact of multifamily housing development in various infill locations. For more information, see <https://modularhomesource.com/blokable-unveils-their-vertically/>.

The truth is, none of those [onsite labor] folks could build our product, our product is completely engineered from the ground up, it's more like a car or a plane than it is traditional construction.

—Blokable Representative

Industry Outlook

For the modular construction business model to work, the Blokable representative advised modular companies to avoid dependence on developers. Developers are generally looking for the cheapest and fastest builder, resulting in modular companies undercutting each other and having low margins (the representative suggested the margin is about 10 percent). Although developers can provide the land needed for modular construction, developers' projects are often "one-offs" that have specific needs and requirements that limit modular companies' ability to build a repeatable and standardized product. The Blokable representative suggested that modular companies be vertically integrated (specifically by incorporating real estate acquisition within the company) so they can sell their product (with minimal customization) to be profitable in the long term.

The reason that modular businesses come and go and rise and fall is because they're dependent on developers who don't care whether modular exists or not; developers just want a cheaper, faster way to build their thing. Once they build their thing, they pay off the modular guy Then the developer takes all of the upside equity and all of the wealth creation and takes it for themselves.

—Blokable Representative

Lessons Learned from Blokable

Like Boxabl in the previous case study, Blokable was a new startup company at the time of the interview. As a result, many claims by Blokable that were discussed in this study are not verified. That said, the Blokable case study provides an example of an innovative business model that shows promise for the production of affordable factory-built housing. As previously stated, the company circumvents many of the challenges, especially financing-related challenges, that other factory-built housing manufacturers face by buying the land on which its units will be located. The company is also able to maintain a high degree of control of the design of its products—using standardized, repeatable designs that increase affordability—by acting as both a developer and a manufacturer.

CHAPTER 4: KEY FINDINGS FROM THE CASE STUDIES

After completing the individual case descriptions, the authors synthesized the information and identified key findings frequently discussed by each of the eight companies. Each key finding in this chapter includes a set of related strategies that reflect best practices companies use to increase the affordability of their factory-built housing. The authors shared draft key findings and strategies with the Expert Panel during a virtual meeting in August 2021. The text that follows incorporates the feedback the Expert Panel provided during that meeting as well as discussion from an earlier meeting in February 2020 and findings from the Market Research Report.

Key Finding 1: The Key to Producing Affordable Factory-Built Housing is Standardized, Repeatable Designs and Standardized Product Lines

Standardizable and repeatable home designs keep the cost of production low and increase housing affordability. Several company representatives reported that using standardized designs and processes in their factories increases the efficiency of production and helps keep costs low. Companies also recognize the importance of using standardized product lines that limit variety in the components used to develop factory-built housing. Clayton Homes, for example, described the benefits of their vertically integrated supply chain and standardized product line in keeping costs low. Standardized product lines help companies buy components used in their housing designs in larger quantities and buying in bulk helps keep costs low.

Despite the known benefits of standardized, repeatable designs and standardized product lines to increase affordability, six companies accommodate customer requests for customizations to existing designs or, in some cases, allow customers to bring their own designs that the companies will “modularize” and ensure that the design is compatible with their factory’s construction process. When customers deviate from the standardized designs, costs increase because the companies will need to incorporate alternate, often more expensive materials or deviate from the standardized production processes that keep costs low.

The representatives from all eight companies stated that variations in state and local building codes create challenges for using standardized, repeatable designs and standardized product lines. A design that meets building code standards in California may not meet standards in Washington and vice versa. In addition, states may require specific types of construction materials that do not fit within companies’ standardized product lines.

Feedback from the Expert Panel supported Key Finding 1. The Expert Panel noted that the companies most successful in producing high-quality units at lower costs are those that incorporate standardized, repeatable designs. One Expert Panel member noted that standardized product lines allow for increased volume in the supply chain, which is “absolutely key” to lowering the price of factory-built housing units.

On the basis of those findings, the authors developed three strategies that factory-built housing companies can adopt to facilitate the use of standardized, repeatable designs and standardized product lines.

Strategy 1: Engage with architects in the early stages of the project. The companies reported that early engagement with architects on housing projects is essential to ensure that the designs are compatible with factory construction. Representatives from Prefab Logic, Guerdon, Clayton Homes, and Z Modular all explained how their in-house design teams work with architects in the planning and design phase. Guerdon even invested in a 3D drafting technology that allows everyone on the team to work from the same shared design.

Strategy 2: Work with state-certified inspectors and research local building codes to ensure compliance. Most companies reported spending significant time gaining an understanding of the differences in building codes in the different markets they serve. Clayton Homes has perhaps the most robust solution, as the company designed manuals to keep track of the different codes and any changes in the various codes. Clayton Homes also provides training in factories to ensure that their products comply with codes where the product will be sited. Most companies also have quality assurance (QA) departments and state-certified inspectors who inspect units to ensure compliance with building codes.

Strategy 3: Offer standardized floor plans and accurate upfront cost estimates. Many companies provide standardized floor plans their customers can choose from, including plans for single-family, multifamily, and commercial and nonresidential units. Z Modular noted the importance of identifying a manageable number of floor plans, as too much variation drives up costs. Another benefit of standardized, repeatable designs is that the cost of construction is easy to estimate up front. Representatives from Impresa Modular and Dynamic Homes both noted that they provide clear cost estimates so customers can choose a design within their budget. Similarly, as a real estate company, the Blokable representative noted that they employ accurate upfront cost estimates, which enable them to easily determine whether a piece of land is profitable to develop.

Key Finding 2: Transportation Incurs Significant Costs

Most companies stated that the transportation of units to the site often is a hidden cost of factory-built housing. States have different permitting fees and size load regulations that add cost to transportation. Often, expensive, heavy equipment is required to transfer the units from the trucks to the site. Other factors—such as road conditions, narrow roads or bridges, and landforms—can also pose challenges. Although most representatives discussed transportation as a challenge, the strategies the companies use differ.

Strategy 1: Attempt to minimize transportation costs through route planning. The company representatives most commonly reported this strategy to reduce transportation costs. It is sometimes possible to plan a less direct route to avoid expensive permitting fees or regulations on oversized loads; however, the route planner must ensure that this practice does not conflict with local regulations. Company representatives also noted that they limit the range in which they deliver their products. Ranges varied slightly: Dynamic Homes transports units within 400

miles of their factory, Guerdon transports within 300 to 500 miles, and Z Modular transports within 500 to 700 miles (typically, but Z Modular will go farther in rare cases).

Strategy 2: Design products to minimize transportation costs. Most companies saw transportation as a constraint that limits what units can be delivered to which locations; Boxabl, however, is an exception. The company designed the Casita to fold and unfold so that the unit can be transported as a standard highway-legal load. Boxabl’s unique application of an innovative design to minimize transportation costs and increase affordability stands out from the other companies in the case studies.

Strategy 3: Use a staging area to minimize the costs of heavy machinery, such as cranes. Dynamic Homes uses a staging area on land near the construction site to store modules. Using a staging area reduces the time a crane is needed at the site because the modules are transferred to the site from the staging area faster. Guerdon also uses staging areas, but the representative discussed this as a challenge because finding available land is often hard, especially in urban locations; so, although staging areas are useful, they can sometimes be hard to find, be costly to obtain, and, potentially, require additional security.

Key Finding 3: Education on the Benefits and Quality of Factory-Built Housing Is Needed to Counter Negative Perceptions

A common theme identified in nearly every case study was negative perceptions about factory-built housing among the public, particularly that it is of low quality. The Blokable representative also believed that local politics can be unwelcoming to factory-built housing, especially in locations where organized labor unions have a lot of sway, because of an impression that factory-built housing will reduce the number of onsite construction jobs. The company representatives believed that the negative perceptions are unfounded, however, and could be easily corrected with education and more exposure to factory-built housing. Following are four strategies that the companies use to counter negative perceptions.

Strategy 1: Use demonstrations that highlight factory-built housing’s quality and speed of construction. Several company representatives discussed performing live demonstrations—Z Modular calls them “stack events”—of housing construction and developing videos and other promotional materials for media outlets, including social media. The representatives from all eight companies believed that seeing the onsite construction process and finished product reduces common misconceptions from community members that factory-built housing is low quality.

Strategy 2: Invite key stakeholders to the factory. Prefab Logic and Z Modular allow local and state government officials to tour the factory to see the quality, precision, and efficiency of the construction process in person. This gesture often helps reduce resistance to factory-built housing. Other key stakeholders may include realtors, appraisers, and building code inspectors.

Strategy 3: Use precise language. Representatives from Impresa Modular and Clayton Homes noted that they use specific terms when referring to their housing to avoid negative perceptions. Impresa Modular uses the term *industrialized* and Clayton Homes uses the term *factory built*.

Both representatives stated that they use those terms to clearly convey the precision and quality of their products.

The Expert Panel noted that the use of incorrect terminology can result in increased monetary and nonmonetary costs related to budgets and financing, data consistency and usability, and building codes and regulations. For example, if state regulations and local ordinances define factory-built housing differently, that lack of a common understanding can create complexities in the inspection and permitting process, as local governments must discern what is and is not part of the various regulations. Potential financiers of factory-built housing may also struggle to understand what exactly it is and what the benefits and risks are. If the terms surrounding the factory-built homebuilding process were standardized, then financing would be more accessible, and regulatory barriers could be reduced.

Strategy 4: Spend time designing a good website. The representatives from Guerdon, Impresa Modular, and Dynamic Homes all mentioned how their well-designed websites really help generate business and clearly convey the high-quality housing they provide. Websites also allow consumers to easily select from available standardized floor plans (see Key Finding 1).

Key Finding 4: The Finance Industry Needs More Information on the Benefits and Risks of Factory-Built Housing

In addition to citing negative perceptions from the public, all company representatives reported that negative perceptions and a lack of understanding of factory-built housing in the financing industry can be a challenge. The representatives distinguished between perceptions of single-family and multifamily homes and, within single-family homes, between HUD Code manufactured and other types of factory-built homes. For precut, panelized, and modular single-family homes, the representatives stated that financing is obtained in the same process as for site-built homes—homebuyers simply apply for a mortgage through a bank.

In the case of HUD Code manufactured homes, financing is available through the Federal Housing Administration and other federal programs (including CHOICEHome® and MH Advantage), but the Clayton Homes representative noted that for homebuyers seeking conventional loans, most banks will offer financing only through a chattel or personal property loan, which typically have much higher interest rates than a mortgage loan. The Clayton Homes representative also emphasized that most banks they encounter are not aware of the federal programs available to help finance HUD Code manufactured homes.

The company representatives discussed the primary challenges with financing in relation to multifamily and commercial or nonresidential projects. They reported that many potential financiers see factory-built housing as high risk because the projects involve a much higher upfront cost than does site-built construction. Moreover, the finance industry has some of the same negative perceptions about the quality of the housing displayed by the public. The following are strategies that companies use to finance their factory-built multifamily housing projects.

Strategy 1: Highlight the faster construction time. Several company representatives noted that the accelerated construction time for factory-built housing translates into revenue generated faster than site-built construction. Educating financiers about the efficiency of factory-built housing is one way to overcome their hesitancy to provide funding. Second, companies emphasized the importance of demonstrating that efficient processes do not sacrifice quality. The Guerdon representative discussed highlighting their rigorous QA process as part of their education strategy when working with financiers.

Strategy 2: Implement factory tours. Several company representatives discussed inviting financiers to tour the factory to see the manufacturing process in action. As discussed in Strategy 2 under Key Finding 3, allowing people to see the process with their own eyes goes a long way in terms of dispelling negative perceptions about quality. In addition, financiers can see the materials that were ordered and other tangible signs that the money they are providing is being spent appropriately.

Strategy 3: Develop payment plans that financiers are comfortable with. The Z Modular and Impresa Modular representatives described different payment plans they use to help potential financiers feel more comfortable with the process. The options they discussed included setting payments to coincide with the percentage of work completed and an option that mimics site-built multifamily construction projects (payments when materials arrive at the factory and additional payments when units are produced, transported, and installed). Both company representatives noted that the timelines for payments are much more compressed under factory-built construction, which is often foreign to financiers with more experience funding site-built construction. They suggest combining the payment plan options with the other strategies (education and factory tours) to help financiers become more familiar with factory-built housing.

Key Finding 5: Efficient Product Processes, Automation, and Robotics May Increase Affordability

Many companies use proprietary production processes to build their standardized, repeatable designs. The company representatives noted that the factory setting facilitates production of standardized and precise units that can fit together in different configurations to form different types of housing. Because the process for developing the units is standardized and highly efficient, the representatives reasoned that their factory-built housing is of higher quality and less expensive than traditional, site-built construction. The Dynamic Homes and Clayton Homes representatives noted that within the factory, construction can be broken up into discrete and repeatable tasks so that units are built in an assembly line. Workers need to know only the task they perform each day, and they can become highly proficient and efficient in the specific task, which increases productivity and reduces costs. In addition, company representative referred to robust QA procedures that happen at different stages in the assembly line. Because an assembly line is a standardized process that workers follow, the QA inspectors ensure that the efficiencies of the process are realized and identify weak points as they arise.

The Expert Panel, however, noted that the assembly line-style production employed by Dynamic Homes and Clayton Homes may not be the best way to increase the affordability of factory-built

construction. The panel argued that alternative methods, such as cell production,⁴⁸ may work better for factory-built housing. Moreover, the experts noted that innovative technologies such as 3D printing and other automation and robotics, which have potentially significant benefits in terms of both cost and quality, often are not suited for assembly-line production. Although the Expert Panel pointed to the limitations of assembly-line production, they agreed that strategies to use efficient production processes, automation, and robotics have the potential to increase affordability.

Strategy 1: Develop a production process that capitalizes on the efficiencies inherent to construction in a factory. As stated previously, several companies have developed production processes and standardized units to increase efficiency. Examples of companies' standardized units include Guerdon's subassemblies, Z Modular's steel frames, Boxabl's boxes, and Blokable's Bloks.

Strategy 2: Implement automation and robotics to develop high-quality modules at lower costs than is possible with a nonautomated and less efficient process. Only the Z Modular representative discussed robotics currently in use in their factory at the time of the Study Team's interviews, but most companies reported an interest in investing in automation and robotics in the future. Boxabl chose panels that are well-suited for robot arms so they can implement automation in their new factory. The Expert Panel and most company representatives agreed that automation and robotics have a strong potential to increase the affordability of factory-built housing units.

The Study Team concluded that future research can work to better elucidate the benefits and challenges of different styles of production in factory-built housing, such as assembly lines and cell production, as well as to identify and understand which technologies are most compatible with different production processes. Moreover, additional research could investigate the potential of automation for creating more customizable factory-built housing that is a cost-competitive alternative to standardized products.

Discussion

The key findings demonstrate the potential of factory-built housing to increase affordable housing in the United States—with several caveats, however. First, the findings show that significant cost savings are best realized with the implementation of standardized, repeatable designs and standardized product lines. That finding means that opportunities for customization of affordable housing are limited, although many companies have developed products that are stackable in numerous configurations. The importance of standardized, repeatable designs and product lines highlights a tension within the factory-built housing industry between maximizing affordability and catering to the unique needs of customers who want some level of customization. Representatives of the large companies interviewed, such as Clayton Homes, have vertically integrated supply chains, more resources, and multiple factories and are able to provide customizations to their products. The smaller and less established companies, however,

⁴⁸ Cell production is a type of mass production in which production is broken up into several small teams, or cells. Each cell is responsible for all aspects of the production process for their units.

such as Boxabl and Blokable, have made strategic decisions to produce much more standardized products to maximize affordability and their own profits. For entrepreneurs interested in entering the factory-built housing space, the decision of how much customization to provide is an important consideration.

Second, although factory-built housing provides efficiencies that can increase affordability, companies face several challenges and costs. Most of the case studies describe difficulty producing products that can meet varying requirements in building codes across states and local municipalities. Some companies spend significant time working to understand the variations in codes and stay current with any changes that may affect their products in the markets they serve. Others, such as Boxabl, elect to use more expensive—but higher quality—materials in the manufacturing process to ensure that the product can meet the strictest building code requirements in any market. Companies also discussed another big challenge around transportation costs. Similar to learning the different building codes, some companies spend time understanding how regulations vary across the markets they serve, whereas others attempt to implement designs that are more amenable to transportation, regardless of regulations. Blokable was an interesting exception to the other companies because their model is to set up a factory in the market they intend to serve. Doing so may reduce the distance in terms of transportation, but the Blokable representative noted that one of their biggest expenses is paying a security deposit to rent factory space in their target market.

Third, although most company representatives said that the public is becoming more open to the idea of factory-built housing, negative perceptions still exist stemming from the view that HUD Code manufactured homes or “mobile homes” are lower quality and poorly designed. All the company representatives interviewed perform activities meant to showcase the quality of their products and the benefits of factory-built housing construction. Those activities range from designing websites with many pictures and floor plans showing their products, inviting key stakeholders to their factory to see the manufacturing process in action, and hosting live staging events for the public. Company representatives reported that many potential financiers of factory-built housing also have negative perceptions or at least are unfamiliar with the product and, as a result, see it as riskier than site-built housing. In addition to providing education, companies said they must think strategically about payment plans that financier will find comfortable. Again, Blokable was an interesting exception, as it takes on the role of developer. Rather than working to finance projects on land they do not own, they work to finance land acquisition and then build their projects on land they have acquired. By becoming a real estate developer, Blokable thus avoids some of the challenges of financing factory-built projects.

Despite those challenges, the representatives of all eight companies reported optimism about the future of the factory-built housing industry and its potential to increase the availability of high-quality, affordable housing in the United States. All representatives also agreed that HUD can and should do more to support factory-built housing. The Conclusion discusses these policy implications and some directions for future research.

CHAPTER 5: CONCLUSION

The potential of factory-built housing to increase access to affordable housing is an important and timely issue. In 2020 and 2021, the COVID-19 pandemic, combined with public recognition and protest of a series of current and historic racial injustices, laid bare many of the inequalities present in the United States. Families and individuals who lack access to stable housing now face additional challenges, such as how to quarantine and how to provide safe spaces for virtual learning and virtual work. Access to safe, affordable, and decent housing for low-income families does not seem to be increasing. Economically well-off households with the freedom to work from anywhere at home are now buying up the limited supply of homes for sale, driving up housing costs for others (Joint Center for Housing Studies of Harvard University, 2021). In addition, the Zumper National Rent Report suggests that the rental market is also starting to experience similar supply shortages and rising prices (Collins, 2022).

This report presents research on eight diverse companies in the factory-built housing space that are working to produce affordable housing. Through interviews with each company, the Study Team learned that factory-built housing using standardized, repeatable designs, standardized production lines, high-quality materials, and innovative manufacturing processes results in significant efficiencies, in terms of both construction cost and time. The Study Team identified five key findings and several strategies that reflect best practices the eight companies use to produce affordable housing. In addition, the Study Team highlighted challenges that those eight companies face, including variations in state and local building codes, transportation costs, and negative perceptions of factory-built housing. Those findings inform four recommendations for HUD, which follow.

Recommendations for HUD

Recommendation 1: Provide education on the benefits of factory-built housing and strategies to overcome common challenges. One clear message from the case studies is that education for developers, local governments, consumers, financiers, and other stakeholders is a key part of encouraging uptake of factory-built housing. The Expert Panel agreed that education, outreach, and marketing efforts—supported by HUD—are promising ways to expand the awareness of factory-built construction.

All stakeholders (for example, developers, local governments, consumers, financiers) could benefit from more education regarding structural innovations and the cost effectiveness of factory-built housing. Civil engineering, industrial engineering, and architectural education currently do not typically engage with offsite construction, so inviting expertise from those industries would be beneficial. The Expert Panel also confirmed that state and local authorities—including governments, housing agencies, and building inspectors—need education about how factory-built homes are constructed and the best practices for ensuring that those structures adhere to local and state code compliance, which can differ from inspections for onsite construction.

Specific ways that HUD can increase education on the factory-built housing industry include the following:

- Sponsor forums, webinars, and conferences to highlight the benefits of factory-built housing for housing affordability. HUD could consider targeting specific audiences—such as local municipalities, the general public, and fields such as civil engineering, industrial engineering, and architecture—with different events.
- Form partnerships and continue work with key stakeholders in the factory-built housing industry to conduct outreach and promotion of factory-built housing. Potential partners include trade associations, such as the Modular Home Builders Association, National Association of Home Builders, and Housing Innovation Alliance; nonprofits, such as the National Institute of Building Sciences (NIBS); public private partnerships; Fannie Mae and Freddie Mac; and other federal agencies.

Recommendation 2: Develop guidance on financing options specifically for factory-built housing. Most company representatives interviewed described the challenges they face obtaining financing for their factory-built housing projects, but some also outlined how they successfully used payment plans in the past. HUD can consider developing guidance for the factory-built housing industry around best practices to finance projects, including options for payment plans and how to work with financiers who may not be as familiar with factory-built housing as they are with site-built construction.

Guidance that HUD develops can also include ways to establish clear liability (for the manufacturer and the financial institution) during different stages in the production of factory-built housing. For example, if permits get delayed, where would the factory-built units be stored, and who would bear the cost? Clear guidelines around risk are important to increase potential financiers' comfort level with factory-built construction.

The company representatives interviewed also noted challenges in using subsidies and incentives, such as tax increment financing and low-income housing tax credits (LIHTC), that could encourage the production of factory-built housing. The Blokable representative mentioned that LIHTC is challenging to work with because the projects are typically structured so that an architect provides the design, and a separate company (which usually must have an established work history providing affordable housing for similar projects) provides the construction. As discussed throughout this report, many factory-built companies use standardized, repeatable designs to increase affordability and thus may not qualify for LIHTC projects that require a separate architect and an established work history with similarly structured projects. Also, government programs may withhold payments for housing until the entire project is complete, creating significant challenges for builders because of the large upfront costs required for factory-built housing. Finally, many federal programs implemented locally (for example, community development block grants [CDBGs], the HUD HOME program), may, due to additional requirements from state or local governments, explicitly prohibit factory-built housing from participation. In response to those barriers, HUD can consider guidance for local governments on best practices to help factory-built housing companies use existing federal programs. HUD may also consider including as a requirement in its programs a certain

percentage of factory-built homes or limiting the ability of state and local governments to exclude factory-built housing from the process.

Recommendation 3: Explore the feasibility of a standardized building code and inspection process for factory-built housing. A common theme from the case studies and Expert Panel is the need for a standardized building code for factory-built housing, similar to the existing regulations for HUD Code manufactured housing. HUD can consider potential options for developing a standardized code; however, acceptance of a single code by state and local governments may be challenging. The Expert Panel suggested a single guideline—such as that being developed by the International Code Council for offsite construction—could provide a standard that can be recognized throughout the United States. The Expert Panel also noted that the federal government can fund efforts for nongovernmental organizations, such as NIBS, to develop a recommended standard based on the latest knowledge from research and key stakeholders that governments can then choose to adopt or not. The *NEHRP [National Earthquake Hazards Reduction Program] Recommended Seismic Provisions for New Buildings and Other Structures* exemplifies the success of that approach, as the Expert Panel noted that the guidelines were adopted by 98 or 99 percent of local governments (FEMA, 2021).

HUD might also consider developing a clearinghouse of information, similar to the manuals developed by Clayton Homes, to document all the variations in state and local building codes and permitting processes for factory-built housing. The clearinghouse could also include information on incentives available for factory-built housing and how to apply them in different contexts (see Recommendation 2). In that process, engaging directly with factory-built housing companies already in operation would be important to understand what specific aspects of building codes they find most challenging.

Recommendation 4: Develop funding opportunities for affordable factory-built housing. To ensure continued support for factory-built housing, HUD has existing funding opportunities, such as the Cooperative Research in Housing Technologies, which encourages more affordable, energy-efficient, resilient, and healthier housing while reducing the cost of construction. HUD could also consider funding additional opportunities for factory-built companies interested in developing affordable housing. Those opportunities could include funding for additional research projects or seed money for demonstration projects of factory-built housing. In its guidance to potential applicants of funding opportunities, HUD could ask for innovative proposals that meet the required outcomes (for example, energy-efficient units, a maximum cost per unit, specific safety requirements of units) and maintain affordability. If HUD structures funding opportunities in that way, it can avoid prescriptive production requirements that may create barriers to participation by factory-built housing companies that use standardized, repeatable designs and product lines.

The Expert Panel suggested that an opportunity exists now for HUD to use factory-built housing—which, in their opinion, is often much more resilient than traditional housing—to replace existing declining government-owned housing stock. Moreover, because of the fast construction time and the high quality of the materials used, factory-built housing can play a

major role in developing temporary housing during disaster response and permanent housing to replace damaged homes after disasters strike.

Avenues for Future Research

The research presented in this report highlights the benefits of factory-built housing and the strategies companies use to develop factory-built affordable housing. The report also identifies some common challenges that companies in the industry face. Several avenues for future research can build on the work of this study.

1. The case studies heavily emphasized modular construction companies and include a diverse range of companies with very different market shares and products (for example, single-family, multifamily, commercial). Additional research could work to spell out key segments of the factory-built housing industry and identify companies and other stakeholders representative of the different segments to understand how findings compare across different companies and segments within the factory-built housing industry. The Expert Panel also stated that including different stakeholders beyond factory-built manufacturers—such as architects, general contractors, developers, financiers, and others—is important to ensure more nuanced and complete findings.
2. Although the case studies found that negative perceptions of factory-built housing exist, little discussion occurred of the reasons beyond stating that people generally think it is low quality. More research targeting potential consumers of factory-built housing could investigate that issue in more depth (see Temkin et al., 2007). Some research topics may include understanding how perceptions differ between single-family and multifamily housing as well as whether negative perceptions are tied to the idea that factory-built housing is meant to target only consumers of affordable housing.
3. Financing of factory-built housing is an area that requires further exploration. Future research could engage with potential financiers (for example, banks, private equity firms, real estate investment firms) and factory-built housing producers to identify best practices for financing factory-built housing projects. In addition, the Expert Panel suggested that additional research should focus on speaking to diverse constituencies—such as general contractors, architects, and developers—who can point out additional financial barriers that factory-built manufacturers may not consider. Future research could also work to identify best practices for using existing programs, such as LIHTC, CDBG Disaster Response, Choice Neighborhoods, and the Rental Assistance Demonstration, as potential avenues to gain subsidies for factory-built housing. Finally, the Expert Panel noted that factories may also qualify for subsidies as job creators and employers through programs such as New Market Tax Credits. Future research can investigate programs that provide direct subsidies for affordable housing and other programs that may support factory-built housing manufacturers even though they do not directly finance affordable housing.
4. Although the case studies point to the importance of standardized, repeatable designs and standardized production processes for affordable factory-built construction, the Study Team was not able to verify what production processes are best for affordability and what specific materials and technologies are the most efficient. More research is needed on the

latest technologies and materials available for factory-built housing construction and the potential of different production processes (for example, assembly line, cell production) to increase affordability. The Expert Panel noted that factory-built housing companies can sometimes be reluctant to implement new technologies, materials, or processes that they see as expensive or prohibitive. Research is also needed to understand the barriers to adoption and successful implementation of new technologies, materials, and processes.

5. Although it was not a focus of this study, the Expert Panel pointed out the need for more information on the potential of the factory-built housing industry to produce energy-efficient housing that reflects green building standards. The panel noted that the factory-built housing industry could capitalize on many existing financial incentives for energy-efficient housing. Future research could investigate whether factory-built housing offers any efficiencies in the production of energy-efficient housing and the best technologies and production processes available. The National Renewable Energy Laboratory is currently conducting work in this area, helping connect factory-built manufacturers to innovative products meant to increase energy efficiency, and this group could be a key partner for HUD in this area of research (Pless,2022).
6. This study does not investigate the potential local contexts most amenable to factory-built housing. Some case studies mentioned that certain municipalities are more favorable than others regarding factory-built housing; however, more research is needed to understand how local areas working to increase affordable housing can better support factory-built housing. Research could also survey key locations where factory-built housing is known to have provided a successful solution for housing. One example is the development of modular homes after Hurricane Sandy in New York.

Those avenues for research are not an exhaustive list. Factory-built housing is a broad area that HUD can continue researching and supporting as it works to identify ways to increase access to high-quality and affordable housing in the United States.

APPENDIX A. PRE-INTERVIEW QUESTIONNAIRE AND INTERVIEW DISCUSSION GUIDE

Pre-Interview Questionnaire

Please complete the table below, to the best of your abilities, with the roles and responsibilities of those staff members who will be participating in the interview.

Name	Title/Position	Role	Field of Expertise	Email and Phone

Please use the space below to include any additional details about your experience with factory-built construction.

What types of factory-built systems does your company produce/sell? Please check all that apply.

- Steel
- Wood
- Panelized—open
- Panelized—closed
- Volumetric modular
- Other (please describe other systems below)

What types of factory-built products does your company produce/sell? Please check all that apply.

- Single-family residences
- Multifamily residences
- HUD Code manufactured housing
- Tiny homes
- Container homes
- Accessory dwelling units (ADUs)

- Affordable housing units
 - Luxury housing units
 - Commercial or nonresidential buildings (for example, hospitals, hotels, and educational facilities)
 - Other (please describe other products below)
-

Interview Discussion Guide

Respondent Background

Thank you for agreeing to speak with me. First, I'd like to get a better understanding of your role at your organization, the market segments you serve, and your experience with developers or customers as they attempt to site or finance factory-built housing units in their communities.

I'd like to get started by getting a better understanding about the background of your role.

NOTE TO INTERVIEWER FOR Q2–Q4: BRIEFLY SUMMARIZE INFO FROM PRE-INTERVIEW QUESTIONNAIRE—COMPANY NAME, TITLE, ROLE, YEARS AT COMPANY, ETC.

1. We know a little bit about your company from our research and the questionnaire. How would you describe your company?
2. How would you describe your primary activities in your current role?
 - a. How long have you been in your role at [COMPANY NAME]?
3. We understand that your company produces [TYPES OF SYSTEMS].
 - Steel
 - Wood
 - Panelized—open
 - Panelized—closed
 - Volumetric modular
 - Other [FILL IN WITH RESPONSES TO PRE-INTERVIEW QUESTIONNAIRE]
4. We understand that your company produces [TYPES OF HOUSING/CONSTRUCTION].
 - Single-family residences
 - Multifamily residences
 - HUD Code manufactured housing
 - Tiny homes
 - Container homes

- Accessory dwelling units (ADUs)
- Affordable housing units
- Luxury housing units
- Commercial or nonresidential buildings (for example, hospitals, hotels, and educational facilities)
- Other **[FILL IN WITH RESPONSES TO PRE-INTERVIEW QUESTIONNAIRE]**

PROBE FOR EACH TYPE OF HOUSING MENTIONED IN Q4: Approximately how many of each type of factory-built housing did you produce/sell in the last year? Have you noticed any trends during your time at **[COMPANY]**?

PROBE: Are there particular reasons why you produce/sell **[TYPES OF HOUSING]** and not others?

5. Could you talk about the typical purchaser of your product—developers or individual consumers?
 - a. In geographic terms, where is your consumer base located? Do you predominantly serve a particular state or region? Could you please explain where your factory-built housing is sited?
PROBE, IF ANSWER IS ONE REGION: Could you explain why just one particular region and not more broadly? For example, logistics, permits, additional costs, or consumer interest.
6. How would you categorize the affordability of your factory-built housing products? For example, are your products considered affordable, moderate, high-end/luxury, or a mix?
PROBE: Could you tell me more about the process you follow for making this determination?
7. How do perceptions of stakeholders—such as homebuyers, builders, engineers, architects, developers, and government officials—impact the production of factory-built housing?
 - a. How knowledgeable are stakeholders about the industry? Do negative perceptions impact the production process?

Manufacturing/Construction Process: Offsite and Onsite

Now, I'd like to learn more about the manufacturing and construction process. We'll start with the planning and design phase and move to the offsite activities that occur in the factory setting, followed by the actual onsite activities that are required for siting your factory-built products.

Planning and Design Phase

Let's start with the planning and design phase.

8. Please give me a brief overview of the planning and design process (as though I were a customer) you use for a factory-built housing project from start to finish.

- a. Who are the different members of the project team who participate in this process? These might be individual homebuyers or professionals such as investors or building developers, contractors, planners, architects, or engineers.
9. Please describe the role “affordability” plays in the planning and design phase.
- a. How important is it that designs and products be affordable to consumers?

Offsite Factory Activities

Now I’d like to talk about the factory setting.

10. Could you talk about the unique processes/innovations you utilize in the factory to achieve cost and time efficiencies? Homebuilding innovations may include new construction methods, materials, techniques, processes, or products that greatly improve the function and/or affordability of homes.
- a. How does your company track these efficiencies in the factory?
 - b. What challenges or barriers have you experienced when attempting to implement these efficiency goals in the factory setting?
 - c. Do these innovations impact affordability of the housing products to consumers?
PROBE: Can you please elaborate on what processes/innovations/efficiencies would be needed to increase the production of affordable housing?
11. What inspection procedures are carried out in the factory setting?
- a. Do these inspection procedures vary by housing type and location? For example, single-family versus multifamily or modular versus panelized?
 - b. Can you please elaborate on how inspection procedures impact costs/affordability and timeline?

Onsite Construction Activities

Next, I’d like to discuss onsite construction activities.

12. Could you please describe the process for siting a new factory-built housing construction project, whether multifamily or single-family? For example, transportation, determining a site location, local regulations
- PROBE:** What types of logistical factors do you take into consideration when siting your housing units? These could include additional time, resources and staffing needed, or requirements related to environmental reviews and permitting. Are there specific challenges?
- PROBE IF PRODUCES BOTH SINGLE-FAMILY AND MULTIFAMILY:** How does this process differ for multifamily versus single-family housing? Are there specific challenges?
13. What are the implications for costs/affordability with respect to site-built/stick-built construction?

PROBE: Are there differences in the labor costs/utilization with respect to site-built/stick-built construction?

- a. Does this process impact the timeline with respect to site-built/stick-built construction?
- b. Are there any innovations your company has implemented with respect to the onsite portion of the factory-built construction process? Homebuilding innovations may include new construction methods, materials, techniques, processes, or products that greatly improve the function and/or affordability of homes.

Materials (Inputs)

We'd like to understand more about the materials you use in your factory-built housing products and any novel or innovative materials that differentiate your factory-built housing products from others on the market.

14. What are the primary materials used in your factory-built housing products?
 - a. How do these materials lead to cost savings and the production of affordable housing?
 - b. What challenges has your company faced in terms of the materials that are used in your housing products? These challenges could include the impact on your overall timeline; additional costs, such as sourcing and transportation; or rising costs of materials.
15. Can you describe any additional novel or innovative materials used in your factory-built housing products?

PROBE: Are there any (additional) novel or innovative materials you would like to use? Why aren't those materials used currently?
16. Are there other unique features of your factory-built housing products that set your company apart from competitors?

Financing

We are interested in finding out more about the way your housing projects are financed, any financing opportunities you provide to your consumer, and any challenges and successes you have experienced with respect to financing factory-built housing.

17. Please describe the different ways your factory-built housing projects are financed and the different construction/finance professionals who are involved in the financing process.
 - a. What successes have you experienced in terms of financing past, current, or new factory-built housing projects?

- b. What challenges have you faced when attempting to finance factory-built housing projects?
PROBE: Are there any specific challenges related to the rules/regulations of financing factory-built housing?
- c. **IF MULTIPLE TYPES OF PRODUCTS:** Can you please describe how financing differs for each type of product you offer? For example, single-family versus multifamily, residential versus commercial, or modular versus panelized.

18. IF SINGLE-FAMILY FROM Q2: How do [HOMEBUYERS/DEVELOPERS] finance your factory-built housing products?

- a. What financing options are available to consumers in terms of creating affordable housing opportunities?

Marketing to Consumers

I'd like to get a better understanding of your company's marketing strategies, what types of consumers make up your market base, and the ways your company wants to expand and grow factory-built housing.

- 19. How would you describe your consumer/market base?
 - a. Please provide details about any marketing strategies that are in place or are planned to expand affordable housing options aimed at different consumers, such as building developers, real estate investors, individual homebuyers, and communities across the United States.
- 20. What strategies does your company use to attract more consumers to factory-built housing?
 - a. How have partnerships impacted your ability to grow your consumer base?
 - b. Do you market to consumers of affordable housing, including communities looking to expand affordable housing options, individual homebuyers, and building developers?
- 21. Are there any special programs to encourage the adoption of factory-built housing in the community, and do those programs directly impact the homebuyer?

Lessons Learned and the Future Outlook

I'd like to learn about your thoughts on the future growth of the industry overall.

- 22. Can you talk about your thoughts on the future of the factory-built housing industry?
PROBE: Will factory-built housing gain/lose market share with respect to traditional stick-built/site-built construction?
 - a. What factors are important in your assessment? For example, innovations, costs, regulations, or consumer demand?

- b. In your opinion, are there any policies that the federal government (or state/local governments) should implement that would increase the adoption of factory-built housing and/or increase its affordability?

Finally, I'd like to learn a little bit more about any successes and challenges specific to your company.

- 23.** What successes has your company experienced with relation to the growth of factory-built housing?
 - a. What types of innovations to the factory-built housing industry could promote the expansion of affordable housing to consumers? Homebuilding innovations may include new construction methods, materials, techniques, processes, or products that greatly improve the function and/or affordability of homes.
- 24.** What lessons learned or challenges has your company experienced with respect to factory-built housing?
- 25.** Please share any additional initiatives your company is looking to implement that would contribute to the future of factory-built housing.

Those are all the questions I have today. Do you have any questions or additional insights you would like to share before we end our session today?

APPENDIX B. GLOSSARY OF TERMS

Term	Definition
accessory dwelling unit (ADU)	An ADU is a small residence that shares a single-family lot with a larger, primary dwelling. An ADU can be located within, attached to, or detached from the main residence. ADUs are also known as an accessory apartment, backyard bungalow, or a secondary dwelling unit. ⁴⁹
affordable housing	Affordable housing is defined as housing for which the occupant is paying no more than 30 percent of gross income for housing costs, including utilities. ⁵⁰
B-markets	B-markets refer to growing areas outside larger, more well-known cities. B-markets have a growing economy, but the housing markets are less competitive than housing in larger markets.
building information modeling (BIM)	BIM is a building process that begins with the creation of an intelligent 3D model and enables document management, coordination, and simulation during the entire lifecycle of a project. ⁵¹
chattel	Chattel is the legal term for personal property, as opposed to real property (for example, a car) which typically includes land and the structures on it. ⁵²
commercial or nonresidential	A nonresidential building means any commercial, industrial, institutional, public, or other building not occupied as a dwelling. ⁵³ A commercial building is one in which at least 50 percent of its floor space is used for commercial activities, such as retail, the providing of services, or food service. ⁵⁴
computer numerical control (CNC) machining	CNC machining is a manufacturing process in which preprogrammed computer software dictates the movement of factory tools and machinery. The process can be used to control a range of complex machinery, from grinders and lathes to mills and routers.
construction loan	A construction loan is one in which periodic draw payments are made to contractors, subcontractors, and suppliers on the basis of work completed. Monthly interest payments are billed to the borrower. ⁵⁵
container home	A container home is a dwelling made from shipping containers. ⁵⁶
expanded polystyrene (EPS)	EPS is a white foam plastic material made from solid beads of polystyrene and is primarily used for packaging or insulation. ⁵⁷

⁴⁹ For more information, see <https://www.aarp.org/livable-communities/housing/info-2019/accessory-dwelling-units-defined.html>

⁵⁰ For more information, see <https://archives.hud.gov/local/nv/goodstories/2006-04-06glos.cfm>

⁵¹ For more information, see <https://www.autodesk.com/solutions/bim/benefits-of-bim>

⁵² For more information, see https://www.nclc.org/images/pdf/manufactured_housing/cfed-titling-homes.pdf

⁵³ For more information, see <https://www.lawinsider.com/dictionary/nonresidential-building>

⁵⁴ For more information, see <https://www.upcounsel.com/commercial-building-definition>

⁵⁵ For more information, see <https://impresamodular.com/about-construction-loans/>

⁵⁶ For more information, see <https://archive.curbed.com/2020/4/10/21165288/shipping-container-house-build-cost>

⁵⁷ For more information, see <https://omnexus.specialchem.com/selection-guide/expanded-polystyrene-eps-foam-insulation>

Term	Definition
factory-built housing	Unlike traditional, site-built housing, in which building materials are shipped to and assembled on site, factory-built housing structures are built off site inside a factory, using a standardized, repeatable design, then assembled on site. ⁵⁸ Many studies define factory-built homes to include HUD Code manufactured or manufactured housing, as well as precut, panelized, and modular housing. ⁵⁹
franchising	Franchising is a technique of distributing products or services involving a contractual relationship between a company that has established a brand name and business system and a franchisee, who pays a royalty for the right to do business under the franchisor’s name and system.
hollow structural sections (HSS)	HSS are high-strength, welded steel tubes used as structural elements in buildings. ⁶⁰
HUD Code manufactured or manufactured home	Manufactured homes, also known as HUD Code manufactured homes, are portable structures completely constructed in a factory. This type of home is built on a nonremovable steel frame, put on wheels or temporary stands, and transported to its final destination, where no onsite assembly or customization occurs. ⁶¹ HUD Code manufactured homes must comply with federal HUD regulations: the National Manufactured Home Construction and Safety Standards (MHCSS) Code of 1976 (also known as the HUD Code manufactured). The federal standards under the MHCSS regulate all aspects of construction, including design, construction strength, fire resistance, and energy efficiency of the home. ⁶²
infill housing	Infill housing is the use of land in an urban area, usually open space, for new construction. Infill housing can be thought of as new houses constructed on vacant, underused lots interspersed among older, existing properties in established, urban-area neighborhoods. ⁶³
laminated veneer lumber (LVL)	LVL is a type of engineered wood product that consists of many thin (less than 1/4 inch) wood veneers adhered with high-strength adhesives. LVL is typically available in lengths far beyond conventional lumber lengths. ⁶⁴

⁵⁸ For more information, see <https://www.huduser.gov/portal/periodicals/em/WinterSpring20/highlight1.html>

⁵⁹ For more information, see https://vtechworks.lib.vt.edu/bitstream/handle/10919/35986/Wherry_GD_T_2009.pdf?sequence=3&isAllowed=y; <https://www.huduser.gov/Publications/pdf/factory.pdf>

⁶⁰ For more information, see <https://steeltubeinstitute.org/hollow-structural-sections/product-overview-benefits/>

⁶¹ For more information, see <https://magazine.realtor/home-and-design/feature/article/2016/11/shunning-prefab-preconceptions>

⁶² For more information, see <https://www.manufacturedhousing.org/hud-manufactured-housing/>

⁶³ For more information, see <https://www.stlouisfed.org/publications/bridges/fall-2007/the-ups-and-downs-of-infill-housing>

⁶⁴ For more information, see <https://myteamengineering.com/what-is-an-lvl/>; <https://www.apawood.org/structural-composite-lumber/>; <https://wisewoodveneer.com/learning-center/what-is-wood-veneer/>

Term	Definition
Leadership in Energy and Environmental Design (LEED) certification	LEED is a rating system that expresses how efficiently a building is designed and operated. Ratings and rankings of buildings are calculated using a number of points given to each structure on the basis of its environmental impact. ⁶⁵
Low-Income Housing Tax Credit (LIHTC) program	The LIHTC program, created by the Tax Reform Act of 1986, gives state and local LIHTC-allocating agencies approximately \$8 billion to issue tax credits for the acquisition, rehabilitation, or new construction of affordable housing targeted to low-income households.
luxury housing	Luxury housing can be defined differently across markets because property values, median resident income, and area development vary across markets. Typically, luxury housing has certain characteristics, such as prime location, high-end interior finishes, and hotel-like amenities such as concierge services and a top-of-the-line fitness center. ⁶⁶
Microllam®	Microllam® is a brand name for LVL beams manufactured by Weyerhaeuser. ⁶⁷
modular construction	Modular construction is a type of factory-built construction in which individual sections called modules are built in a factory and assembled on site. Modules can be of different types—fully enclosed modules, partially open-sided modules, or open-sided modules. ⁶⁸
multifamily dwelling	A multifamily dwelling is a structure containing more than one separate residential dwelling unit intended, in whole or in part, as the home or residence of one or more persons or households. ⁶⁹
non-volumetric construction	Non-volumetric construction is the production of building elements that are connected once they are on site. Examples of non-volumetric building elements include structural elements (for example, frames, beams, and columns), wall panels and interior partitions, floor planks, and roof trusses. ⁷⁰
single-family home	A single-family home is a structure that is maintained and used as a single dwelling unit. A single-family home has direct access to a street or thoroughfare and does not share heating facilities, hot water equipment, or any other essential facility or service with any other dwelling unit. ⁷¹

⁶⁵ For more information, see <https://www.ldproducts.com/aboutus/leed>

⁶⁶ For more information, see <https://realestate.usnews.com/real-estate/articles/how-to-define-luxury-real-estate-in-todays-market>

⁶⁷ For more information, see <https://www.weyerhaeuser.com/woodproducts/engineered-lumber/microllam-lvl/>

⁶⁸ For more information, see <https://vanguardmodular.com/about-modular/>; <https://vestamodular.com/blog/volumetric-construction/>

⁶⁹ For more information, see <https://www.lawinsider.com/dictionary/multifamily-dwelling>

⁷⁰ For more information, see https://content.aia.org/sites/default/files/2019-03/Materials_Practice_Guide_Modular_Construction.pdf

⁷¹ For more information, see <https://www.lawinsider.com/dictionary/single-family-residence>

Term	Definition
tax increment financing (TIF)	TIF is a tool used by local governments to finance real estate development costs. The additional property taxes paid as a result of development in a district are used to pay for the development cost. ⁷²
tiny home	A tiny home is essentially a small house, typically sized under 600 square feet. It can be on wheels or be built on a temporary or permanent foundation. ⁷³ Tiny homes are considered an accessory dwelling unit (ADU) when they are permanently installed. Otherwise, when placed on trailers with wheels, they are classified under recreational vehicles. ⁷⁴
vapor barrier	A vapor barrier is a material, typically a plastic or foil sheet, used to prevent water vapor from diffusing into the wall, ceiling, or floor of a unit. ⁷⁵
vertically integrated company	A vertically integrated company is one that controls two or more stages of production normally operated by separate companies. ⁷⁶
volumetric construction	Volumetric construction is the offsite construction of individual three-dimensional units of enclosed space that are then connected on site to form a single building. Volumetric modular construction is often used for multiunit residential projects, such as hotels, dormitories, and apartment buildings. Generally, volumetric approaches fabricate up to 95 percent of a building off site. ⁷⁷

⁷² For more information, see <https://www.house.leg.state.mn.us/hrd/issinfo/tif/mech.aspx>

⁷³ For more information, see <http://bctinyhousecollective.com/what-is-a-tiny-house/>;
<https://www.tinyhomebuilders.com/help/tiny-house-movement>

⁷⁴ For more information, see <https://www.aarp.org/content/dam/aarp/livable-communities/livable-documents/documents-2019/ADU-guide-web-singles-071619.pdf>

⁷⁵ For more information, see <https://www.iko.com/comm/introduction-to-vapour-barriers-and-vapour-retarders/>;
<https://www.certainteed.com/insulation/resources/do-i-need-vapor-barrier/>

⁷⁶ For more information, see https://www.ey.com/en_us/consumer-products-retail/how-vertical-integration-is-impacting-food-and-agribusiness

⁷⁷ For more information, see https://content.aia.org/sites/default/files/2019-03/Materials_Practice_Guide_Modular_Construction.pdf

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