

Building Affordability by Building Affordably: Exploring the Benefits, Barriers, and Breakthroughs Needed to Scale Off-Site Multifamily Construction.

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About the Turner Center

The Turner Center formulates bold strategies to house families from all walks of life in vibrant, sustainable, and affordable homes and communities. Our focus is on generating constructive, practical strategies for public policy makers and innovative tools for private sector partners to achieve better results for families and communities. For more information visit: www.turnercenter.berkeley.edu/

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Introduction

In the United States today, nearly one in three American households spends more than 30 percent of their income on housing.¹ These numbers are more pronounced in high-cost regions like the Bay Area, where skyrocketing rents and home prices mean that even middle income earners are struggling to find a place they can afford to live. This new reality is the result of a number of converging factors such as the chronic under-building of housing in the face of consistent population growth (resulting in a constrained supply of housing) and an explosive growth in the costs associated with building new homes.

Practical strategies that can facilitate the cost-effective production of more housing are urgently needed to relieve the cost pressure on the market, and on the working American family.

This will require innovation in *both* state and local land use policy as well as private sector practices and their impact on the market. Through our [Housing Development Dashboard](#), the Turner Center for Housing Innovation provides a clear visual of how together, land use policies (such as zoning and parking requirements) and market conditions (such as the cost of construction) interact to influence the economic feasibility of new housing development. The Dashboard provides insight into how we might better balance these factors to achieve movement and greater supply development in the housing market.

Meanwhile, the Center is also exploring policy innovations at the state level that have a track record of, and/or potential to, facilitate more affordable development in places that need it most. A 2016 paper looks at [Massachusetts' Chapter 40B](#), a policy designed to streamline the approvals process for affordable housing development and limit the barriers posed by local land use policies. The paper provides discussion of how Chapter 40B might be adapted and adopted in California. In the coming months, the Center will be exploring and sharing several other tools and innovations that can provide creative, bold solutions to supply challenges through market and policy innovation.

In this brief, we focus in on a solution that could help to expand the supply of housing by specifically tackling the high and growing costs of construction. As these costs have swelled - on one project in Southern California by as much as 45 percent according to a local developer, and by at least 25 percent in the entire Bay Area since 2014 - we examine off-site construction as an alternative production method that has significant potential to bring them down.² At scale, this innovation has the potential to reshape the housing industry and deliver more housing, more affordably and more rapidly, for those who need it most.

Off-site construction is an alternative method of housing production done largely in manufacturing facilities. This brief looks specifically at the production of three to five story wood-framed multifamily buildings (both rental and condominium) built either on-grade or over a concrete parking podium, with 50 units or more of housing. We document the cost and time savings potential of this method, compared with traditional construction, and explore the contributions off-site construction could make to the labor market, sustainability efforts, and the technological efficiencies in housing production. We then explore challenges that developers and manufacturing facilities currently face in their efforts to bring off-site construction to scale. We propose a number of strategies to help overcome current challenges, and ultimately, call on the leaders in the construction sector to leverage this business opportunity to its maximum impact, for the benefit of the industry and the millions of working American families struggling to find an affordable place to live.

Much of the research supporting this paper comes from a professional report completed by Allie Stein in May 2016 under the Turner Center’s guidance in partial fulfillment of the degree requirements for the Masters in City Planning at UC Berkeley. Insights in the report were also generated from interviews with industry participants, site visits to a number of factories including ZETA in Sacramento, California, Guerdon in Boise, Idaho, Katerra in Arizona, and Nemo in Lathrop, California, and a roundtable co-hosted by the Turner Center and the Bay Area Council.

History and Definitions of Off-Site Construction

The term “off-site construction” often holds various meanings, depending on the specifics of the design and implementation process. In this paper, we use the term to describe the construction method in which either individual components or modules of a development are built off-site in a factory and then transported and assembled on-site. The modules are set on a foundation, stacked vertically and connected horizontally. While some modules exist as a complete unit, others may take several modules stacked together to create a unit, analogous to a set of interlocking Lego blocks.

Figure 1: Completed development comparison images.

*Conventional multifamily construction.
Photo courtesy of First Florida Contractors*



*Off-site multifamily construction.
Photo courtesy of BRIDGE*



As can be seen in the above images, units manufactured off-site look very similar in finished product to conventional multifamily construction. They are permanent and subject to stricter state and local building codes than, for example, mobile homes. Other related techniques include “kits” which get assembled on-site while parts are developed in a factory, or “panelization” where the structural frame is built on-site and the interior and exterior components are built off-site.

Versions of this building method have been practiced around the world since as early as the 1830s. In places like Finland, Japan and Sweden, off-site construction has been generating a significant portion of housing stock for decades.³ Meanwhile, countries like the United Kingdom that have not traditionally produced large amounts of housing off-site are currently experiencing a spike in interest in this method.⁴

In the United States, off-site construction has gained momentum sporadically, experiencing its most notable growth spurt in the period following World War II. At the time, a high demand and severe shortage of housing spurred mass construction across the board, including with off-site methods.⁵ Then in the late 1960s, the federal government launched Operation Breakthrough, a \$72 million effort intended to support the expansion of off-site construction. At the time, all of this effort was focused on single family suburban production.

In spite of these early efforts, off-site methods of construction have yet to scale meaningfully in

this country. Today, though interest in the concept is increasing, only a few factories generating relatively little housing stock are in operation. Relative to other industries like manufacturing, the construction industry continues to lag in its productivity, in part because it has been slow to adopt innovations like off-site construction at scale.⁶

The following sections articulate the numerous benefits an expansion of off-site construction might generate (including improved efficiencies), identifies the challenges that are currently impeding this expansion, and proposes a number of solutions that might meaningfully reduce the cost of multifamily housing to make it affordable to more families.

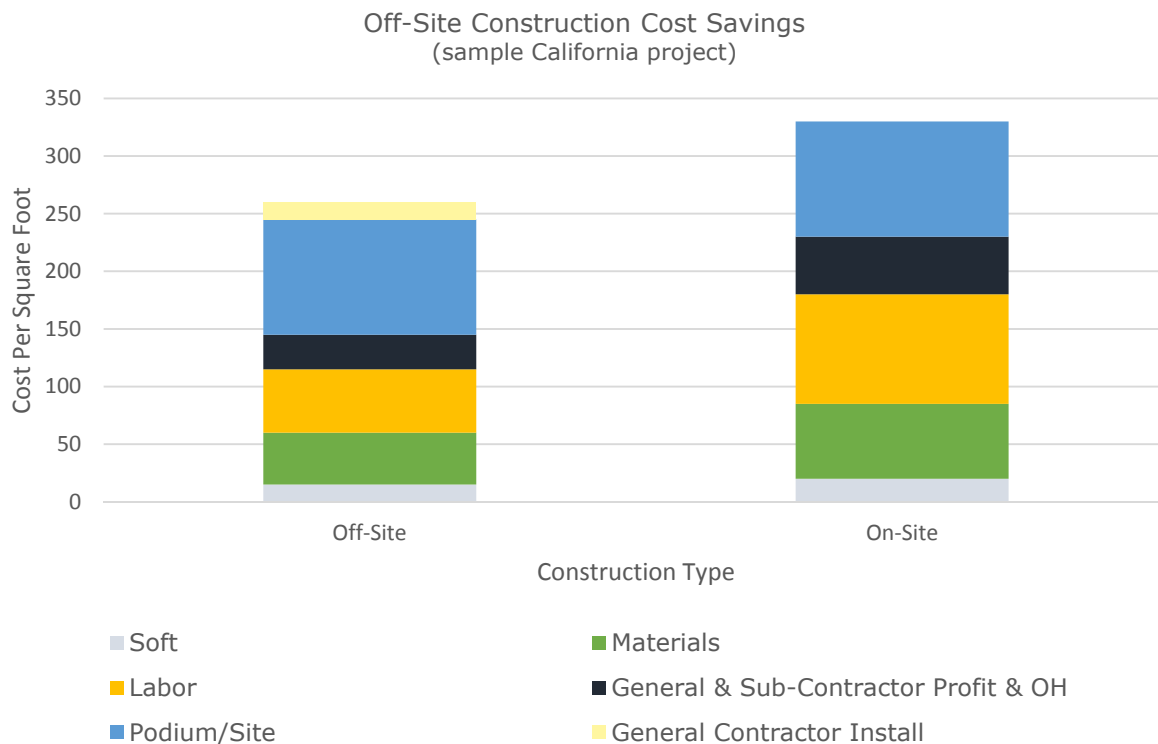
Benefits of Off-Site Construction

The primary appeal of off-site construction is that it provides a time and cost-savings in the construction process, and facilitates more rapid production of an affordably-built supply of housing. Off-site construction also offers the promise of technologically-driven enhancements in efficiency and precision in the construction process, a safer and more productive work environment for factory employees (as compared to traditional construction sites), employment opportunities for a more diverse labor pool, and a number of other benefits described below.⁷

Cost Savings

Evidence from developers suggests that off-site construction, as it is currently practiced, can save up to 20 percent on the cost of construction for a three or four story wood frame multifamily apartment building, translating to significant savings for consumers. These savings are achieved primarily in reductions in labor time and costs, economies of scale in material use, and procurement savings.

Figure 2: Comparison of construction costs by development type.⁸



Labor Related Cost Savings

Because the off-site construction process is more controlled, labor and production efficiencies can be achieved. The production environment is enclosed, meaning all the equipment and workers are in the same place (rather than moving to, from, and within a construction site) and are less vulnerable to delays or impediments from weather. Further, much of the work in off-site construction is done via assembly lines and automation, maximizing production efficiency and requiring fewer specialized skills. A less skilled and less expensive labor pool can complete work off-site that would require costly subcontractor labor on-site.

Economies of Scale and Procurement Savings

The efficiency of material supply chains also greatly influences the cost of construction. In off-site methods, because many design components and materials are standardized across projects, orders can be placed with greater consistency and at higher volumes, driving down the cost in both respects.

Purchasing also originates with the manufacturer rather than subcontractors, meaning that material suppliers aren't working with middle men, and therefore the overhead and profit of subcontractors is substantially reduced or eliminated.

Time Savings

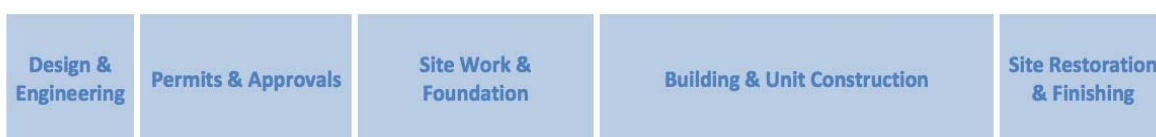
For a typical multifamily development with 20 or more units in the United States, the average construction time from authorization to completion was over fourteen months in 2015 (excluding time for planning approval and entitlements).⁹ Off-site construction can reduce project construction time by between 40 and 50 percent, because several aspects of the construction process can be completed simultaneously, rather than sequentially as is required in traditional construction (see figure 4). Site infrastructure and foundation preparations logically must precede building and unit construction in on-site construction, but in the off-site process module manufacturing can occur *while* site work and foundation preparation is underway. Fewer months on-site also reduces expenses such as general contractor fees, utilities, security, and other related facility costs. A shorter time frame also has the benefit of minimizing length of impact on neighbors.

Figure 3: Off-site vs. on-site construction timeline

Off-Site Construction Timeline



On-Site Construction Timeline



The time savings associated with off-site construction also reduces financing costs, as compared with traditional development. Reduced timelines translate to both a faster return for equity as rental revenue is accrued more quickly *and* reduced interest on construction loans, as debt can be paid back sooner.¹⁰ For example, on one Bay Area project which cost approximately \$40 million for 100 apartments, over \$500,000 (or approximately two percent of total construction costs) was saved from less construction interest and other time savings.

These combined savings translate into a critically important benefit: the possibility of housing delivered with significantly lower rents. A sample 900 square foot apartment built with traditional on-site construction methods in the Bay Area, for example, costs an average of \$350/square foot or \$315,000 in hard construction costs alone (this excludes land, financing, fees, architecture, etc.). If off-site construction methods are used instead and a 20 percent savings in hard construction costs are achieved, that total goes down to \$252,000. If that cost is amortized at a five percent interest rate over 30 years, the rent needed just to cover the cost of construction would be \$1,352, or \$338 less per month, per renter than would be needed for the on-site method.¹¹

Additional Benefits

The time and cost savings associated with off-site construction can be passed on directly to the consumer in the form of more affordable housing options. It can also make possible projects that were simply not economically feasible before, relieving pressure on the market, and deescalating market rent increases. Meanwhile, this construction method has several additional benefits. Off-site techniques can leverage advanced technology such as Building Information Modeling (BIM) and embedded technology, which provide environmental and quality improvements to the construction process. BIM allows for digital prototyping and advanced coordination of designs, minimizing mistakes and delays in the field. Off-site methods also allow for greater precision in the manufacturing process, resulting in less waste. These technological tools also enable innovations in design, providing consumer-focused “smart” home services such home security, temperature control, and entertainment.

Off-site construction also provides a safer, healthier, working environment than that of a traditional construction site, with fewer physical demands. The environment is also more controlled, meaning there is less need for improvisation and contingency planning.

*Figure 4: Katerra Factory Employees
Photo Courtesy of Mark Skalny Photography*



This also has an important benefit for employees and their compensation: while in traditional construction, workers may experience erratic stretches of unemployment when work is halted due to inclement weather, in off-site construction this volatility is removed. Further, employees travel to the same work site each day, allowing for more routine and predictability in their personal schedules.

Because the tasks associated with off-site construction are less specialized, there is also a larger labor pool from which to hire, meaning typically underrepresented individuals such as women can access employment opportunities. The workforce of the Katerra factory (pictured above) for example, was comprised of 40 percent women in February 2017, compared to nine percent in the broader construction industry.¹²

A final benefit of off-site construction is that it is significantly less disruptive to the surrounding community and neighbors than traditional construction. In addition to taking less time overall for a project to be completed, the installation process of modules produced off-site is significantly less noisy, requires far fewer workers, and creates fewer traffic and other human impacts on and near the site. Nearby businesses, schools, and residents all share in this improved experience during the construction process.

Challenges to Scaling Off-Site Construction

With all of these potential benefits, off-site construction appears to be an ideal construction method for multifamily homes. However, to date, off-site construction has struggled to perform within the current practices and norms of the construction industry, with factories either going out of business or struggling to maintain viability. As a result, the few developers who are eager to integrate off-site construction into their development plans are struggling to persevere beyond their first attempt.

For instance, in the Bay Area today, only five projects have successfully utilized off-site construction, generating only 777 units (with over half in one project) since 2013. This means less than two percent of the housing stock was produced with offsite methods - hardly a contribution to the overall supply challenge that continues to squeeze residents.^{13, 14} Looking ahead, only eight new projects are underway for the region, slated to produce only 1,000 additional units.

What is standing in the way of more widespread adoption of off-site construction? Our analysis revealed four areas in which current practice makes scaling a challenge. Three of these challenges, in Materials and Design, Regulation, and Construction Site Conditions, pose technical issues that we will briefly discuss below. The fourth area, surrounding the business model and financing system of off-site construction, will require more extensive discussion: this complex challenge demands a more fundamental shift in industry operations and culture, which, if achieved, may have significant positive impact for the entire industry.

Technical Challenges

Developers seeking to undertake off-site construction projects may face a number of unique challenges related to **materials and design** using this method. For example, a developer may:

- have less flexibility in timing and type of adjustments made to unit design
- need to include additional materials that protect the structure of modules, both in transit and on site.
- experience limitations of conventional equipment (e.g. mobile cranes) in module installation
- experience water damage to products delivered and installed on-site in inclement weather without proper protection

To overcome these challenges, developers will need to make a shift in the practices they might be familiar with in on-site construction. For example, designers and architects will need to produce an original set of standard design templates that are well-suited for off-site construction, and which are ideal for transporting and installation – rather than trying to convert and adapt

templates from off-site construction. If expectations for a different process are set and normalized, these types of materials and design issues can be overcome.

Off-site developers may also face challenges in the permitting and **regulations** surrounding the transportation, installation, and inspection of modules. For example, codes for permitting and inspection of modules are promulgated at the national level but they are the responsibility of the state to enforce. Meanwhile, local building officials who also review for local code compliance do not generally trust state officials and/or their privately contracted inspectors. There is not yet a standard process by which local inspectors can ensure compliance at a logical point in the production process (e.g. prior to modules arriving on-site with plumbing already installed within walls). If inspectors were to engage with factories directly and become more familiar and comfortable with standards, practices and protocols of off-site development, these regulation issues could also be overcome over time.

Finally, the **characteristics of some sites** may make the installation of modules challenging. Sites must be large enough to include a staging area where modules can be delivered and stored for a short period of time. There are also some sites, based on topography, that are simply not a good choice because they are too sloped or otherwise inhospitable to the installation of modules. Though these are not necessarily challenges that can be solved for every site, they are easily identifiable and, as with zoning laws and other issues that dictate development eligibility for sites, can be adapted to.

The Challenge of Off-Site Financing and Business Model

Good leaders in every industry know that for business, stagnation is death. Experienced leaders also know that change and innovation can be difficult to adopt as technical barriers like those discussed above abound. The earlier these are anticipated and resolved, the more likely innovations are to be integrated and sustained. In the case of off-site construction, the technical challenges presented by regulations, site features, and materials and design issues have served as real obstructions to widespread adoption. However, as the costs of traditional construction methods continue to rise, the motivation for solving these technical barriers has increased; the industry is beginning to engage in these challenges and find solutions.

Alongside these technical challenges usually comes more complex issues that must be confronted as well. These issues demand a fundamental rethinking of the industry business model, and therefore are harder to effectively solve. Two aspects of the current business model of multifamily development - the financing and capitalization of projects and the development pipeline and the fragmented structure of the industry - are posing this more complex challenge, and serving as a significant impediment to the broader integration and scaling of off-site construction.

What is the nature of these challenges, and how will we overcome them?

Financing and Capitalization: Challenges and a Way Forward

Challenges

In traditional construction, developers rely on a combination of debt and equity, the percentage of each varying with the type of developer and project. For example, a developer using the Low Income Housing Tax Credit as equity for affordable developments may have as much as 85 percent debt through a construction loan, taken out by more tax credit equity once a project is completed. Meanwhile, a market rate developer may have closer to 55 or 65 percent

construction debt, which is replaced by more debt, supported by revenue from rents, once a project becomes occupied. Either way, there is usually a substantial construction loan. The loan repayment is secured by the land and improvements on the site. Construction loans are typically paid out monthly through “draws,” as the percentage of completion of work on site is inspected and verified.

This process doesn’t work for manufacturing off-site, and the industry currently faces a mismatch in expectations and needs between real estate developers and their sources of capital on the one hand, and those of an off-site manufacturing facility on the other; the financing for off-site construction is needed upfront. Factories need capital *prior* to any construction starting to cover overhead costs and order the materials needed for the modules, which comprise about 60 percent of the total cost of the module. Of this cost, manufacturers generally expect an upfront payment of 50 percent of the module cost and the time the order is placed. And to remain on schedule, factories need almost all of the materials and parts within a very short period of time (a few weeks), as each module or “box” is built in a day.

In practice, this mismatch has presented a significant challenge. The ZETA factory in Sacramento, for example, began to acquiesce to the timeline and process of the traditional construction industry, accepting much of its payment *after* the modules were delivered and set on-site. This resulted in insufficient capital to 1) pay their suppliers in a timely manner 2) hire personnel to begin working on pre-construction activities for the next job. Ultimately, this lack of timely capital and challenges of cash flow management were a major reason for ZETA’s demise.

Another developer noted that they had several construction lenders who refused to finance the project, and the lender who ultimately agreed required extensive negotiation and a high level of exceptions to standard bank policy.

A Way Forward

How might we improve this system? To begin, a significant proportion of the work must be financed with more affordable construction loan debt rather than more expensive equity. To do so, one or more traditional construction lenders could lead on the design of a new construction loan, evolving from traditional loan structures in the following ways:

- Develop and deploy a digital tracking system to identify materials in the factory designated for a specific project and take a collateral or security interest in those materials and allow for a construction loan draw for those materials in the factory (with proper insurance).
- Send bank inspectors to the factory to assess percent completion and approve construction in process in the factory.
- Require a limited form of completion and repayment guarantee from the factory, *independent* of the developer, and assess the factory’s overall capitalization and financial stability as is currently done for developers.
- Engage philanthropy or government backing in the form of loan guarantees to assist lenders across the industry in gaining experience with this type of product and its risks.

Lenders are becoming more comfortable with these structures, and collaborations with off-site developers will help to enhance and integrate these adaptations to traditional loan products.

Meanwhile, for a factory to ensure it has a long term, sustainable business model, they would benefit from capital that does not require an immediate return, nor that depends on the business going public on the stock market. A source of patient equity or capital to finance plant and equipment and/or provide working capital for start-up costs would enable the factory to test and prove the profitability, sustainability, and replicability of the model for further growth.

Pipeline and Capacity: Challenges and a Way Forward

Challenges

Consistent with the manufacturing industry broadly, a steady flow of development projects and business output is essential to the business model of an off-site development factory. However, real estate development is a cyclical business where factors such as regional economic strength and job growth can impact the financial viability of projects and create more uncertainty and inconsistency. In these “down cycles,” developers and general contractors using traditional construction can scale back and “sit out.” There is often loss of jobs and profit, and individual companies or subcontractors do sometimes go out of business. However, the pain is generally distributed across a supply chain and harm to financial investors is relatively limited.

A manufacturing facility, on the other hand, has more fixed costs and less flexibility to adapt to economic fluctuation. Typically, much more is invested in the plant and equipment, for example, where the manufacturer either owns the land and plant, or has a long-term lease obligation. Either way, these large financial obligations are more vulnerable in down cycles because they have been financed with equity from investors who are relying on steady returns on their investment. In addition, the workforce is all on one payroll, rather than employed on a job-by-job basis by a subcontractor to a general contractor. There is a significant financial challenge in either trying to maintain a workforce in these times, or laying off and then re-hiring and training later on.

Economic downturns can also exacerbate the issue of limited capitalization. A thinly capitalized factory is forced to focus all of its energy on delivering on existing commitments. This means few resources are leftover to develop new and future projects and for those new clients who *are* considering pursuing an off-site project, a concern that the factory may be at capacity and may not be able to produce modules on time. The result? Even in “good times” such as 2016, we see off-site facilities struggling to attract new business generate sufficient future pipeline.

The severity of these pipeline and capacity issues can in some ways be shaped by the particular business plan decisions of the off-site manufacturer. While one manufacturer might be vertically integrated, relying only on their own development pipeline, this model risks over-reliance on a few individuals to be successful in bringing only their own real estate deals to the factory. On the other hand, another manufacturer could have a large sales team, but this strategy significantly balloons overhead. It is critical that these trade-offs be deeply understood in order to reduce the risk for investors and provide a more viable business model.

A Way Forward

The ability of a factory to generate sufficient pipeline is primarily a function of the diversity and strengths of the management or owner team of the factory. It is essential that an off-site construction facility be led by a team of managers experienced in *both* traditional multifamily development *and* off-site manufacturing. In most of the case study factories, management teams lacked prior multifamily building experience as a core expertise, instead bringing a background in single family off-site construction, industrial engineering or in some cases, no development expertise at all.

The sustainability of a factory, as with most businesses, requires a strong understanding of the customer(s); factory management should bring expertise in multifamily development, traditional general contracting, manufacturing, and design in order to have fluency with the needs and operation of developers, general contractors, architects, and project lenders involved in off-site development. This agility would also allow the factory to better manage its pipeline of projects and cyclical risk challenges. Further, an integrated team would provide developer customers a greater level of confidence that they are working with people who understand their business and would likely lead to lower overhead in the form of fewer sales personnel and designers for the factory itself.

In addition to a more diversified, higher-capacity team, off-site manufacturers could solve for pipeline challenges by developing a customer incentive structure, akin to the outdoors store REI for example, where customers (developers and/or general contractors) use a factory and pay fair value for their modules, but *also* get a dividend based on how much business they put through the factory as an incentive to keep a steady flow. This is simply an example of one “customer loyalty” mechanism that can attract and keep good customers (developers and general contractors).

Off-site manufacturers would also benefit from a diversification of product offerings to increase pipeline. For example, Guerdon Modular Buildings is manufacturing hotels in the same low-rise building typology as multifamily development. Specialized housing products such as student housing, specifically designed micro-apartments (whether for homeless individuals or young tech workers) or dedicated affordable housing can provide counter-cyclical business, and would contribute to pipeline stability.

The Last Mile: Getting to Scale

When the technical challenges are solved for, and off-site developers have advanced a more viable business model for its product, the final stage of evolution for this industry will be in its production process. Today, most manufacturers still try to take architectural designs and then turn them into digitally-produced shop drawings that work in the factory. Architects and most general contractors are still compensated for their work based on a percentage of the construction costs.

A more sophisticated process would instead make standard a set of predetermined designs (which could have some provisions for modest customization) and developers would buy *both* the module and the design - an integrated approach more akin to the car industry. A customer would still have different models to select from, and perhaps different companies with different designs and prices competing in the marketplace, but the range of customization and need for individualized design services would shrink.

To deploy these many solutions and catalyze this industry towards its full potential and potential impact, the off-site construction industry will need visionary, dedicated teams of experienced real estate, technology, manufacturing, and financial partners. They will need to forge a new hybrid development process that includes elements of both conventional construction and traditional manufacturing, and bring thoughtful and entrepreneurial energy and a willingness to break with traditional methods.

As renters and homebuyers strain under the growing cost of homes and apartments, and the cost of conventional construction grows, the process needs to be revamped so that developers can deliver more housing, in more cost-effective ways, to the market. We need to inspire a shift in housing production to better integrate the cost and time-savings benefits of off-site

construction for the sake of the people it is being done for.

The savings seen to date under current off-site construction practices while important, are the tip of the iceberg in terms of what can be achieved with a re-imagined process and the solutions to scale described here. A lowered cost of production with off-site construction translates to increased economic feasibility of development broadly, and taking up this charge could result in profitable and sustainable business model that can be replicated and scaled.

Experimentation and experience over the past several years has taught those involved valuable lessons. By taking those learnings and those identified here and applying them, scale *is* within reach. The time has come to leverage this significant business opportunity and rapidly increase the production housing for families currently burdened by soaring costs. There is no time to waste.

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⁷ More details regarding these benefits can be found in Allie Stein's 2016 Master's professional report: *Disruptive Development: Modular Manufacturing in Multifamily Housing*.

⁸ This chart reflects costs of construction only, and does not include a number of other costs associated with delivering of units.

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¹¹ These figures are generated from a recently completed off-site construction project in California.

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¹⁴ According to SOCDS building permit data (<https://socds.huduser.gov/permits/>) and census new residential construction data (<https://www.census.gov/construction/nrc/lengthoftime.html>) 2.5% of permitted projects don't get started and .5% of starts don't get completed in Bay Area. Therefore, 97% of all Bay Area projects (~61,000 units according to SF Chron) = ~58,000 units built in Bay Area. 777 units of modular is therefore < 2% units overall in Bay Area.