

# 2.3

## Mass-Customization in Housing: Designing Systems Rather than Objects

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### Introduction

*Housing in the United States seems to be in some sort of crisis. It has always seemed that way, with the needs of a growing population and inflationary construction costs.<sup>1</sup>*

*To make design more relevant is to reconsider what “design” issues are.<sup>2</sup>*

The relationship between architecture and housing has historically been an uneasy one. After a period of flagging interest from the 1970s into the 1990s, design interest in housing is again on the rise, particularly in terms of innovative materials and production systems, “green” building, and an activist interest in providing for a broader spectrum of people.

The production of housing today ranges from the hyper-customized singular house for a distinct user to completely mass-produced manufactured housing and repetitive builder models. Recently, “mass customization” has become a term used to describe housing production that falls between these extremes. This term, long used by industrial designers, suggests a production system that has the stability of quantity (“mass”) and the flexibility of custom design (“customization”). To be applied effectively in architectural work, mass customization must be understood as a systems approach that includes not only design, production, and construction but also communication, economics, and risk management.

## A Little History

Architects have been interested in houses since the beginning of time, but housing as a systemic undertaking focused on the production of shelter for many people largely begins with the Industrial Revolution. In the early twentieth century, the *Neue Sachlichkeit*, among others, concerned themselves with establishing dimensional standards for minimum dwellings as well as efficient use of new materials and technologies. Le Corbusier's *Maison Dom-ino* was likewise designed to be an inexpensive, flexible system of mass housing production using current materials and production systems. In both cases, new systems of mass factory production were fundamental.<sup>3</sup>

After World War II, the implementation of mass production systems developed during the war were adapted to housing production and companies like Levitt and Sons re-shaped the building industry by producing affordable, desirable houses en masse. At the same time, architects were also experimenting with mass production, attempting to bring design to housing production through John Entenza's Case Study House program. But while the Levitts created what is now the standard for housing production in the United States, the Case Study Houses became one-off design jewels.

In the 1980s, new manufacturing technologies including CAD, CAM, and FMS emerged that enabled factories to produce a greater variety of products with more options without requiring highly skilled labor or long production times. At the same time, customers began demanding more types of products of higher quality. As a result, mass customization using website selection processes and computerized production methods have become a competitive standard for products ranging from jeans to furniture to cars.<sup>4</sup>

Mass customization has, however, crept only slowly into the housing industry despite the increased use of digital technology in other areas of building fabrication. While a number of architects have been working for some time with prefabricated systems involving varying degrees of customization, this kind of system has really only recently entered architectural parlance through promotion by magazines like *Dwell* and *Metropolis* and exhibitions like the Museum of Modern Art's "Home Delivery: Fabricating the Modern Dwelling."

## Approaches to Mass Customization

In "Prefabrication and Sustainability" Kieran Timberlake's Kevin Pratt states that in the United States today, "over 90% of all new homes are site built, the great majority by small contractors and without significant architectural input."<sup>5</sup> In this system, standardization is associated with affordability while customization is associated with diversity, quality, and expense. As Masa Noguchi explains, "Today's homebuilders are encountering a production gap between the need for product standardization that helps reduce construction costs and the need for product customizability that satisfies diverse demands of contemporary consumers."<sup>6</sup> In other words, builders are trying to mass produce housing in order to create stability and minimize risk. At the same time, more types of consumers are entering the market and more consumers of all types want to have a larger voice in the design of their homes.

To bridge this gap requires a system that is familiar and standardized enough to allow the construction industry to embrace it while also malleable enough to respond to



1. All American Homes factory, Dyersville, Iowa. Photo by author.

the diverse needs of consumers at all positions in the economic and cultural spectrum. Architects and producers of prefabricated, mass customized housing are today attempting to create just such a system in which affordability and quality/diversity/sustainability are not mutually exclusive.

### The Modular Approach

Most prefabricated housing produced today is based on a system of “box” modules built in controlled factory conditions using standard framing techniques. The “boxes” are designed to fit within dimensions that allow them to be shipped from factory to site using standard trucks and roads. All American Homes, a major producer of this kind of housing in the U.S., on their website describes their work as follows, “Each custom-built home is made of superior materials by carefully trained craftsmen using the latest technologies in a controlled environment.”

A major feature of this kind of construction is that, because most of the construction takes place within the controlled environment of a factory, typical on-site problems with weather and dimensional variations can be avoided. Also, because of controlled conditions the modules are typically finished from inside to outside, beginning with drywall, allowing wall penetrations to be sealed, thus minimizing air leakage (Figure 1). All American Homes in particular also uses 2x6 rather than 2x4 wall construction, allowing for thicker insulation. They offer a range of insulation types and are progressively using higher R-Value, self-sealing insulations like Icynene.

In addition to their standard insulation and sealing practices, All American Homes also actively promotes “green” building and energy savings by offering customers a range of “green” options. They have a line of solar homes, an Energy Saver Package, solar heating and hot water options, and a full range of finishes and other features available in their Green Options catalogue. They have also built model exhibition homes for both the U.S. Department of Energy and Michelle Kaufmann Designs.

A number of architects have worked in the modular paradigm, most notably Michelle Kaufmann, creating an idiom of “prefab modern” with clean lines and an emphasis on sustainability. While Kaufmann’s houses are undeniably beautiful and certainly follow conventional modular logic, they never engendered enough mass appeal to be viable and Michelle Kaufmann Designs closed its doors in spring 2009. It appears that the designs were too far outside the norm for the manufacturers hired to produce them, resulting in high prices that consumers could no longer finance in the current marketplace.<sup>7</sup>

### The Panelized Kit Approach

This type of mass customized housing is perhaps the most similar to other kinds of mass customized products such as shoes, cars, and handbags that allow a customer to select and combine product elements as he or she desires within the constraints of the options provided. The FlatPak House by Charlie Lazor and Rocio Romero’s LV Series fall into this category. On the FlatPak website, a consumer can walk through the steps involved in designing a FlatPak house and see options available. Although it is not possible to make real selections online, the process is similar to that of “designing” your new Insight at Honda.com.

The LV Series Home is described as a “modern kit home” that is “affordable, easily built, and highly customizable.” The website furthermore goes so far as to say it can be built by “any general contractor,” thus implying that other houses of this type are too specialized to be viable in the construction industry. In addition, the LV Home consists only of a kit of parts for an exterior building shell. All finishes, services, foundation, and some structure must be installed on site by the contractor. By limiting the scope of their involvement, Rocio Romero LLC is able to focus on a well-detailed yet simple and easily constructed basic building system. This system is also highly affordable while



2. Ability House style options. Drawings from Fall 2008 Bridge Studio by students Cole Baessler, Chris Cummings, Thomas Grier,

allowing the consumer to determine the cost level of the final product.

This kind of system is not a new idea; in Sweden, for example, a number of companies developed prefabricated housing systems between 1965 and 1975 in response to increased need, the energy crisis, and developing technology. In addition to modular systems, these included large-panel systems similar to today's Structural Insulated Panels (SIPs) and the LV Series and small-panel/component systems akin to FlatPak.<sup>8</sup>

### The Component Approach

This kind of mass customized housing system takes available off-the-shelf components and uses them to create modular building and furnishing elements that can be assembled in a variety of configurations. Kieran Timberlake's Cellophane House, built for the Museum of Modern Art's "Home Delivery: Fabricating the Modern Dwelling" exhibition, exemplifies this type of system.

The Cellophane House uses a multi-directional basic extruded aluminum section that is assembled into sub-frames. These can be connected in multiple ways and other sub-assemblies like wall finishes, cabinets, and plumbing fixtures can be attached to them. Like the parts of an erector set, the various assemblies and sub-assemblies can be removed, rearranged, and recycled.

According to Kieran Timberlake's website, this system is "a bottom-up approach" that comes from the assembly system itself rather than a "top-down" approach used in more conventional prefab construction. This suggests something more egalitarian, available to more people. In theory, the house can be assembled by virtually anyone and can accommodate the needs and desires of anyone. However, because the system is so different from conventional construction, most contractors would charge more for this kind of system than conventional framing simply because it is different and represents a risk. Thus while the Cellophane House certainly pushes the envelope of technical and conceptual ingenuity, its applicability as a mass housing system remains to be seen.

### The Ability House

Since 2007, the Bridge Studio at Iowa State University has been working with

3. Ability House multi-unit configuration. Drawings from Fall 2008 Bridge Studio by students Cole Baessler, Chris Cummings, Thomas Grier, Jeremy Perrault.



local non-profit organizations to develop prototype designs for affordable housing that increase the level of sustainability and design quality for affordable housing while maintaining current budgets. In the fall of 2008, the studio focused on mass customized modular systems to try to achieve a budget of \$150,000 total construction costs (hard and soft) for a single-family 1200 square foot house in Cedar Rapids, Iowa.

Four student teams developed independent projects, competing in a design competition sponsored by the Iowa Finance Authority. The winning project, the Ability House, provides an example of how it may be possible to achieve the goals of high quality design and sustainability within a low budget while also offering the flexibility possible with mass customization.

Based on the modular construction system used by All American Homes whose Dyersville factory is located near Cedar Rapids, the basic one-story house consists of two modules that can fit on a single truck, thus minimizing transportation costs. A variety of second story configurations are possible, again all using only one additional truck for shipping. Using standard production costs provided by All American, a basic two-story, three bedroom house would cost approximately \$125,280 including full basement and garage pad, not including land cost. This price already includes Energy Star appliances and a 95% high efficiency heating and air conditioning system. For maximum energy efficiency and sustainability, the final design also includes Icynene insulation, Low-E Energy Star rated windows, a heat recovery ventilator, fiber cement exterior cladding, a natural gas tankless hot water heater, low flow plumbing fixtures, low-VOC paint, and sustainable floor finishes. In combination with current energy rebate programs, the final house cost comes to around \$135,000.

Flexibility in terms of both style and configuration was a critical aspect of this design. As a result of meetings with neighborhood residents and local government officials, it became apparent that while many people liked the “prefab modern” style that the students had used for the original design, others were interested in a more traditional design. Using the factory’s prefabricated hinged roof system, the students were able to modify the design so that it had multiple stylistic variations – a modern design with low slope roof, a shed roof design, and a traditional gable roof design (Figure 2). By moving the same window components to different locations and using the same siding materials in varied applications, they were able to enhance the stylistic variations without adding materials.

The Ability House can also be configured in multiple ways and expanded in the future. The basic one-story unit is fully accessible with a bedroom and full bathroom. The second floor can be configured with as little as one additional bedroom or as much as three additional bedrooms and one bathroom. Because of its corner entry, the house can be placed on lots of varied configurations to take advantage of solar orientation and units can be combined together to create a townhouse configuration (Figure 3).

Overall, the Ability House is a well-designed, spatially efficient house that expresses its modularity without over-emphasizing it and uses minimal materials well. As a housing system, it combines the efficiency of modular construction and the familiarity of conventional construction methods with the flexibility of mass customization to bring sustainable, high quality housing to as broad a range of people as possible. Designed to be produced by non-profits using HOME and CDBG funds, the budget meets the requirements for a family group with an income level at or below 80% of the average median income for the area.

## Conclusions



For architecture to truly engage the housing system in the United States, architects need to acknowledge that cost and a narrow range of building systems have driven the market for decades. To move beyond the custom “architect house” and serve a broader public, we need to both partner with and look beyond conventional systems. We also need to listen to the wishes of people who have not been our customary clients. To do this requires a move away from design focused on the built object toward design of larger systems like those exemplified by the projects described here.

Mass-customization in housing can serve as a model for a systems approach to design that shifts the role of architectural design from the production of discreet buildings to the articulation of systems that address not only aesthetic and technical but also environmental, social, and economic issues and, in doing so, bring global and local factors into dialogue in the production of the built environment. It reconsiders what design issues are and what design can be, thus extending design’s reach to include many who have previously been underserved.

## Endotes

- 1 Edward Dean, “The New Foreign Import: Manufactured Housing Systems,” *Journal of Architectural Education* 37, n.3-4 (Spring-Summer, 1984): 12.
- 2 Bryan Bell, “Expanding Design: Toward Greater Relevance,” in Bryan Bell and Katie Wakeford, eds., *Expanding Architecture: Design as Activism* (New York: Metropolis Books, 2008), 15.
- 3 See for example Kenneth Frampton, *Modern Architecture: A Critical History* (London: Thames and Hudson, 1985). For European housing in the inter-war years, refer to Catherine Bauer Wurster, *Modern Housing* (Boston: Houghton Mifflin Company, 1934).
- 4 Suresh Kotha, “Mass Customization: Implementing the Emerging Paradigm for Competitive Advantage,” *Strategic Management Journal* 16 (1995): 21.
- 5 Kevin Pratt, “Prefabrication and Sustainability,” Kieran Timberlake, [http://www.kierantimberlake.com/research/prefabrication\\_1.html](http://www.kierantimberlake.com/research/prefabrication_1.html).
- 6 Masa Noguchi, “The ‘Mass Custom Design’ Approach to the Delivery of Quality Affordable Homes,” Mass Custom Home, <http://www.masscustomhome.com>.
- 7 The closing of Michelle Kaufmann Designs has been covered extensively in the mainstream and architectural press. See for example “Green Prefab Firm Michelle Kaufmann Designs Is Closing,” *Los Angeles Times*, May 26, 2009, Arts section, Online edition. According to Michelle Kaufmann Designs, the cost for their designs ranges from \$250 to \$300 per square foot. While this is reasonable compared to costs for custom site built homes in the area (California), prices for modular housing is much lower, ranging from \$55 to \$90 per square foot for a lower end manufacturer to \$100 to \$125 per square foot for higher end manufacturers.
- 8 Dean, “New Foreign Import,” 15.

## Image Notes

1. All American Homes factory, Dyersville, Iowa. Photo by author.
2. Ability House style options. Drawings from Fall 2008 Bridge Studio by students Cole Baessler, Chris Cummings, Thomas Grier, Jeremy Perrault.
3. Ability House multi-unit configuration. Drawings from Fall 2008 Bridge Studio by students Cole Baessler, Chris Cummings, Thomas Grier, Jeremy Perrault.