



Design Implications for Technology Innovation in Housing

Prepared for:

Affordable Housing Research and Technology Division
Office of Policy Development and Research
U.S. Department of Housing and Urban Development
Washington, DC

Prepared by:

Steven Winter Associates, Inc.
Norwalk, Connecticut
www.swinter.com

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Disclaimer

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Executive Summary

How, why, and when do architects decide to create or adopt innovative building technologies in a housing project? What factors come into play when the architect is trying to see that innovation come to fruition? What hurdles or roadblocks might an architect encounter and what successes can be achieved when an innovative technology is implemented? How can those successes be communicated out to a larger audience and/or make an impact on the architectural profession and the housing industry?

Over the past year, those questions were explored as part of a project sponsored by the Partnership for Advancing Technology in Housing (PATH) examining the role of the architect in advancing innovative technologies, and the role of the architect in creating innovative technologies for use in the housing industry.

Relying upon a team of industry leaders to guide and inform the project, this report summarizes the research, activities, and outcomes of the work and its importance and relevance to the architectural community and housing industry. Additionally, recommendations are provided that can lead to new and expanded ways of engaging the architectural community, building industry, and PATH in the technology innovation process thereby improving the quality of America's housing.

A variety of mechanisms were utilized to explore those questions including: conducting an expert panel meeting; conducting interviews with housing experts (the results of which were captured in White Papers on four market sectors of the housing industry), and conducting two expert roundtables. Information gleaned during each task was presented to a different group in the following task in order to solicit feedback and additional input.

Conclusions and Recommendations

There are different types of approaches, examples, and energy in the profession of architecture regarding technology innovation. However, there is very little consistency, coordination, documentation, or communication of the successes or failures of these innovations to a larger audience of architects or to the housing industry. The following recommendations offer possible solutions to engaging more architects in the process of innovation as well as helping them to take the lead in sharing examples of successful technical innovations. For the most effective result, each of these or a combination of these proposed recommendations should be implemented as part of a long-term effort.

1. Education and Outreach

It is essential to expand efforts to educate architects about the resources that currently exist within the profession of architecture as well as PATH, and to refine them to better appeal to architects. It is also recommended that a mechanism be developed and implemented within the PATH program for the continued sharing and engagement in the issue of technology innovation processes and examples of successes and failures among peers. Continuing education is a requirement for AIA member architects. It is essential to work within that system to provide educational programs that offer value and continuing education credits, and subject matter that is relevant, up to date, and timely for housing architects. The form of education must be succinct, easy to access, and offered in a variety of formats to serve the various approaches to learning within this industry.

2. Link Efforts to the Green/Sustainability Movement

The green or sustainability movement was repeatedly cited as a major driving force in all areas of the housing industry during this project. It is critical to link that effort and the momentum, as well as work to influence it. Sustainability is still growing and gaining strength as an approach and as a set of standards for the industry. Suggestions include educating architects about specific technologies that are renewable, help meet LEED requirements, and/or reduce energy use and costs.

3. *Develop an Awards or Recognition Program*

Awards or recognition programs are useful vehicles for raising awareness as well as setting standards within the profession of architecture. Many of the roundtable participants, interviewees, and speakers commented on the need or desire for such programs as a way to highlight, educate, and inspire professionals and the industry on the issue of technology innovation. Programs of this type also have the added benefit of building key relationships, further advancing and sharing useful information and resources, and setting the standards for technology innovations and advancements in the architectural profession as well as in industry. It is suggested that an awards or recognition program be developed in the near future. In order for such a program to be successful, it should include information on installed performance, installed costs, and be viewed with a “whole building” or systems approach to innovation versus a “widgets” approach.

4. *Develop Additional Case Studies on Technology Innovation*

The case study is also growing as a preferred method for educating the architectural community on a broad range of topics. The examples captured during the roundtables can continue to be shared and serve the purpose of educating a broader audience. They offer a range of approaches, issues, and outcomes in different project types and regions of the country. Additional case studies should be developed that highlight the design and innovation process and implementation of technology innovations. These case studies should be communicated through a variety of mechanisms including websites, publications, articles, workshops, and chat rooms. It is also possible to tie efforts into the existing continuing education requirements for architects by developing case studies that are part of an educational course with learning units. The most effective case studies should include information on installed performance and installed costs of technologies to be useful and valuable to the intended audience.

I. INTRODUCTION AND OVERVIEW

A. History and Background of the Research Project

This study focuses on the unique role that architects play in shaping the built environment and, more specifically, in influencing construction practices in the residential building industry. At least in theory, architects are uniquely situated to stimulate greater innovation in the home building industry, since they have the potential (depending on the nature of the project) to be involved in every stage of the design and construction process, from initial design and product specifications to construction oversight and payout inspections.

In practice, however, the role of the design profession in the home building industry varies greatly. The role of architects varies from none (where builders use their own designs without the use of design professionals) to extensive (where architects are intimately involved in every aspect of design and construction). Architects have been leaders in the shift to green building, as evidenced in two recent exhibits at the National Building Museum: the “Big and Green” exhibit that highlighted innovations in the commercial sector, and an exhibit on affordable housing that features residential projects with energy efficiency or green building techniques.¹



But with the rise of production home building over the past half century, the role of the architect has been severely curtailed. In production housing home builders may utilize in-house professionals or retain outside firms, but in both cases typically replicate standard models and designs.

According to one study, less than 7% of all single-family home construction in North America (almost all at the top end of the market) involves the services of an architect.² The study cites Edward Ford's observation that the trend began early in the 20th century, when “the profession largely abandoned the single family housing industry and abdicated its responsibility to planners, builders and developers.” Ford argued that attempts to reverse this trend did not succeed because “they focused too narrowly on issues primarily of interest to architects, such as new materials and technological innovations, without accounting for the entrenched production processes that actually define the industry.”³

There has, in fact, been a long history of the architecture profession exploring the use of new technologies to lower building costs – sometimes with mixed commercial success or long-term impact. Prefabrication of building components has been a major theme of this experimentation. Architects and designers as diverse as Le Corbusier, Walter Gropius, Jean Prouve, Albert Frey, Buckminster Fuller, Richard Rogers, Archigram, Kisho Kurokawa, Phillippe Starck, and others have all experimented with prefabricated building technology. Frank Lloyd Wright's Usonian house was a kit of parts that included a concrete slab, an insulated roof slab, and sandwich wall panels. Walter Gropius' interest in prefabrication began with a housing system developed for the *Weissenhofsiedlung* in 1927 that consisted of a light steel skeleton, compressed cork infill panels for insulation, an asbestos-cement panel attached to the exterior, and a synthetic panel attached to the interior. For his later copper houses he developed complete panels that included both exterior and interior finishes as well as windows.

In the 1960s, Moshe Safdie's Habitat project in Montreal pioneered the use of modular units. A recent book⁴, *Prefab*, identifies some of the more contemporary approaches that seek to combine panelization and factory-built components with housing affordability and design quality, including Shigeru Ban's “industrial minimalism” and Greg Lynn's digitized aluminum prototypes.

¹Examples include: Lawrence Scarpa's design for Colorado Courts in Santa Monica that utilizes photovoltaic panels and other techniques to become the first “net energy use” apartment building in the U.S. and Peter Landon's design for Archer Courts that projects energy bills of \$200/year for town homes built – in Chicago – using concrete wall panels.

² John Brown, “The Architect and the Single Family House,” *International Journal for Housing Science*, Vol 26, No.4, 2002.

³ Ford, E. *The Details of Modern Architecture*, MIT Press, 1990, cited in Brown *op cit*

⁴ Bryan Burkhart, Allison Arieff, *Prefab*, 2003.

These examples illustrate the long tradition of the architecture profession in advancing innovative building technologies. Currently, however, this innovation is often found in higher-end housing or outside the residential sector entirely. Nor for the most part have these design experiments made it into mainstream production building. Conversely, design considerations are often given short shrift in considering new technologies, which are often developed without sufficient attention to design.

This study addresses the potential for design to function as a catalyst for technology innovation that enhances rather than detracts from housing affordability. It taps the best thinking of the architectural community and develops new paradigms for integrating design with technology and construction innovation in housing, by bringing architects together with other home builders and other PATH constituencies to develop strategies for increasing the affordability and durability of housing through innovative use of building technologies as well as innovative design strategies.

B. Research Methodology

One goal of the study was to understand how architects make their decisions about *adopting* an innovative technology or *creating* a new technology. Another goal of the study was to gather information about the process that architects undertake when innovating, and collect and share examples of technology innovation successes as well as failures.

A variety of mechanisms were utilized to explore those questions including: conducting an expert panel meeting; conducting interviews with housing experts (the results of which were captured in White Papers on four market sectors of the housing industry), and conducting two expert roundtables. Information gleaned during each task was presented to a different group in the following task in order to solicit feedback and additional input.

Expert Panel

Key individuals in different markets of the housing industry provided a wide range of geographical and professional perspectives to discussions on the process of examining the role of architects in innovation. Architects, builders, and engineers from small, medium, and large firms or companies, in manufactured, production, custom/sustainable, and affordable housing sectors gathered for an expert panel meeting in Washington, DC in December 2005. The meeting set the stage to begin collecting examples of technical innovation from the panelists, as well as identifying roadblocks and opportunities for marketing, establishing key relationships, and developing more effective communications among key audiences.

White Papers

Interviews were conducted with architects in four market sectors of the housing industry. Geographic representation and companies of different sizes and types were included in the study which explored the role of the architect in advancing technology innovation within their market sector. Various approaches to the role of the architect in innovation were cited along with different forces driving the markets. However, it was noted that green/sustainable design is a major driving force across all the market sectors.

Roundtables

Two roundtables, one of which was a web cast, brought together key members of the AIA Housing Committee, architects innovating in the housing industry, and attendees from around the country. The programs were structured to provide attendees with an overview of this PATH study and its findings to date, the PATH program, technology innovation examples, and time for reaction and discussion. Regional differences, approaches, and concerns were cited and many ideas were exchanged about the need to document and communicate the innovation process and implementation examples of technology. AIA Housing Committee participants interjected thoughts and ideas about making technology innovation a priority within their Committee.

TECHNOLOGY INNOVATION CASE STUDIES

A. Introduction

This section of the report provides case studies that offer a glimpse into the rationale behind technology innovation by architects, the process involved in identifying and implementing the innovation, and the outcome. These examples demonstrate that it is possible to implement new and innovative technologies in a variety of project types as well as in a variety of contexts. There were regional differences in terms of what may drive a project, but in all cases, gathering data locally or from a trusted regional source was considered an important aspect of allowing the technology innovation to move forward. While some of these ideas have only been implemented in one location, they have the potential to be implemented in a wider range of project types and in different regions of the country.

B. Case Studies

Refabricating Architecture

by James Timberlake, FAIA, KieranTimberlake Associates

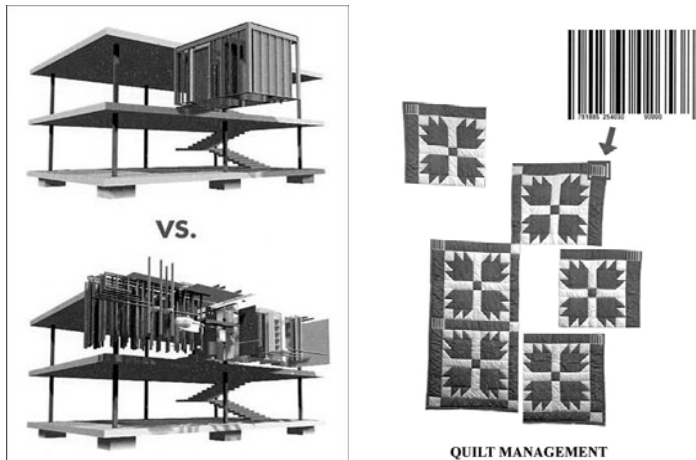
The architectural firm of KieranTimberlake, in Philadelphia, PA, places significant importance on the role of research. Receiving the Latrobe Fellowship for Research enabled the firm to promote research as a main component of their practice and dedicate three to four staff members to applied and non-applied research. The focus on applied research enables information to feed directly back into contracted projects. Research has served as a vehicle for exploring innovation in projects ranging from educational facilities, to housing, and commercial projects.

The firm wanted to manage risk and find ways to address quality assurance and quality control, at the same time seek constant improvement in their process and projects. So they became ISO certified and began to map out their processes. They now have their own risk management tool called KTMS. Being ISO certified and having their own risk management tool allows them to apply their research in ways that benefit their clients and to share information, including through their website.



In housing, they are incorporating Building Information Modeling (BIM) concepts and practices. They use GT Digital Project, which they have in-house, and AutoCad REVIT especially on large projects. They do a lot of rapid prototyping including 3-dimensional printing and modeling. So they incorporate BIM beyond traditional rendering into cost analyses, scheduling, and modeling. Because BIM documents are integrated, they can be shared with contractors and clients. They found that their clients, especially their institutional clients, are pushing the firm to adopt this methodology, and work to a full set of as-built drawings.

Using GT Digital Project and REVIT software on projects to explore modular and integrated component assemblies

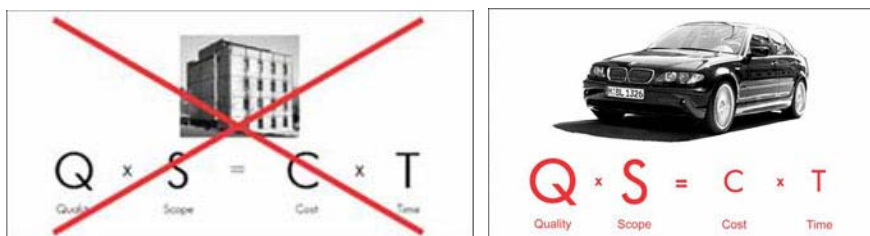


Left to right: Conceptual imagery used to explore the difference between traditional approaches to building such as column and slab vs. inserting components within them; “Quilt management” strategy incorporating UPC codes

They developed a term called “quilt management” that is a strategy for coordinating all the different pieces of a project, sometimes by off-site fabrication of components that streamlines the construction time, improves the quality, and the way things come together on-site. They furthered this idea by looking at other software that uses UPC codes to allow for coordinating different pieces to come together, both in real time and in terms of improving communications among suppliers, contractors, architects, designers, consultants, and the client.

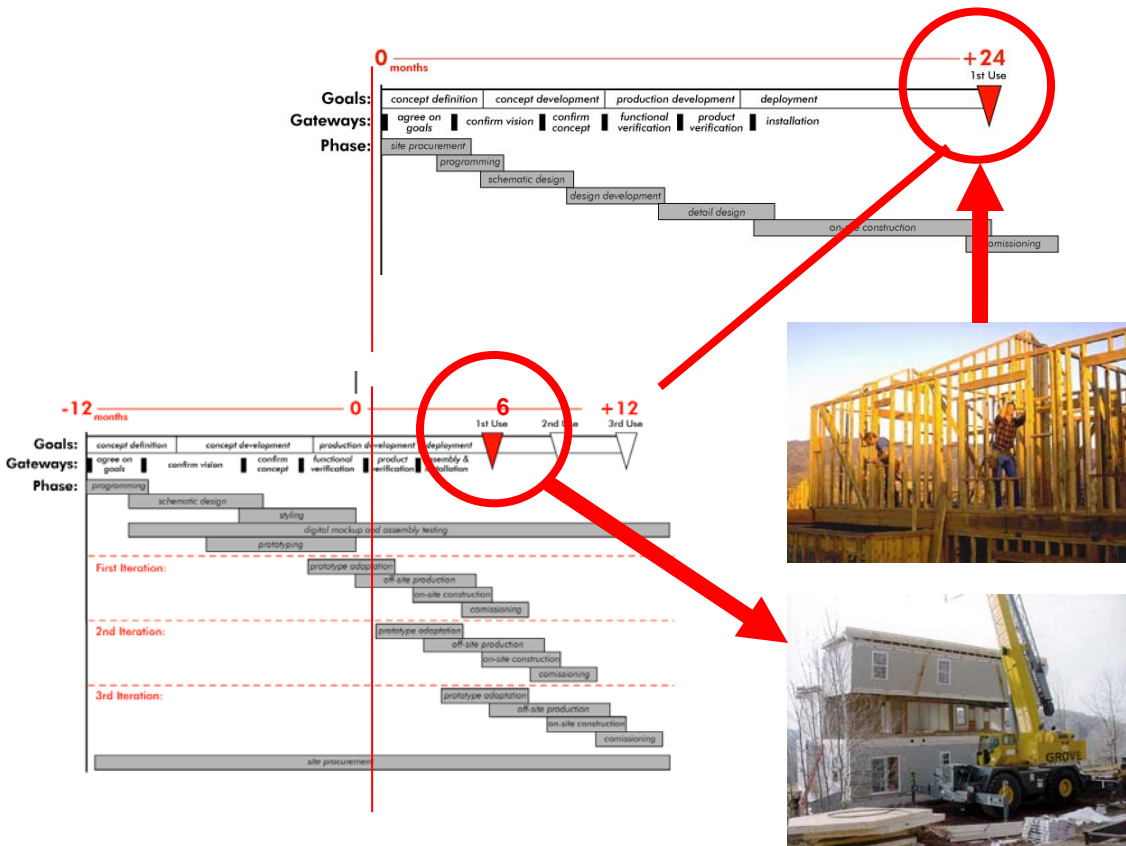
KieranTimberlake also explores a concept they call a volumetric hybrid as a way to build a variety of components that might include panelization and chunks that are spatial to minimize the components, joints, and parts to bring them together. This volumetric hybrid is in some ways superior to building fully off-site and shipping things to the site. It allows for greater site adaptation, greater mass customization, and the ability for the design to change and morph over time.

These ideas are responding to a new client mandate which the manufacturing industries such as automotive, aerospace, and shipbuilding were being affected by 5-10 years ago. Quality and scope used to equal cost and time in balance. But today, clients want more quality and scope for no more time and money than they were used to in the past. In some cases they want more for less. Another overlay in this is environmental quality which is having an impact on all aspects of a project.



Left to right: Old client mandate of quality and scope equals cost and time in balance; New client mandate of more quality and scope for the same cost and time

Using time as an example, the graphic below shows how a stick-built project takes 24 months to complete using a linear process, versus the bottom image and schedule which shows the design done up front and several pieces of the process occurring simultaneously allowing for the project to be constructed with some pre-fabricated elements within 6 months. They relate this to 4-dimensional modeling, which includes time, and demonstrate that more can be done with less time, especially after some of the design work has been completed.



Above: Innovative Construction Practices – Schedule and Build-time 4-d modeling



Melvin J. and Claire Levine Hall, University of Pennsylvania
 Left to right: Pre-fabricated curtainwall system being installed and the completed project

The curtainwall example above is an integrated component assembly which includes all its muttoms, frames, gaskets, glass, blinds, electronics, duct hook-up, and all the fasteners ready to go, off-site assembled, globally supplied, shipped to the site, and tipped into place. It minimizes staff and labor time but increases quality with only about a 10% cost increase for a comparable curtainwall product. In this particular example, the integrated curtainwall assembly is also the mechanical system allowing air to move up through it and hook to the duct work. These types of integrated component assemblies offer great possibilities for volumetric hybrids.



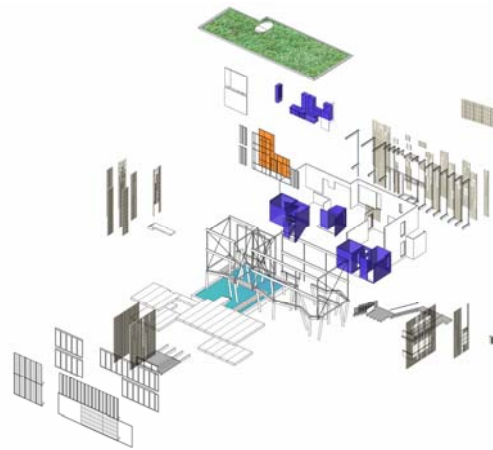
Pierson College Upper Court, Yale University

Left to right: Dorm modules being constructed and all of its finishes being applied in the factory; Transporting the shrink-wrapped unit to the site on a flatbed truck; Module installed by a blind pick over the university with structural steel moment frame, full wide brick exterior, wiring, mechanicals, and 60% of the finishes in place

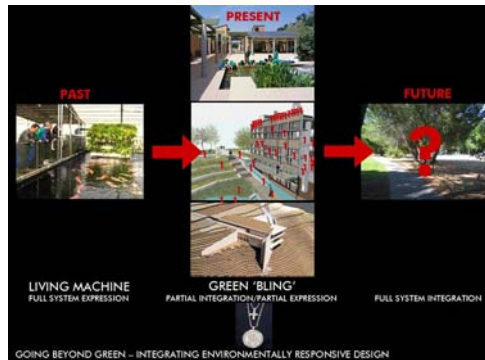


Loblolly House

Left to right: View of house on pilings and the Bay beyond; Axonometric showing the integrated component assemblies of the house



Loblolly House, a 2,500sf private residence designed by the firm, is located in a wetlands site near the Chesapeake Bay in Taylors Island, Maryland. The client wanted a house that investigated new technologies. The firm suggested that it be an integrated component assembly. The exploded axonometric above shows all the parts of the house including the floor cartridges, the aluminum frame, bathroom and kitchen modules in blue, a series of exterior components including the exterior wood façade, and an offsite modularized green roof which was grown in a tray. Once the pilings were in place, the architects expected that all the pieces would come together within five days on site to create an occupiable house. They also designed the supply chain for the project as a way to control the coordination of bringing all the pieces together. The house was designed in a “cradle to cradle” way in that the same way the house was assembled, it could also be disassembled and recycled in the future.



Kieran Timberlake coined the term “green bling” to describe the current trend of applying elements to a building just to meet LEED requirements. Instead Kieran Timberlake is working on a comprehensive approach to meeting environmental challenges: full system integration. This continued exploration allows for the connected process of design, technology, and research to coexist as a way of doing business for the firm.

Prefab Green

by Joseph Remick, AIA, Michelle Kaufmann Designs



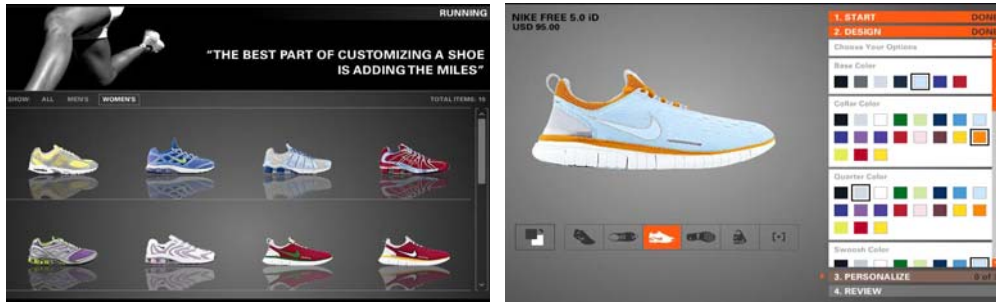
Michelle Kaufmann Designs has blended its view on technology innovation with that of product development. Citing an example of a shoe product line that offers sizes, colors, and styles, the firm found that the approach is a direct response to different needs of the diverse market. This idea drove the creation of 3 different manufactured housing designs that have the potential to be built in any part of the country. The house designs respond to site conditions and materials choices, and offer an efficiency of scale that also contributes to a reduced environmental footprint while providing a quality home environment that can be adapted to different tastes and lifestyles. The firm is so committed to the idea of these houses that it recently purchased a manufacturing facility for the home designs. This will allow the firm to refine and tailor the product as well as enter into new markets with it.

Elements of their philosophy that are applied to the design of these homes include:

- Build only what is needed
- Maximize resources and efficiency
- Minimize dependency
- Create healthy environments
- Let the green in

Michelle Kaufmann and her husband were shopping for a home and became exhausted with the process. They either found a home they liked with a price tag they couldn't afford, or a house they could afford that didn't meet their needs. It was frustrating that any home designed with architectural sensibilities was out of reach to the average home buyer. Statistics state that approximately 2% of new homes in California are designed by architects, which leaves 98% as houses produced by developers without a true sense of place and that are not gentle on the environment.

The firm felt they could do better. From this experience they established the firm's mission – to make thoughtful sustainable designs accessible to more people. Modular is their chosen means to an end. This construction method allows them to achieve their goal of creating thoughtful, sustainable design that is accessible to more people, while still maintaining high quality. Modular construction allows the client to save time and money, with a more streamlined process than the typical architecturally designed, site-built process.



Housing as a Product

Shoe manufacturers use a selection of predefined materials, shapes and colors to allow for mass produced customization. In a few clicks online, anyone can create an affordable, custom shoe that is delivered in 4-6 weeks. Kaufmann Designs thought that this same thought process could be brought to the architectural arena by looking at housing as a product. They developed six steps to home ownership that clarify for the client not just the outcome of working with an architect but also how the firm makes it an efficient process to save time and alleviate frustration (part of the typical architectural process that is more circular in nature). The process is defined and accepted before design decisions are discussed. From there they employ standard building elements from a defined set of parts that can be reconfigured in multiple ways to create a custom solution for the client. A constant theme throughout their practice is to get away from the idea that bigger is better, but that better is better.



Interior of housing structure that includes clerestory lighting, bamboo flooring, and gliding glass door wall

Their designs—through the use of shallow footprints—promote natural ventilation so air flows from the open wall to the clerestory windows. The windows wash the ceiling and wall surfaces with natural light allowing for a more evenly lit environment – naturally. Interior lights are only needed at night. They often specify bamboo flooring, which can be harvested in three to five years. This rapidly renewable flooring is an attractive and durable substitute to conventional hardwoods that can take two to three times as long to regenerate. They recommend using wood flooring throughout the home to avoid the use of conventional carpeting, which can contain many toxic chemicals and hold onto allergens. A gliding glass door wall offers maximum views and blurs the boundary between interior and exterior – making the space expand. This also extends the design of the home to fully embrace the outdoor environment. Many exterior rooms are created from the organization of the built modules, thus expanding the useable space of the entire environment.

Modular and Site Built Case Study

The firm developed a case study to examine the questions:

- How much time, money and problems will the modular process save?
- How much more sustainable is the house?

They built two identical homes: one modular and one site built. Their experience demonstrated that when materials arrive on site, they are stored outdoors, due to lack of covered storage. Once materials are left

outside for more than two weeks, rain and sun compromise the materials' integrity. In a factory materials are stored in a climate-controlled environment so the materials are not compromised. There is a high level of quality control: all the workers are under constant supervision. The assembly line construction creates maximum efficiency and worker specialization.

As is typical with site construction, when there are extra or cut materials, they are thrown away since the contractor doesn't usually have storage capacity. The factory has storage capacity, so when there are extra or cut materials, they can be stored and reused for the next home coming down the line. For example, if an 8' long 2x6 wall framing member is cut down to 6' to accommodate a high window, that extra 2' of length is kept and stored so the next time a 2' long 2x6 framing member is needed, it is there to use.

The site-built home cost about 25% more than the identical modular home. Costs for the site portion (i.e. grading, landscaping, utility lines, garages and pools) cost the same in both, so they were not included in the comparison. There are time savings (which also result in cost savings). The *site-built* Glidehouse took 21 months of total project time to complete (including design, engineering and permits) — 14 months of that being construction time. The *modular* Glidehouse was completed in 10 months start to finish — 4 months construction time.

House Product	Construction Method	Construction Time	Total project time
Glidehouse	Site-built	14 months	21 months
Glidehouse	Modular	4 months	10 months



Modular Glidehouse being shipped to the site then lowered onto the foundation

In the modular example, the house is constructed in the factory and then shipped to the site. While the house is constructed in the factory, the foundations are built. When the house arrives at the site it is rolled off of the truck and lowered with airbags onto the foundation. The entire house is set in a day and utilities are connected while the modules are secured to the foundation. The remaining exterior materials to complete the enclosure are loaded in the modules (in their order of need) at the factory. At the end of that first day, bathrooms are working and other infrastructure is in place. With the “ship loose” items ready as they are needed the house is completely put together in a matter of weeks.

All homes are solar ready. If a client can't afford the PV panels right away, everything is in place so they can easily be added in the future. The firm is working towards the goal of making solar PV arrays standard on all house products.



Exterior sunshades allow for natural breezes to enter rooms, and deflect heat from direct sunlight into the interior spaces. The hydronic HVAC system that is installed also supplies the domestic hot water from the same high-efficiency boiler – reducing the energy needs associated with storing hot water in tanks. Low-flow fixtures and dual flush toilets (one button for liquids, one for solids) also help reduce the water usage of the home. Native landscaping and xeriscaping eliminate the need for heavy irrigation. (A chart from the local water utility showed that Michelle’s Glidehouse uses a third as much water as the average home in her town.)



While energy and resource efficiency are part a major part of the decision making process, so is a healthy environment. Only Icynene i, a superior spray-in insulation is used. It offers a barrier 37 times more effective than fiberglass batts or boards, helping achieve maximum indoor air quality and no dust or outside contaminants. It also drastically reduces noise pollution from outside sources. When the foam expands there is no room for air or water in the wall cavity, an environment where mold cannot grow.

Additional Applications

These ideas of modern, modular sustainability have also been reconfigured into other products such as the Breezhouse. The same general design strategies of passive environmental design with sustainable materials are used to create a different product. The result is a house that connects to its environment with expansive indoor/outdoor spaces. Breezhouse uses repeatable elements that are configured in multiple ways to create custom solutions for individual clients. In this example, the same basic elements are configured into a two-story home. They can also be configured to work in a narrow lot.

sunset® breezhouse™
6 steps to ownership



The firm recently launched their newest product, the mkSolaire that allows for sustainable living in an urban infill or rowhouse environment, and the offerings keep expanding.

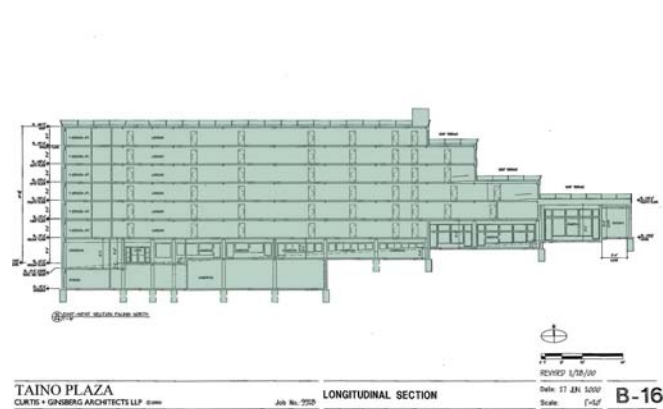
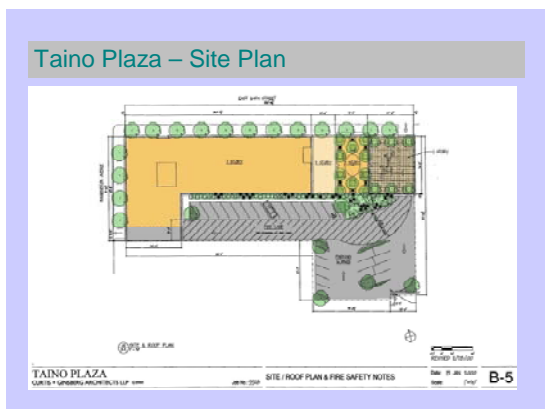
Sustainable Design and Multifamily Residential Construction
by Mark Ginsberg, FAIA, Curtis + Ginsberg Architects



Exterior view of Taino Plaza, Bronx, NY

Mark Ginsberg of Curtis + Ginsberg Architects in New York City offered a view into the design and construction of large-scale multifamily affordable housing in New York where cost is critical. Examples of innovations that were accepted and implemented and why, as well as those that were not, were shared.

One example, the Taino Plaza project, was the first solar energy installation in the south Bronx. Ginsberg commented on the need to reduce energy loads and operating costs as a driving force behind the project. The site plan is an L-shaped building with parking in the rear taking up the entire site. There are two roof terraces on the 4th and 5th floors to create some recreational space for the tenants. The ground floor comprises a series of commercial spaces and the main entrance. The fourth floor has a playground structure, roof terrace, community room, and laundry. It's a typical double-loaded corridor apartment on a steep site. The architects went through a process with the New York State Energy Research and Development Authority to achieve the requirements for electrical energy loads to get funding to support technologies. NYSERDA wants payback in 6-8 years so they considered a wide range of options. One of the biggest concerns in affordable housing is that authorities tend to focus more on first costs and less on operating costs.



Left to right: L-shaped Site Plan; Section of Taino Plaza

Technology Innovations

Dual level light fixtures were installed in the exit stairs because code required that lighting be on at all times. The light is generally on at 30% of its lighting level, which helps to reduce energy use and energy costs. The light has a built-in motion sensor that activates the fixture to full power when someone enters the exit stair. The lighting required a small adjustment but was one of the simplest energy-saving strategies to implement.

Measure	Incremental Cost	Energy Savings	Pay Back	Life-Cycle Savings
Energy Monitoring System	\$12,580	336 mmBtu	3.7 years	\$36,050
R13 from R 11 Insulation	\$4,680	70 mmBtu	6.6 years	\$5,552
Aerco Condensing Boilers	\$29,750	407 mmBtu	7.3 years	\$29,213
HW immersion coils in Boiler	\$4,000	164 mmBtu	2.4 years	\$19,708
Heat Recovery	\$41,500	575 mmBtu	7.2 years	\$41,735
Setback Thermostat in Commercial spaces	\$1,656	56 mmBtu	3.0 years	\$3,049
Common Area Lightings	\$17,966	34,212 kWh	3.4 years	\$26,871
Occupancy Sensors	\$1,180	1,178 kWh	6.4 years	\$374
Glazing upgrades	\$16,160	180 mmBtu	9 years	\$9,892
Efficient elevator	No Data			
Replace electric residence heating with Hydronic in Baths	\$23,250	19745 kWh	7.5 years	\$21,617
Apartment Lighting	\$18,890	103,275 kWh	1.3 years	\$21,617
Refrigerator upgrade	\$800	1,194 kWh	4.1 years	\$628



Energy efficient lighting and boilers

Two condensing boilers were used for both heating and hot water. NYSERDA and the manufacturer never stated that the standard baseboard radiator used required a water temperature of 170° for the condensing boilers to operate, and the highest efficiency is usually supplied at 160° and returned at 140°. The radiators have been less than satisfactory. The first year heating the apartments was also problematic. There were some initial problems for the residents to understand summer mode (where the

system is just producing hot water) and heating mode (where it is producing hot water and heat). The operator of the boiler was not knowledgeable about the equipment.

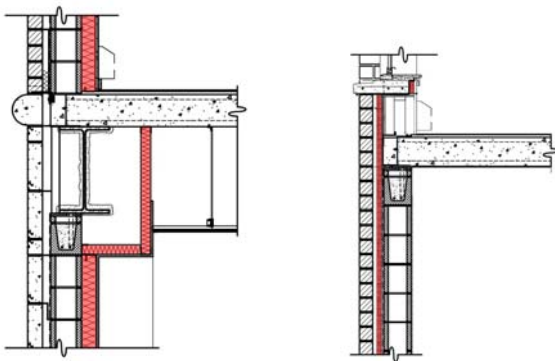


Taino Plaza is the first installation of photovoltaic (PV) panels in a multifamily housing project in the Bronx. The payback on PV doesn't work without a significant subsidy. Subsidies were received from NYSERDA and the borough president's office. In New York City affordable housing surplus energy is not allowed to be pumped back into the grid. The surplus energy was used to light and ventilate the common spaces. It took nearly a year to resolve some issues regarding the correct installation and some connections of the PV for safety and continued flow of electricity in a blackout.

30kW rooftop photovoltaic array was the first solar energy installation in the Bronx

Photovoltaics Summary	
Energy Production	42,000 KWh
Price	\$268,757
Rebate	\$149,310
Payback	3 years

The left image below is a basic wall section used in Taino Plaza which shows the insulation inside a standard masonry bearing wall plank construction. A steel beam is used to support store front openings. Where the plank goes through the building there is no insulation, creating a thermal break. The right image shows an insulated cavity wall. This is more expensive but it takes the thermal mass inside the heated envelope and makes it much easier to create a vapor barrier because it is on the exterior of the masonry wall. The plank does create a thermal break. It also helps reduce water penetration. The wall is working very well and so it is being utilized more often in new projects.



Wall Sections

What Didn't Work

Energy efficient elevators were vetoed by the client because only Otis Elevators were approved for use in New York City. In a low-income neighborhood with few installations there was concern about getting service and using one supplier.

Top floor bathrooms typically have heating. The typical solution is an individual electric heater which is

not energy efficient. The payback period was considered to be too long so a more energy efficient solution was not implemented.

Bathroom and kitchen exhaust heat was to be recovered to heat the corridors. The seven-year payback period for this technique was not acceptable. NYSERDA will pay 40-50% of the cost at the end of the project. The client paid half and also covered the cost of construction.

When the firm utilized an aerated concrete block product they learned that the block provided a higher insulation value in a smaller space due to its compact size while reducing labor costs, even though the product was more expensive. However, Ginsberg learned along the way that the block could only support two floors of plank due to structural limitations.

The Application of Panelized in Mid-Rise Residential Construction

by Jack Inglesse, AIA, PE, Inglesse Architecture and Engineering



Panelization factory

Jack Inglesse is an architect and engineer in New Jersey who has successfully utilized an open panelization system with dens-glass fiberglass faced gypsum sheathing on the outside, but open on the inside, in mid-rise residential construction over four stories. The innovation in panelization was taking a traditionally field-built building component, i.e. walls and bearing wall structure, and fabricating it in a shop, as it adds both strength and quality to the product while reducing job-site waste.

The client's need to build higher density housing forced the issue of moving from wood-frame construction to steel because of code requirements above four stories. This allowed him to finally introduce and incorporate the panelized system that is now being used in a number of applications. The process entails prefabricating portions of the building, primarily wall sections, in a factory for delivery to and assembly at the job site.

A key driver of the architect's shift to panelization was the poor workmanship he received on his first attempt at light gauge steel framing. The subcontractors on the job only had interior partition experience and could not maintain the tolerances needed for exterior applications. Panelization has proven far superior in terms of quality – and cost – management.

Panelization is appropriate for use in conjunction with wood framing, light-gauge steel framing, hybrid light gauge, and heavier steel members. Inglesse commented that panelization may not change the way buildings are designed in a significant way but it can allow better buildings to be built.

Panelization is an excellent choice for residential and mid-rise because:

- Residential floor plans typically incorporate short floor and roof joist spans, which favor bearing wall construction.
- Most larger residential building plans typically incorporate repetitive features which simplifies design of panel components.
- Projects are often large and often incorporate multiple similar structures.
- Typically these systems can be constructed at lower cost than other alternative framing systems.
- This structural system works for mid-rise construction; anything larger tends to be flat plate concrete or other systems.

Compelling reasons to prefabricate parts of a building include:

- Improved quality control in a factory setting, especially for steel-frame bearing walls.
- Reduction of on-site waste.
- Easier sheathing installation as panels usually can be delivered sheathed.
- Reduced time that the building is exposed to the weather because erection time is shortened.

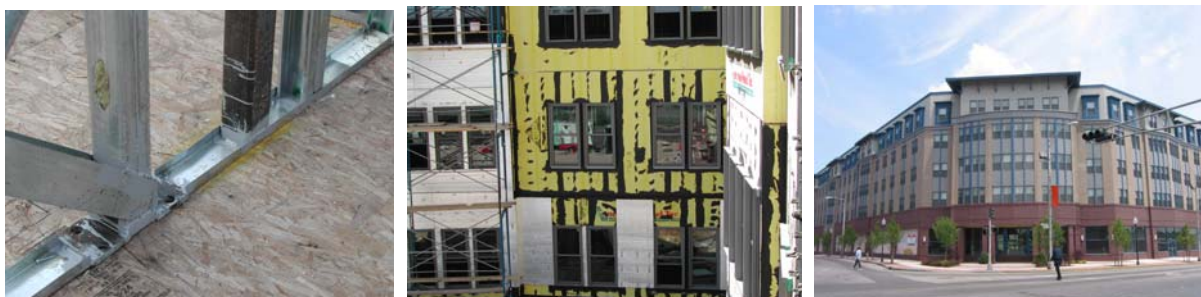
Example

Dr. King Plaza - East Orange, NJ
96 affordable units with ground floor retail
Inglese Architecture and Engineering
American Panel Tec manufactured steel panels
PDJ Co. manufactured floor trusses

There were some miscellaneous structural steel pieces fabricated into the panels. Where there were shear walls, square tube sections were incorporated as posts in the panels. The panelized system started at the second floor, as the building's first floor was all retail and it was constructed of conventional steel frame to create a more open plan at this level.



Left to right: Steel framing and wood trusses (Type 3 construction); two of four floors in place; panels fabricated with internal support angles which receive nailer for trusses which keeps trusses entirely out of non-combustible exterior wall assembly.



Left to right: Panels fabricated with diagonal shear wall straps, as well as additional tubular steel sections for concentrated loads; steel stud exterior walls come sheathed, but exterior insulation is installed in the field to overcome thermal bridging.; Dr. King Plaza completed

Timothy Commons: A Green Affordable Housing Community in Santa Rosa, CA
by Katherine Austin, AIA Architect



Timothy Commons, a green, affordable housing development in Santa Rosa, California, required the architect to focus on the use of a relatively new technology called Liquid Boot[®], to address and resolve site clean-up and preparation issues to meet California's stringent green building standards. Timothy Commons is located on a brownfield, infill site. Mitigation for potential toxic fumes from a past fuel spill was required. Katherine Austin, the architect for the project, identified the Liquid Boot[®] system, which had been utilized in another project in the region successfully. The system was new and innovative to her and her client, so she needed additional support information, close communications and coordination with the client and the product applicator to see the project and the implementation of the Liquid Boot[®] system through to completion.

Applying Liquid Boot[®]

Liquid Boot[®] is a system developed in the late 1970s to vent residual fume and has been installed successfully for the past 28 years. Over fifty million square feet of Liquid Boot[®] has been installed under hospitals, schools, libraries, high-rise commercial and residential buildings, single-family housing developments, and major public works projects throughout the United States. Liquid Boot[®] is a cold, spray applied membrane used for gas vapor barriers, at grade and below grade waterproofing, and as a liner for potable water tanks. The Liquid Boot[®] membrane is typically sprayed to a thickness of 60-100 mils, depending on the conditions of the project. Liquid Boot[®] is water-based and does not contain any VOCs. It is sold manufacturer direct to approved applicators, who then apply the product.

This system allowed the project to proceed on this infill site. Petroleum had been dumped at the site many years ago. While all the detectable contaminated soil was removed, there was concern that deep vapors could surface. The Liquid Boot[®] systems allows for those vapors to be vented away from the occupants and dissipate into the air.



Left to right: Once the forms are up and the slab bases are rocked, chalk is used to lay out the location of the under-slab vents. Containers on right are the liquid used to seal the system.



Left to right: Flat egg crate type vents are laid down over prepared rock and sealed at connections. Connections to pipes are at the perimeter. Any vapors that could percolate up from the soil will hit the rock layer which will be carefully sealed. These vapors then migrate sideways into the permeable vents. Once inside they will be drawn by the pipes by convection and out to the roof. All work is carefully inspected and documented.



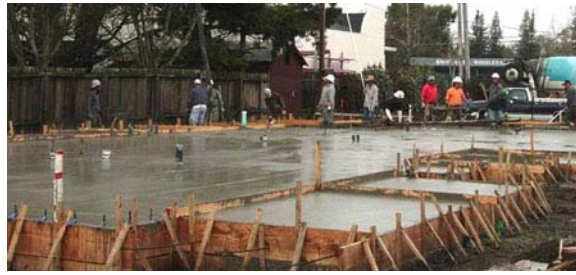
Left to right: Once layout is complete and all joints are sealed the first coat of fabric is placed over the assembly. The first coat of liquid boot is sprayed on. Each sprayer has two nozzles which hold two components that combined become a strong sealant.



Left to right: The first layer is completely saturated and all joints are carefully sealed. Once this is complete a Smoke Test is done. The smoke test will detect any leaks in the system. Smoke is blown through a hole in the middle of the system and any leaks are promptly sprayed.



Left to right: Once the first layer has been checked thoroughly for leaks and sealed the top coat is then applied. The top coat is a rubberized fabric that is laid over the first coat exactly. All joints are carefully overlapped. Edges are folded up the concrete forms. Areas not covered will be exterior porches. Once all six buildings were prepared and checked, the slabs were ready to be cabled. The system is wrapped up the sides of the forms so that the perimeters will be sealed.



Left to right: The cables were suspended by anchors that are flat on the bottom and sit on top of the Liquid Boot[®]. It is imperative that nothing puncture the surface of the rubberized fabric. The vent tubes were all marked with a red top. These continue up the walls of each unit and terminate above the roofs. With the cables set, the concrete slab pouring begins.



Once the system is complete, the vents are no more noticeable than typical roofing vents.

III. INNOVATION IN THE HOUSING MARKET SECTORS

A. Introduction

What role do architects play in the various market sectors of the housing industry? How and when do they decide to create and/or implement a new or innovative technology in a housing project? These and other questions were discussed during interviews conducted with professionals in four housing market sectors to establish an understanding of the unique aspects of each market as well as observations of commonalities or disconnects regarding the role of the architect in creating and implementing innovative technologies. The market sectors considered during this study include:

- Affordable, Multifamily, Seniors
- Custom and Sustainable
- Production
- Factory-built

There was geographic and demographic representation in the interviews by including professionals from around the country and from different types of firms or companies in the four market sectors of the housing industry as listed above. The questions were organized around the role of the architect as user and creator of technologies and an exploration of PATH's role in supporting innovation. The questions posed to interviewees were framed to allow for expansion and clarification of the concepts of technology innovation, which include:

Architect's Role in Advancing the Use of Innovative Technologies

- What is your role in getting new technologies used in the projects you design?
- How do you hear about new, innovative technologies?
- What motivates you to investigate a new technology?
- What type of information do you need?
- Where are you most likely to look for this information?
- What barriers or obstacles keep you from using a new technology?
- What needs to happen – how do the stars need to align – for you to take the plunge?
- Any recent examples?
- Are you aware of/excited about any new technologies – ones that you may not have used, at least not in housing - that show promise for residential applications?

Architect's Role as a Creator of Innovative Technologies

- Have you created any innovative technology solutions in your projects - solutions that aren't readily available in the marketplace but could potentially be replicable or mass-produced?
- What problem did your technology "fix" try to solve?
- How did you develop your "fix"?
- What obstacles did you encounter?
- Do you think there might be a market for your technology "fix"?

PATH's Role as a Supporter of Innovative Technologies

- Are you aware of the PATH program, PATH Technologies, the PATH Top 10 Technologies?
- Have you used any of the PATH Top 10 technologies recently?
- How might an innovative technology resource such as the PATH website be more useful to you?
- Have you encountered any design problems that existing technology – and your inventiveness – weren't able to solve?
- Would you be interested in a PATH awards program recognizing the creation of innovative

technology?

- Where do you see the next opportunities for technological innovation in the homebuilding industry?

B. Summary and Conclusions by Market Sector

a. Affordable, Multifamily, Seniors Housing Market

The architects interviewed have varied approaches to the incorporation of technology into their projects. However, some commonalities emerge that include the following:

- Most architects see themselves as part of a team when introducing new technologies although they are often at the center of the effort to do so.
- They seek information about new technologies in sources that are concise and accurate.
- Talking to other architects about their experiences is considered the most valuable way to get good, dependable information.
- Most architects are motivated to investigate and use new technologies to improve building performance and meet sustainability goals.
- Technical data and specifications are important, but cost and performance data are very important but difficult to find. In larger firms in this market sector, there is usually a dedicated person conducting research on technology.
- New technologies are most often considered during the design phase, but several interviewees noted that tweaking of technology happens during the construction documents phase and often during construction.
- There is a strong desire to manage risk when using something new.
- Time was cited as a barrier to innovation which included the time to fully investigate a technology as well as construction time.

Despite their time and budget constraints, this group incorporates many unconventional technologies and strategies into their work, usually in a highly inventive way. In fact, their budget constraints often seem to be the inspiration for finding a better, cheaper way to do something. Mechanical systems and ventilation are common areas of focus for these innovations. While all of the interviewees participate in outreach efforts to tell others about their projects, many are disappointed at the lack of exchange among members of the profession about lessons learned.

The PATH program does not seem to be a tool used by the interviewees. It is seen as not progressive enough in the technologies it highlights, and too “technology specific” rather than systems driven. The PATH site was considered difficult to navigate and overly burdened with text.

Recommendations

1. Make the PATH website navigation more intuitive and reduce the amount of text on the home page. Most architects are visually oriented. They need to be able to find what they need quickly and easily without wading through too much text. If the site is too cumbersome, they will not use it.
2. Provide leading-edge content, geared toward more sophisticated users. The Top 10 technologies were considered fairly established items by the architects interviewed for this white paper. Newer content would be more interesting to them and may entice them to use the site.
3. Provide climate-specific content. Certain technologies are not appropriate for all US climates. Directing users toward content based on where they are practicing will help organize the site and manage the amount of information to be reviewed.
4. Provide a “what’s new” section on the site and or send out email alerts when something new is introduced. Architects are increasingly overwhelmed by information. Isolating new content will

- help them use the site more efficiently.
5. Include technologies not limited to single-family homes. The technologies included on the site appear to be most appropriate for single family dwellings. Builders of affordable housing are often designing multifamily buildings with very different technical requirements than small-scale residential construction. Site content that addresses multifamily buildings would be helpful to them.
 6. Provide a forum on the PATH website where architects can trade “war stories” about different technologies and post technical needs. Learning from other practitioners’ experiences is extremely valuable to architects. A forum for the communication of those experiences would be a valuable, unique resource. Several specific technical needs emerged from the interviews, these could be posted on the PATH site for industry members to see and potentially respond to.
 7. Stress systems over individual technologies. The thinking behind the “tech sets” should be expanded upon to influence more of the site content. Rather than lists of unrelated technologies, integrated systems should be stressed.

b. Custom and Sustainable Housing Market

Talking to building community colleagues is a critical part of how architects analyze new technologies in the custom and sustainable market. It does not suffice in and of itself, but an architect rarely uses a technology for the first time without some form of personal discussion(s) with other designers, engineers, installers and/or contractors. Custom and green architects have a somewhat different approach to evaluating new technologies. Custom architects are primarily (although not exclusively) concerned with how the technology will affect the people who use the building. Green architects, on the other hand, also consider how the technology enhances performance of the building itself and how it will affect the environment. These are important concerns for custom architects as well, but typically secondary concerns. For green architects these issues are more prominent in the analysis and decision-making process concerning new technology. Designers - custom or green - prefer initial information on a new technology in short formats (e.g. one-page or less) with a strong visual orientation. Facts and figures don’t matter – at least at first. Europe appears to be a key source of new technology inspiration, especially for green architects.

Suggested methods to advance technology innovation include:

- A technology-focused “forum” to facilitate discussions among and between members of the building community
- A listserv for architects that keeps them updated on new housing technologies.
- Case studies to explain new technologies to architects, as long as they address critical issues – cost, installation and performance – clearly and honestly.

Firm size influences who within a firm takes responsibility for technology; the smaller the firm, the more likely the lead designer will also be directly involved in analyzing and, ultimately, specifying a new product. In larger firms, the analysis process is more diffuse and the ultimate decision is usually made by a team.

Perceived risk is also a key barrier. While architects have an “innate spirit of experimentation” they are also cautious when it comes to products they’ve never used before. It is unclear how this barrier can be overcome, but case studies and access to previous users seem to be important factors. With respect to risk, innovative hardware and finishes are a lot more likely to be used than innovative structural and/or other critical building systems. Architects do innovate, but do not typically share information on their innovations with others outside their firms. Architect’s housing projects are huge potential “data mines” for innovative design and technology information. Architects already look closely at other projects for inspiration and design ideas. If the technology innovations in these projects could be made more prominent and visible, everyone in the building community would benefit. If this flow of information from architects and their projects can be effectively captured and categorized, it can also provide building

product manufacturers information to assist their product development efforts.

The custom/sustainable architects group has very little knowledge or even awareness of the PATH program. Education is a key mechanism for transferring technical information and should be part of any information dissemination program undertaken by PATH, at least for architects.

Information on the installed performance of innovative technologies is critical to architects trying to make decisions. Monitoring installed applications might be an effective way to facilitate the generation and collection of this data. The definition of “technology” should be broadened to include creative applications/adaptations of existing technologies if such applications/adaptations improve the overall performance of the home. An awards/recognition program showcasing technology innovations in housing would be a useful addition to the knowledge base.

Recommendations

Based on the information collected over the course of the project and the conclusions delineated above, the following recommendations are made to HUD and the PATH program.

1. Substantially expand awareness of the PATH program among architects. Consider an outreach program to drive architect traffic to the web site. (The site, or at least the entry pages, may need to be modified to be more “architect friendly.”) Most of the architects interviewed were simply unaware of the site or the program.
2. Develop a “forum” function on the PATH website where architects can share information about technology innovation. The forum should encourage sharing “war stories” about using individual technologies, but should also encourage architects to describe innovative design and detailing approaches they have used in their projects. The forum should, to the extent feasible, be considered a vehicle through which architects can talk directly with their peers about technology.
3. Develop an architect-focused listserv to keep the profession updated on new technologies and on the PATH program.
4. Establish an ongoing case study development and dissemination program focused on architects. Make sure the case studies directly address areas of key concern to architects: installed cost, installation details, delivery issues, and installed performance.
5. Mine existing data sources for information on the application of new technologies in housing. Many existing sources – especially architectural and shelter publications – feature innovative house and housing projects on a regular basis. However, innovative technology uses and applications are rarely featured. Perhaps this could change if PATH influenced the process in this direction.
6. Initiate a PATH awards program recognizing innovative uses of technology in housing.
7. Transfer data collected from architects by PATH on their innovative uses/applications of technology back to product manufacturers to help them upgrade and/or develop new technologies and products. This “reverse information flow” may open up a new role for PATH vis-à-vis building product manufacturers.
8. Develop educational materials and training programs focused on innovative technologies as a means to better disseminate information on these materials. Consider developing specific educational materials specific to architects, followed by materials for code officials.
9. Expand PATH's focus beyond individual technologies (products) to include innovative approaches to design and detailing that are being developed in housing designs across the country every day – assuming these applications improve the quality, durability, energy efficiency, environmental performance, and/or affordability of housing. Transferring information on these innovations, in addition to the technologies in the PATH inventory, will provide a new, and much needed, addition to the process of advancing technology in housing.

C. Production Housing

Interviewees noted that there are a variety of forces at work in the production housing industry that pushes technology innovation including:

- Market demand with buyer's desires shaping their client's marketing plans, which in turn dictates what gets designed.
- Sustainability or green building movement that is driving their decision-making and it has become a consistent theme for builders who work across many market sectors.

It was also noted that smaller builders are more likely to try new innovations because they are looking for a marketing edge to compete with larger builders, especially in down markets when builders need to stand apart from the crowd. New Urbanism, urban planning, and new regulations that must be responded to are also playing important roles in decision making for much of this industry.

To respond to the green/sustainability movement, most often designers are pursuing new technologies that do the following:

- Reduce environmental impacts
- Reduce life-cycle costs, and
- Make housing more affordable.

Many examples were cited including:

- renewables and energy conservation systems
- heat reflective exteriors
- zero run-off drainage
- ground source heat pumps, and
- filled-cell concrete block hurricane-resistant designs.

Most interviewees commented on the need to respond to both the buyer and builder by investigating new or innovative factory-built technologies that offer potential cost savings. This translated to both first-cost and operating costs. Additionally technologies that offer market differentiation for a builder's product line will motivate the architect in this industry. Most commented on the need to address technologies that contribute to cost savings early in the design and process as well as throughout their marketing plans.

Each of the experts interviewed for this paper brought a different perspective of how HUD's PATH program influences development and application of design and construction technology in production-built affordable housing. Not all of the interviewees had an awareness of PATH, but some had previous involvement in PATH program activities, and all were aware of production housing technology resources available through the program. However, none viewed PATH as a preferred or convenient source for obtaining technology information on production affordable. Several consistent themes emerged in the course of the interviews of the production housing design experts and summarized below.

- Increase collaboration and between architects and the PATH program thereby improving the quality, performance and affordability of new U.S. housing.
- Increase involvement of architects in the development and application of innovative housing technologies in their projects.
- Engage and involve the architectural profession through a sustained outreach and collaboration effort through PATH.
- Build PATH's brand recognition among housing buyers and market demand for affordable housing technologies.
- Refocus PATH's current and new housing technology information resources and programs to better serve the needs of the public for housing that is affordable to obtain, operate, and maintain.

Recommendations

1. Engage Major National Homebuilders - Mainstream architectural firms are not part of the vertically integrated housing industry. PATH outreach and marketing efforts should be focused on designers, manufacturers and consumer groups who are engaged in the affordable housing arena.
2. Focus on Production Housing Design Practitioners – Architects interviewed for this paper noted that production housing developers and builders approach projects very differently than in custom, sustainable and modular/manufactured housing. Production housing is very market driven and attention to public demand for architectural styles and features, construction materials and building equipment determine product development. With regard to production housing, the PATH program should focus its outreach efforts on design firms involved in the production housing industry.
3. Address Risks of Using New Technology - Several interviewees noted that major production homebuilders are risk-averse to trying new innovations and technologies. The major national homebuilders are publicly held companies and see themselves as large targets in cases of materials or product failures. For this reason, major national homebuilding companies are not likely to be champions of trying new products or systems with unproven track records. Because the major national builders are viewed as standard setters, PATH information and resources on technology innovation should address issues like durability, service life, manufacturer's warranties and guarantees and product testing.
4. Promote Efficient Land Development Practices – Most of the architects interviewed cited land costs and civil infrastructure costs as the most significant factors influencing housing costs. One architect noted that advancements in housing technology offer only incremental reductions in the price of affordable housing, while community acceptance of greater density in land planning and zoning laws reduces housing costs more significantly. PATH should therefore include land-planning practices within its definition of housing technology and develop resources on best practices in land planning for affordable housing.
5. Increase Public Awareness – The majority of design professionals are unaware of PATH. Several interviewees felt the best way to raise designers awareness of PATH was through raising awareness among housing consumers.



Duany Plater-Zyberk & Company provided its development client with urban design, architectural design codes and unit prototype designs for Alys Beach, a 158-acre resort community occupying the last piece of beachfront property on the Florida Panhandle. Alys Beach is designed as a walkable community with homes that feature concrete block construction, white surfaces for reduced heat absorption, interior courtyards for outdoor living, and a “no airconditioning” option.

d. Factory-Built Housing

In the factory-built market sector, there tends to be more of a systems-based approach to addressing technology. This is a result of housing being looked at as a product. Low cost and the efficiency speed of construction tend to be the driving forces for factory-built houses, many times at the request of the client. The industry is generally on the lookout for technologies that appeal to the consumers in the marketplace that the consumer views as adding value. The industry also tends to embrace ideas or technologies that both perform better and look better even if there is no cost savings.

However, there are also obstacles within the factory-built industry such as:

- Companies that construct sub-standard modular housing which gives the entire industry a bad image
- Cases when an architect is not hired because of the perception of added cost
- Difference between how an architect and a developer or builder approach design and technology. An architect wants to start with a blank slate and work through the goals and objectives of the project in order to create a design for the client. The technologies and systems that respond to that design are not always determined at the outset. Clients who generally want a building system defined at the beginning of a project tend not to work with architects. Taking a systems approach to housing design is considered counterintuitive to most architects.
- Community acceptance of architectural styles and techniques
- User education
- Cultural issues
- Turnover in facility management that points to the need for technology that is simple to operate.

Larger companies can also afford to investigate new products and technologies. It is more difficult for smaller builders to accomplish. Typically modular builders need to investigate technologies that help them compete on the factory floor. Additionally, new technologies will be investigated if they can easily be incorporated into the company's production and delivery processes, provide an opportunity for projects to run more smoothly, reduce the amount of field construction, and result in happier clients.

Labor and competition were also cited as issues that affect how or when a technology is introduced into the factory and building process. Factories and financiers of projects can be a challenge to convince when it comes to a new technology, since factories aren't set up to modify quickly, and financiers have a hard time appraising unique or innovative solutions.

Trends in the factory-built industry include:

- site-built production housing that looks custom but is offered near a production price
- integrated design
- zero-energy and/or off-the-grid homes
- SIPs are expected to become very popular.

Architects in this industry tend to rely on word-of-mouth references, professional colleagues, industry trade publications, conventions and seminars, and the Internet for sources of information on technology.

The industry tends to document their projects very carefully since it helps with the following:

- selling their services to new clients
- working better with the factories that bid on their work
- increasing public awareness of modular and factory-built technologies
- using the information as an internal educational tool especially for systems and technologies that are going to be used again and again.

Recommendations

1. Increase Public Awareness - The majority of design professionals are unaware of PATH. Several interviewees felt the best way to raise designers' awareness of PATH was through greater

awareness in housing consumers.

2. Engage Housing Practitioners - Mainstream architectural firms are not part of the vertically integrated housing industry. PATH outreach and marketing efforts should be focused on designers, manufacturers and consumer groups who are engaged in the affordable housing arena.
3. Highlight Technology's Value - PATH resources don't present a "value proposition" to the public and designers. PATH resources should press designers' "Hot Buttons" about why a technology should be used. Develop future PATH resources to highlight the key benefits of using a new or innovative technology or that result in tax deductions, lower first costs, and lower operating costs.
4. Feature Technology Successes – Market forces will continue to shape demand for housing products and technologies. PATH should highlight the successful application of factory-built housing technologies through increased consumer satisfaction and demand for housing that is affordable to obtain, operate and maintain.
5. Engage Architects in the Process and Benefits of Factory-built Housing – Not many design firms utilize modular construction on custom housing. Architects could contribute more to this market sector if they learned how to offer a custom solution at an affordable price that also incorporates modular construction to optimize economies of materials and site labor.



The Cambria Model, by Palm Harbor Homes, is an affordable modular design created to compete more effectively with lower end site-built production housing. The four-bedroom, 2.5-bath unit demonstrates how architects can apply factory-built manufacturing technologies in creating in what Tony Lucas calls a commodity affordable housing design.

C. Overall Conclusions

On the Role of the Architect as User of Technology

While each market sector had unique and varying approaches to technology innovation, it became clear that sustainability or green building design is currently driving all the markets. Clients, the market, architects, and the industry are all contributing to advance housing design and production, research, technology, and construction in order to respond to the green building standards, programs, and awareness that are currently in place and becoming a requirement in some cases.

Perceived Risk is a key barrier to trying a new technology in all market sectors. The building community is conservative relative to its client base. It does not want to push out in front because of liability among other issues. But interviews indicated that architects do have an innate spirit of experimentation. In the case of opportunities that exist to innovate, architects will. But when it comes to new technologies that haven't been tried before, they are very cautious. There is a dilemma within the architectural profession between the architect as designer/artist who wants to create and innovate and the business person who is concerned about the long-term vested interest in the viability and the liability of the firm. These two issues are at war with each other in terms of making decisions.

Information that is available to architects about products comes from a wide range of sources and has a wide level of credibility, from the "take it with a grain of salt," information supplied by the manufacturers, to the assurance of an ASTM test for performance. Reliance upon colleagues who have installed a technology was extremely important to the architects interviewed. Ultimately, installing a new technology comes down to relying upon a conversation with someone an architect trusts. Installed performance and costs were critical factors--not just data on how much it costs or what its performance characteristics are

supposed to be—but the installed performance and cost.

Electronic sources of web-based exchange were considered an important and desired avenue for sharing information and facilitating peer-to-peer discussions for architects making decisions about technology. Some concerns were cited regarding about how such a site would be managed.

Case studies were also cited as an effective and preferred method for learning. Again, interviewees expressed the need to delve into more depth and include installed performance and installed cost information in order for the case studies to be useful. It is very hard to get field performance information from manufacturers and contractors because they don't want to go on the record. So the question is: Where can the architect get reliable, candid information to make good decisions about these technologies?

On the Role of the Architect as Creator of Technology

The architects interviewed indicated that they were regularly innovating with technologies, whether it was a technology being used in a new way, or utilizing a technology that was meant for one purpose but used for something other. One example was an architect looking for an interesting partition for a house. They found a track device used in meat packing installations and adapted it for use in a house. The interviewees indicated they were doing something similar to that or something different than they had done before. Many of the solutions come down to materials and methods, and details.

It was suggested that the default definition of technology, which is something new manufactured by a company, could be broadened to include those innovations that architects create by modifying or finding a new application for a technology.

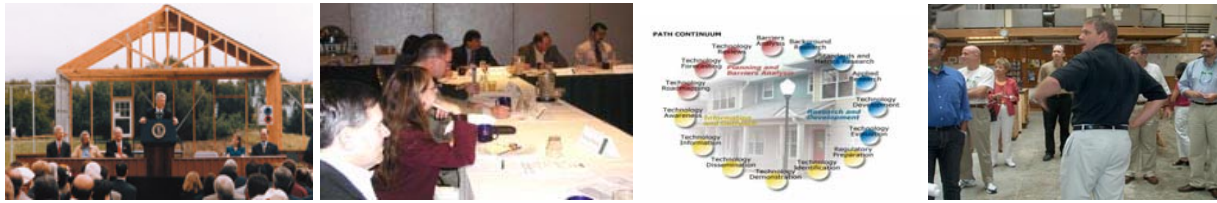
Architects don't usually share information about their projects or technology and as much as they would like to share, they aren't very good at doing it. There is also the issue of proprietary information that firms don't want to share.

It was suggested that architects' housing projects could also serve as huge data mines for information on innovative technologies. But they are not seen as innovative most of the time. *Record Houses* shows formal experimentation and some interesting potential ways of doing things at a large scale. It is suggested that if more research were conducted the number of examples that could be found and shared would increase tremendously. There is a need to make technology innovations more prominent/visible.

If data on architects' design and technology information could be effectively collected it could:

- Strengthen the design and performance of housing.
- Be a potential source of new ideas for building product manufacturers.

IV. PATH'S ROLE AS A SUPPORTER OF INNOVATIVE TECHNOLOGIES



A. Summary of Research Findings

This study also explored PATH's role in innovation from the architect's perspective. A few key issues emerged that involve PATH in a new or expanded ways in promoting and advancing technology innovation.

1) Education has become a key vehicle for transferring technical information.

PATH could be more proactive in using education as an information dissemination vehicle. Clearly, education has become a key vehicle for transferring technical information to the architectural community with continuing education a requirement for AIA members. Manufacturers are approaching architects with educational courses on their products through continuing education seminars, webcasts, convention training, and other vehicles. Manufacturers are also moving more toward an educational approach versus an advertisement approach to get their information out the architectural community. There is much emphasis on a good technical education on how a technology performs.

2) A PATH-sponsored awards/recognition program could be useful to architects that showcase technology innovations in housing.

Most interviewees were interested in an awards or recognition program, while a few others were skeptical due to the large number of already existing programs that PATH would have to compete with.

Additional questions about a recognition or awards program included:

- What information should be included and recognized?
- How would a recognition or awards program be administered?
- How could the architects be more encouraged to share the kind of information that would be recognized?

3) PATH is not a commonly used tool by architects. The following reasons were cited by the architects interviewed:

- Lack of awareness
- Focused on single-family builders and not architects
- Technologies not progressive enough
- Too technology-specific rather than systems-focused

An interesting finding was that the architects interviewed are more interested in how an assembly works rather than just a piece in the assembly or "widget" of technology.

A recommendation across this project is for more targeted information and better marketing to the architectural community by PATH. It was also suggested that PATH take on a role that supports and advances "trend setting" or "standards" by expanding the view beyond technology to include performance, safety, durability, cost-effective, and other "whole building" issues, etc.

B. Current PATH Programs

PATH's mission is to improve and increase the development and widespread use of technology in the housing industry. PATH works to improve the affordability, durability, energy efficiency, environmental performance, disaster resistance, and safety of the nation's housing stock.

The three main areas of focus within PATH are:

- research and development
- information dissemination
- overcoming barriers to innovation

For the past 20 years, there has been huge growth in the housing market. It is considered the longest and strongest run in investment in housing, which amounts to a fixed investment of about a trillion dollars. There has also been a real change in the housing market with new construction reaching 1-1.5 million new units each year. However, the construction of these homes is undertaken by a very fragmented group of builders. In the past 25 years, there has been some consolidation of builders, but it is still a fragmented industry with many builders targeting individual market sectors. PATH has been looking at ways to increase innovation in this industry. The housing industry is not prone to innovation and so it has been critical to look at what role architects can play in technology innovation.

C. Available PATH Resources

Of use to the architectural community are a variety of resources available through PATH's website www.ToolBase.org and www.PATHNet.org including:

- Technology Inventory
- Tech Sets
- CAD drawings
- Tech Practices
- Concept Home

Additionally barriers to innovation are explored including looking at:

- Building Regulations
- Risk and Liability
- Financial Incentives for R&D
- Skills, Training, and the Labor Force
- Pre-Construction Needs
 - Vendors, Suppliers, Retailers, Architects
- Post-Construction Needs
 - Appraisers, Realtors, Lenders, Inspectors

PATH's research has revealed that

- Architects' services are used on less than 10% of homes built.
- Architects know homeowner preferences.
- Architects envision and apply new technologies readily (often to a fault).
- Architects link technological and design innovation.
- Architects need due diligence on innovation, including standard specifications and certifications.

Additional questions that continue to be raised at PATH include:

- Are architects merely gatekeepers to innovation?
- When do architects spur innovation?
- What information do architects need to spur or simply adopt innovations?
- What barriers do architects face?

V. APPENDICES

Appendix A. Interview Questionnaire

HUD/PATH Project
The Role of Architects in Advancing Technology Innovation in Housing

Interview Questions

Your Role in Advancing the Use of Innovative Technologies

- What is your role in getting new technologies used in the projects you design?
- How do you hear about new, innovative technologies?
- What motivates you to investigate a new technology?
 - Are new technologies on your mind more in the design or construction documents phase of a project?
- What type of information do you need?
 - How relatively important are the following sources:
 - Technical data/specs. Marketing information. Non-commercial technical data. War stories.
- Where are you most likely to look for this information?
 - How relatively important are the following sources:
 - Advertisements. Product websites. Spec sheets. Sales reps. Government sources. Word-of-mouth/fellow users. Professional membership associations, colleagues.
- What barriers or obstacles keep you from using a new technology?
 - Are any of these obstacles peculiar to the (production, custom/sustainable, manufactured, affordable) home building industry?
 - Do you see any potential solutions/opportunities for overcoming these obstacles?
- What needs to happen – how do the stars need to align – for you to take the plunge?
 - Who do you need to fight/convince to get this new technology used?
 - What is your role in this process?
- Any recent examples?
 - What innovative technologies have you used recently?
 - Have you used something you wouldn't use again?
 - What information would have helped you avoid that mistake?
 - Have you used something you would use again?
 - What information would have helped you ensure that success?
 - Do you record or capture that information and/or share it professionally in order to duplicate that process?
- Are you aware of/excited about any new technologies – ones that you may not have used, at least not in housing - that show promise for residential applications?

Your Role as a Creator of Innovative Technologies

- Have you created any innovative technology solutions in your projects - solutions that aren't readily available in the marketplace but could potentially be replicable or mass-produced?

- What problem did your technology “fix” try to solve?
- How did you develop your “fix”?
- What obstacles did you encounter
 - Regulatory? Fabrication? Cost? Owner acceptance? Etc.
- Do you think there might be a market for your technology “fix”?

PATH’s Role as a Supporter of Innovative Technologies

- Are you aware of the PATH program, PATH Technologies, the PATH Top 10 Technologies?
 - If so, what are your impressions of the value of PATH?
- Have you used any of the PATH Top 10 technologies recently?
 - If yes, what results? If no, why not?
- How might an innovative technology resource such as the PATH website be more useful to you?
- Have you encountered any design problems that existing technology – and your inventiveness – weren’t able to solve?
 - How could the PATH program help?
- Would you be interested in a PATH awards program recognizing the creation of innovative technology?
 - If so, please explain why.
 - If not, what kind of awards/recognition program would you be interested in.
- Where do you see the next opportunities for technological innovation in the production homebuilding industry?

Appendix B. Speaker Bios

ROUNDTABLE SPEAKER BIOS

Katherine Austin, AIA

Architect
Sebastopol, California

Katherine is the principal and owner of Katherine Austin Architect in Sebastopol, California which she founded in 1995. She has been involved in all aspects of the housing arena over her career which spans more than 20 years. She has served on a variety of committees and boards, including the AIA's Advisory Group Member for Housing Knowledge Community, the U.S. Green Building Council, Congress for New Urbanism, and the International Code Council. She also was elected Mayor of the City of Sebastopol serving from 1997-1998.

Ms. Austin received her M.F.A. at Boston University, an M.Arch from UCLA, and a Professional Certificate in Green Building Design from SSU. She has taught at California State University, Sacramento and West Los Angeles College among others.

John “JAK” Inglese, AIA, PE., B. Arch, B.S.C.E., M.S.C.E, NJIT

Inglese Architecture and Engineering
East Rutherford, New Jersey

John is a registered architect, professional engineer and principal in the firm of Inglese Architecture and Engineering in East Rutherford, New Jersey. He has been involved with residential development, urban design and building systems engineering for the past 25 years, and affordable housing in particular for the past 17 years. As the design professional for five of New Jersey's sustainable/green development projects and numerous energy star projects, he has had the opportunity to apply some of the principles of sustainable development and energy efficiency to affordable multifamily and single-family housing, working with developer/builders to achieve improvement in their building practices within limited budgets.

WEBCAST ROUNDTABLE SPEAKER BIOS

Deane M. Evans, FAIA

Executive Director
Center for Architecture and Building Science Research
New Jersey Institute of Technology

Mr. Evans is a registered architect and a Fellow of the American Institute of Architects.

From January to December 1998, Mr. Evans served as the founding Director of the Partnership for Advancing Technology in Housing (PATH) – a public/private partnership housed at HUD. Before accepting the PATH Directorship, Mr. Evans was the Vice President for Research at the American Institute of Architects. Prior to joining the AIA, Mr. Evans was a Principal at Steven Winter Associates, Inc., an architecture/engineering firm in New York City, where he concentrated on applying innovative technologies and systems to buildings, particularly housing.

In January 1999, Mr. Evans left the federal government and returned to private practice, where his principal

area of concentration was high performance, sustainable buildings, particularly housing and schools. During this period he created the *Affordable Housing Design Advisor*, a unique, electronic tool that provides step-by-step guidance for affordable housing developers and community leaders on how to create better designed affordable housing.

On October 1, 2001, Mr. Evans left private practice and accepted appointment as Executive Director of the Center for Architecture and Building Science Research at NJIT. Among other duties at the Center, he maintains the *Design Advisor* web site, coordinates the nationwide "Campaign for Excellence in Affordable Housing Design," and supervises the national "Show Your Green" affordable housing design recognition program in cooperation with the American Institute of Architects. He also recently authored *Good Design: The Best Kept Secret in Community Development* for the Local Initiatives Support Corporation.

Mr. Evans has a B.A. from Yale University and a Masters in Architecture from Columbia.

Michael Freedburg

Policy Advisor

Office of Policy Development and Research

U.S. Department of Housing and Urban Development

Michael Freedberg is trained as an architect and urban planner who has been involved in affordable housing and community development for many years. He is currently senior policy advisor for energy and urban policy in HUD's Office of Policy Development and Research. He has been involved in many key Departmental initiatives, including the Consolidated Plan, Empowerment Zones, community development banking and a range of economic development initiatives. As co-chair of HUD's Energy Task Force, he coordinates the implementation of the Department's Energy Action Plan.

Prior to joining HUD, he launched an award-winning transit-oriented development strategy for Chicago's Green Line, including a prototype innovative mixed-use transit center designed to contribute toward the region's transportation and air quality goals.

He also has had extensive experience in building or financing low-cost housing. He worked with the Urban Homestead Assistance Board (UHAB) in New York to develop the nation's first "sweat equity" projects that incorporated pioneering uses of solar and wind energy with limited equity cooperative ownership.

In Chicago he was responsible for engineering services for energy efficient retrofits of almost 7,000 units of multifamily apartments, and directed legislative and policies initiative to address the problem of housing abandonment in low-income communities. He also developed a web-based Housing Abandonment Early Warning System to assist local government and community organizations to forestall demolition of abandoned buildings and to provide critical data for comprehensive community planning.

Michael is a graduate of Yale University and received his Masters in Architecture from the University of Illinois-Chicago under Stanley Tigerman. He co-authored several of HUD's *State of the Cities* reports, an annual "report card" on the progress that cities are making in their transition to the new, high-tech global economy.

James Harrison Timberlake, FAIA

Partner, KieranTimberlake Associates LLP
Philadelphia, PA

James received his Bachelor's degree from the University of Detroit, with honors, and his Master of Architecture from the University of Pennsylvania, with honors. He is a recipient of the Rome Prize, American Academy in Rome, 1982-83. Prior to his involvement with KieranTimberlake Associates, Mr. Timberlake was employed by Louis Sauer Associates (1976-77) and was an Associate of Venturi, Rauch and Scott Brown (1977-84).

A registered architect in Pennsylvania, New Jersey, New York, Delaware, Maryland, Virginia, Vermont and Washington, DC and an NCARB member, he is also an adjunct associate faculty member of the University of Pennsylvania School of Architecture.

In addition, he has served as Eero Saarinen Distinguished Professor of Design at Yale University with Mr. Kieran, and has taught at seven universities including Princeton University and the University of Texas at Austin.

Joseph Remick, AIA

Project Manager, Michelle Kaufmann Designs
Oakland, CA

Joseph received his Bachelor of Science in Structural Engineering and his Masters of Architecture at the University of Kansas. After completing his Masters, Joseph worked for George Sexton Associates, a museum and lighting consulting firm in Washington, DC. While at GSA, he gained valuable experience in daylighting design, lighting optics and lighting control systems before moving to Minneapolis to work for a large Architecture/Engineering firm, Hammel, Green and Abrahamson.

At HGA, Joseph was instrumental in opening the San Francisco branch office where he worked as a project architect for many cultural and higher education projects in California establishing a deep desire to create a more sustainable built environment. After several years as a practicing architect in California, Joseph joined MKD where he oversees product development and develops custom modular solutions with clients. He employs his interests in daylighting, sustainable materials and building systems to create thoughtful, modern architecture with clients.

Mark Ginsberg, FAIA

Partner, Curtis + Ginsberg Architects LLP
New York, NY

Mark Ginsberg, FAIA is a founding partner of Curtis + Ginsberg Architects LLP (C+GA) whose practice covers commercial, institutional and residential projects, including award winning architecture and urban design projects. He is a registered architect in the states of New York and New Jersey. Mark received a Master of Architecture degree from the University of Pennsylvania, a Bachelor of Arts degree from Wesleyan University and is a native New Yorker. He is in charge of all multi-family housing and urban design projects at C+GA, along with providing expert testimony on New York City zoning issues. He has been designing housing, particularly affordable, for over twenty years.

Mark was the 2004 President of the AIA New York Chapter, and a past director of AIA New York State. He is a member and former co-chair of the New York New Visions (NYNV) Executive Committee and was a co-chair of the Growth Strategies Team of NYNV, a coalition of 21 architecture, planning, and design organizations that have provided pro-bono services in an effort to address the issues surrounding the rebuilding of Lower Manhattan following the September 11 terrorist attacks on the World Trade Center.

Along with Mark's experience in the design of housing, his expertise in housing extends to his activities as a former co-chair of the AIA New York Chapter Housing Committee; a member of the AIA National Housing Task Force from 1997 to 2000 and a 2002 member of the AIA Housing Committee advisory group; and former co-chair of the AIA New York Chapter Planning and Urban Design Committee. Mark was a 2001 Juror for the AIA/HUD Secretary Awards, and sits on the Board of Directors of the New York Housing Conference and trustee of the National Housing Conference and is an executive committee member of Citizen's Housing and Planning Council.

Appendix C. Webcast Roundtable Pre-event Questions

Pre-Event Questions

1. Have you recently created or implemented a cutting-edge technology in a housing project?
2. Are you familiar with the PATH (Partnership for Advancing Technology in Housing) program?
3. If so, what PATH resources have you utilized?
4. What types of housing work are you currently involved with?

Appendix D. Webcast Polling Questions

POLLING QUESTIONS

#1 Would you or someone in your office be likely to participate in a free, web-based forum where you could discuss and exchange information on new housing technologies?

Very Likely
Somewhat Likely
Not Very Likely
Unlikely

#2 Have you created a design or construction innovation – like a really clever detail – that you've never seen anywhere else?

Yes No

If yes, would you share it with other architects if you could have access to similar innovations that they have created?

Yes No

Do you think your innovation has any commercial potential – as a new product that someone might manufacture or implement on a large scale or broad basis?

Yes No

If yes, have you explored the possibility of commercialization?

Yes No

#3 Would you like to see some form of national awards/recognition program for architects using housing technology in innovative ways?

Yes No

#4 Would you be interested in educational programs – eligible for continuing education credit – on new technologies in housing?

Yes No