Examining the Feasibility of Applying the Energiesprong Model to Manufactured Housing

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ABSTRACT

There are 8.5 million manufactured and mobile homes in the United States (MHI n.d.). A 2012 report found that 55% of manufactured housing residents reported household income less than $30,000 (MHI 2012). The individuals living in these structures are more likely to experience very high energy cost burdens and health problems from exposure to poor indoor air quality (Unger 2016). Weatherization of these homes has been challenging for many reasons, including the treatment of these homes as chattel property (rather than real property) and structural challenges such as lack of attic and wall cavities where additional insulation can be installed. New approaches to rapid energy efficiency retrofits such as "Energiesprong" may emerge as a solution for delivering retrofits of manufactured homes. Manufactured housing is inherently standardized in dimensions due to constraints associated with transportation from a factory to the final site and the factory-built nature of these homes. This results in a significant opportunity to improve delivery of efficiency retrofits to these structures by packaging envelope and equipment upgrades in factory-built panels which can be installed in a day or less. This paper will examine the opportunity for energy efficiency and electrification of manufactured housing through rapid retrofit approaches such as factory-built envelope improvements.

Introduction

The 8.5 million manufactured homes in the United States house about 22 million people (MHI n.d.). These homes are an appealing building type for energy efficiency improvements because many of these units are inefficient, leaving the occupants with high energy cost burdens. Improving the efficiency of these homes has proven difficult in the past. Due to the relatively standardized dimensions of manufactured homes, it would initially appear to be straightforward to apply a panelized retrofit in the style of the Dutch Energiesprong model.

Manufactured homes were first regulated under the 1976 Manufactured Home Construction and Safety Standards which are administered by the U.S. Department of Housing and Urban Development (HUD). The standards, commonly referred to as the HUD code, have not had updates to the minimum energy efficiency requirements for newly constructed homes since 1994. Much effort has been expended to develop effective efficiency treatments for existing manufactured homes, yet few cost-effective scalable approaches have emerged. Applying the Dutch philosophy of "Energiesprong" seems to offer a promising solution to this problem. As commonly referenced, Energiesprong relies on factory-built panels that can be delivered to a home site and quickly (two weeks to as little as one day) installed with minimal disruption to the occupant. The panels are installed over the existing façade and roof, providing the additional benefit of updating the appearance of the home and extending the life of the building. These panels also include replacement windows, ducts (in some instances), and an 'energy pod' package that contains heat pump-based heating, ventilation, and air conditioning

(HVAC) equipment as well as heat pump water heaters. Typically, homes receiving Energiesprong retrofits also include solar photovoltaic panels. In the Netherlands, Energiesprong retrofits are designed to produce all electric, net zero energy homes. We will refer to this as the panel and energy pod model of Energiesprong in this paper.

This paper investigates the opportunity to apply the Energiesprong philosophy and panel and energy pod model to manufactured housing in the United States.

Manufactured housing

While manufactured housing units of all vintages are often referred to as mobile homes, the housing industry differentiates between mobile and manufactured homes based on the year that they were built.[1] Homes constructed prior to the adoption of the 1976 HUD code are referred to as mobile homes, while manufactured housing is constructed to the HUD Code and built after 1976. The HUD Code's efficiency provisions were last updated in 1994. Table 1 below explains this taxonomy and how the HUD Code applies. A draft rule to update the HUD code was published by the U.S. Department of Energy in 2016 but was never finalized (Unger 2018). The HUD Code specifies dimensions to allow for over the road transportation from the factory to the homesite. These standards require that a housing segment (segments can be combined to form a house made up of one, two, or three segments) to be no more than 18 feet wide, 13 feet and 6 inches in height, and 80 feet long, though state laws vary (O'Dell n.d.). Manufactured homes are treated differently from factory built modular homes, which are built on permanent foundations and must comply with the building codes of the jurisdiction in which they will be assembled for occupancy.

Manufactured housing provides an important source of affordable housing in the United States. A 2012 report found that 55 percent of manufactured housing residents reported annual household income less than $30,000 (MHI 2012). However, the residents of these structures are more likely to experience very high energy cost burdens[2] and health problems from exposure to poor indoor air quality (Unger 2016). Research has found that occupants of rural manufactured homes experience an energy burden 42 percent higher than occupants of rural single-family homes (Ross, Drehobl and Stickles 2018). To achieve equitable outcomes for the families and individuals that live in these homes, as well as meeting energy and climate targets, it is vital that effective energy efficiency programs be developed and delivered to and for these residents. Unfortunately, for many years the manufactured housing sector has proven difficult and expensive to reach for energy efficiency program administrators.

Manufactured housing is typically located in two contexts, manufactured home communities (also known as parks) or distributed on private property in rural areas. The distribution of manufactured housing across communities and private property varies by state. In Minnesota, the distribution of homes in parks and those on private property is nearly even (Seventhwave 2016), while in Alabama, only about 30 percent of manufactured homes are located in parks (L. Latham, Alabama Manufactured Housing Association, pers. comm., March 5, 2020). Nationally, 66 percent of manufactured homes are located on private property and 34 percent are located in communities or parks (MHI 2018).

[1] Manufactured homes are also treated separately from recreational vehicles and tiny homes.

[2] Energy burden has been defined as "…the percentage of household income that goes toward energy costs…" (Drehobl 2016).

Manufactured home financing. Many manufactured homes are purchased with a chattel mortgage. A chattel mortgage is used for "personal" property, rather than "real" property. Because manufactured homes are generally not considered permanently attached to the land upon which they sit, they are classified as personal property, though manufactured homeowners who also own the land can sometimes obtain traditional mortgages. All individually owned manufactured homes that are on leased land (such as a manufactured home community or park) are financed with chattel loans (Fannie Mae 2019). A chattel mortgage differs from a traditional mortgage in several ways. The terms are traditionally shorter, with 20-year terms, rather than 30-year terms, and have interest rates as much as 2-5 percent higher (Fannie Mae 2019). Manufactured homes can be financed through traditional mortgages, if the borrower owns both the land and the home. Although about 48 percent of households living in manufactured homes own both land and home, only about one-quarter of new homes have been titled as real estate since 2004, a figure that was declining, with only 14 percent of new manufactured homes titled as real estate in 2013. Another 30 percent of manufactured homes residents rent the land that the home sits on and own the home, and about 18 percent rent both the land and the home (Fannie Mae 2019).

Manufactured housing community types. Manufactured housing communities have a variety of ownership structures, including investor owned communities, communities owned by non-profit organizations to preserve affordable housing, community land trusts, local government housing authorities, and cooperative, resident owned communities. The last category, cooperative ownership models, sometimes called resident owned manufactured home communities, are emerging as some states have made it easier for communities to organize and purchase the community assets. However, the number of these communities is still small, at only 2.4 percent of all manufactured home communities (Freddie Mac 2019). In cooperative or community owned parks, the residents of a park create a resident association to access financing to purchase their community assets from the owner (Freddie Mac 2019, National Consumer Law Center 2020). Resident owned manufactured housing communities offer significant benefits to their occupants, including protections from large lot rent increases, which often occur when a community changes ownership. Additionally, residents of resident owned manufactured home communities may be eligible for traditional real estate loan products with lower interest rates than chattel mortgages. Resident owned manufactured home communities may also be eligible for federally backed community development block grants and for U.S. Department of Agriculture rural development grants for major renovations community assets (National Consumer Law Center 2020).

What is Energiesprong?

Energiesprong started in the Netherlands as a government initiative to deliver rapid renovations of existing multifamily buildings to achieve net zero energy performance. The first buildings to receive the Energiesprong treatment were "social housing" which is similar to public housing in the United States. Originally funded by the Dutch government, the model has been used to successfully retrofit 5,000 homes to net-zero energy (Energiesprong Foundation n.d.). While the Dutch Energiesprong model is now known for the use of façade panels and mechanical equipment in pods, Energiesprong was developed as a technology neutral approach to high performance energy retrofits. The Dutch set a performance target and price parameters and solutions providers then developed solutions to achieve the performance and price targets

using any method they could devise (G. Simms 2018). Social housing was selected as the first building type for renovation because demand could be aggregated from multiple housing associations. New York state and California have also selected mid-rise multifamily public housing as the first building type for deployment of Energiesprong style retrofits. Demand aggregation creates scale that can motivate companies to develop the products and services needed to rapidly and affordably retrofit buildings for increased efficiency (G. Hale, NYSERDA, pers. comm., March 11, 2020). As the supply of innovative products (such as façade panels and energy efficient mechanical equipment in pods) increases, the cost of innovative new products may decrease as a result of learning curve effects and economies of scale. Learning curve and scale economy effects may be manifested not only in manufacturing but also in delivery of the upgrades, including transportation and assembly/installation; permitting and regulatory matters; and finance, marketing, and service.

The Energiesprong panel and energy pod model incorporates innovative methods to upgrade the façade, replace air handling equipment, ducts, and domestic hot water systems of the home while allowing the resident to continue living in the home during the retrofit process. The average timeline for installing a retrofit is about two weeks and some have been completed in as little as one day. The Energiesprong panel and energy pod model has since expanded to several other European Union countries and is being explored for further deployment in New York state by the New York State Energy Research and Development Authority and in California by Rocky Mountain Institute.

The Dutch Energiesprong model utilizes a system of unitized façade panels which may be structural insulated panels, light gauge steel, and timber framed panels in combination with packaged systems for HVAC (including energy recovery ventilation [ERV] units) and domestic hot water (DHW) (Rocky Mountain Institute 2018). HVAC and DHW needs are met using heat pumps. Energiesprong retrofits in the Netherlands also include updates to bathrooms and kitchen, with replacement of combustion appliances with electric, if applicable. Combustion appliances are replaced with electric appliances to reduce greenhouse gas emissions and improve indoor air quality.

In addition to innovative envelope and equipment upgrade methods, Energiesprong relies on innovative financing to deliver retrofits at no additional cost to the building occupant. In the Netherlands, this is achieved by allowing Housing Associations to take 30-year low interest loans and be repaid through the energy savings and the use of on-site renewable energy to further reduce energy expenditures. In this way, the Energiesprong model is similar to an Energy Service Performance Contract. The savings are guaranteed by the solutions providers within a specified energy budget. Dutch Housing Associations are organizations that provide affordable housing for elderly people and people with disabilities. The Housing Association may own the homes and lease or sell homes. Of the 3 million rented homes in the Netherlands, 75 percent are owned by Housing Associations (Government of the Netherlands). Another 1.2 million home homeowners (of 7 million total) are members of a homeowners association. Housing Associations and homeowners associations may borrow from the Dutch National Energy Saving Fund at low rates for 30-year terms to achieve net zero energy consumption (Energiesprong Foundation 2019b).

What are the challenges?

New manufactured homes start as low as $43,000 for the purchase price of a single unit home, not including additional costs, such as transportation to the site where the home will be installed, electrical and plumbing connections, and site preparation (L. Latham, Alabama Manufactured Homes Association, pers. comm., March 5, 2020). The average cost of a new manufactured home in 2019 was $75,747, and the average pre-owned manufactured home selling price was $46,173 (AMHA n.d.). As previously noted, residents of manufactured homes tend to have modest means, with average incomes of less than $30,000 per year. Manufactured homes built between the 1976 introduction of the HUD Code and the 1994 HUD Code update are between 44 years old and 26 years old in 2020. These homes have a life expectancy of about 50 years.

Table 1: Manufactured housing taxonomy and applicability of HUD Code

Home type	**Age**	**Subject to HUD Code?**
Mobile homes	45+ years	no
Manufactured homes 1976-1994	44- 26 years	yes
Manufactured homes 1995 to present	25-0 years	Yes, updated 1994 code

Residents of manufactured homes may not own the land beneath their home. This introduces several challenges, including difficulty obtaining financing, potential limits to the amount of the lot which can be occupied, or violate zoning ordinances that specify the minimum distance between structures, which may make retrofitting difficult. There is also the question of structural soundness of manufactured homes and mobile homes to support the additional weight of the façade panels, if the panel and energy pod style retrofit is to be implemented.

Why Not Just Replace Existing Manufactured Homes With New Manufactured Homes?

In considering the Energiesprong panel and energy pod approach to retrofitting manufactured homes, some may ask why we do not simply replace the old home with a new home, perhaps even an ENERGY STAR model. As previously noted, the HUD code that sets energy efficiency requirements for manufactured homes has not been updated since 1994, so efficiency gains from replacing homes is likely limited. Because the standard has not been updated, savings for a new manufactured home may not be significant, particularly at the low end of the market, where it is possible that no additional efficiency features may be present in a current design when compared to an existing post-1994 model. ENERGY STAR Manufactured Homes do offer better performance, using about 30 percent less energy than a 1994 HUD code manufactured home and costing between $1,000 and $4,000 more (DOE 2015). A 2012 report by the Washington State University Extension Program found that replacing existing manufactured homes with new manufactured homes was not cost effective for residents. The study found that the energy savings alone did not offset the cost of financing new energy efficient manufactured homes. The same report surveyed residents of manufactured homes and found that most did not want to replace or undergo major retrofits to their homes for several reasons including aversion to new debt and to moving out of their current home. Study respondents were mostly residents of manufactured home parks for adults 55 years of age and up. Perhaps most importantly, the residents liked their homes and did not want to leave them (Salzberg 2012).

Newer manufactured homes tend to be larger than the existing mobile homes that they might replace, which introduces additional challenges to replacement programs, particularly when the homes are located in parks where the lot size and municipal codes and zoning ordinances may not allow the structure to encroach on lot boundaries (e.g. a structure's exterior wall may not be closer than 5 feet to the lot boundary). A pilot program to replace manufactured homes in Oregon has encountered this challenge when working to replace mobile homes with new manufactured home models. The pilot has also found that significant investment of time is required to bring in participants (K. Kent, Program Consultant, Clear Result, pers. comm. Mar. 18, 2020).

Energiesprong and Manufactured homes

The Energiesprong panel and energy pod model of home retrofit initially appears to be a great opportunity for manufactured homes. The homes are fairly standardized in dimensions, the housing stock is in need of efficiency retrofit, and the occupants would see immediate and likely significant benefits. When retrofits are performed on homes in parks, a program administrator could quickly seed interest in participation as neighbors see rapid retrofits performed and hear about the benefits from a community member.

The relative standardization of manufactured homes in dimensions could simplify set up of factories to manufacture façade replacements. Nearly all manufactured housing is single story, so the need for cranes for lifting panels into place is reduced or eliminated. In the Netherlands, some façade panel manufacturers have incorporated duct systems into the panels, potentially allowing for the elimination of the problem of sealing and repairing old, potentially leaky duct systems and simplifying the incorporation of heat pump HVAC systems into the retrofit, as well as reducing need for time on site and difficult bellyboard work.

There is a good opportunity to use the technology neutral Energiesprong philosophy to find solutions. The challenges of retrofitting manufactured homes are well known: leaky ducts, poorly insulated and sealed envelopes, inefficient HVAC and water heating equipment, and lack of funding. If the Energiesprong philosophy can be applied to solve these challenges--such as cost-effective, low-impact (on the resident) retrofits--the energy, air quality, environmental, and health benefits could be significant for manufactured home residents. The Energiesprong philosophy of creating retrofit solutions that can be implemented rapidly with minimal disruption of life for the resident is a desirable goal. To reach this target, policy makers should consider how to create policies and program structures to encourage innovation in this sector.

However, the panel and energy pod model of Energiesprong retrofits for manufactured homes appears to present unique barriers to implementation. It is not clear that all manufactured homes could support the additional weight and may need structural reinforcement or additional foundation construction. Additionally, current estimates of the cost for panel and energy pod Energiesprong retrofits from early applications in New York for multifamily affordable housing buildings of 5-8 stories are $40 to $50 per square foot, with a potential to come down to $25 per square foot with learning curve effects (Hale, NYSERDA pers. comm., March 11, 2020). Back-of-the-envelope calculations based on a commonly sized single-unit manufactured home result in a cost estimate of between $108,000 at $50 per square foot and $54,000 at $25 per square foot[3]. However, costs based on Energiesprong-type retrofits performed on 5-8 story multifamily buildings should be re-estimated for a manufactured housing context where, on the one hand,

[3] Assumes home size: height 13.5 feet, length 64 feet, width 16 feet.

lifts, cranes, and additional skilled labor for multistory installation of heavier panels would not be required. On the other hand, individual homes would be individually retrofitted, potentially reducing economies-of-scale on per-residential-unit basis. Clearly, these prices must be driven down for this approach to succeed in this housing segment. The above price estimates only account for the façade upgrades, and do not include re-roofing, bellyboard repair/upgrade, mechanical improvements, or photovoltaic panels which would be included when seeking to reach net zero energy consumption. In 2019, the average cost to construct a new manufactured home was $50 per square foot (AMHA n.d.). At this price, it is unlikely that the panel and energy pod model of Energiesprong retrofits would be deemed cost effective on energy savings alone.

The area underneath a manufactured home (a.k.a. "the bellyboard") contains the home's plumbing, insulation, and in most cases, duct work. The bellyboard was often cited as the primary obstacle to applying the Energiesprong panel model to manufactured housing by experts consulted by the authors. The bellyboard in manufactured homes often requires repair to restore the envelope as a result of water damage or damage to the belly caused by duct or plumbing repairs. It is common for the bellyboard to be opened when the ducts or plumbing are accessed, and it is frequently not resealed after this type of repair work is performed. Applying the technology neutral approach of Energiesprong to this challenge to ask solutions providers to develop innovative solutions within cost parameters could lead to new and scalable solutions.

How Might Energiesprong Be Implemented For Manufactured Housing?

To enable the Energiesprong panel and energy pod model to work in the United States, the first homes to receive the treatment would likely be located in a resident owned manufactured home community, in a community owned by a community land trust, housing authority, or a combination of several communities with different ownership structures. Communities of these types may be more willing to partner with an entity such as a state energy office, the U.S. Department of Energy, or a non-profit efficiency organization to attempt a community wide Energiesprong inspired efficiency retrofit program. A relatively large number of homes should be identified for retrofit in order to begin the process of lowering the cost of producing the retrofit components.

Additionally, long term, affordable financing must be made available to support this type of retrofit. To address the challenge of financing these retrofits, policymakers should consider creating mechanisms that enable manufactured housing parks and communities, particularly those that are community owned, to access long term low interest loans which can be used to finance retrofits across a community. For example, California's Mobilehome Park Rehabilitation and Resident Ownership Program (MPRROP) offers Blanket Rehabilitation Assistance Loans with terms of up to 40 years with 3 percent simple interest rates, and applicants are permitted to request lower rates (CA Dept. of Housing and Community Development 2016). This program does not specify energy efficiency as qualifying rehabilitation work, however, mechanisms such as this one could be expanded to provide loan products for energy efficiency retrofits. Alternately, manufactured home communities could be permitted to participate in Property Assessed Clean Energy programs or to participate in programs similar to Energy Service Performance Contracting. The key element is to make available long term, low interest financing which can be repaid through guaranteed energy savings. This may require allowing community associations to collect energy fees.

To catalyze this market and achieve sufficient scale to engage solutions providers, the initial efforts to develop such a program should focus on resident owned manufactured home

communities or on communities owned by local housing authorities due to these organizational structures long-term ownership interests. In contrast to investor owned communities, these community types are more likely to hold the property for the long term.

It will be necessary to bring manufactured home communities together to create aggregated demand for Energiesprong style retrofits designed for mobile and manufactured homes. One possible way to achieve this level of demand aggregation is to identify a resident owned manufactured home community or a group of resident owned manufactured home communities. Partnering with these communities, along with a state energy office, utility, and financing from an entity such as the U.S. Department of Agriculture's Rural Energy Savings Program (RESP) or a private sector entity to create an initial wave of demand could serve as the initial spark to building the supply chain and achieving learning curve improvements that drive down costs.

In order for the Energiesprong panel and pod model to work, the idea will likely need to be deployed in manufactured home communities before it can be deployed for individually owned homes on private land. Policy changes may also be needed in order to enable the park to take out long-term debt as a community (rather than as individual homeowners) and to enable cost recovery through an energy services charge, as is done in the Netherlands. If this type of structure can be developed, it is possible that the Energiesprong model could be successful for improving the energy performance of manufactured homes.

Conclusion

The Energiesprong philosophy and panel and energy pod model could be successful in delivering significant energy efficiency improvements, and perhaps even net zero energy retrofits to the mobile and manufactured home building segment. To achieve this outcome, it will be necessary to bring together several elements. A large group of manufactured home owners or a group of manufactured home communities that would like to receive significant energy efficiency retrofits must be identified. The communities must be eligible to receive long term, low interest financing that is tied to the home and the community, rather than the individual homeowner or resident. Sufficient demand for innovative products for envelope, HVAC, domestic hot water, the "bellyboard", and roofing (potentially with incorporated solar photovoltaic panels) and simplified transportation and installation procedures must be developed. These measures must also be able to be delivered with minimal disruption to the occupant and at a modest cost.

While the challenges are significant, efforts modeled on Energiesprong in New York and California may begin to serve as a catalyst for demand for this type of product, resulting in price declines from economies and scale and learning curve improvements that can be transferred to this housing type. By applying the philosophy of Energiesprong to present solutions providers with performance and cost targets and ensuring a healthy market once the solutions are developed, we may be successful in unlocking energy efficiency for this building segment.

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