
GREEN INFILL HOUSING: ENVISIONING A MODULAR “KIT OF PARTS”

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“For Pennsylvania’s economy to thrive, it needs a housing market that meets the needs of low- to moderate-income residents. Those needs are far from being met and are increasing along with the demand for housing by the Marcellus Shale gas industry.” (State Sen. Eugene Yaw, R-Loyalsock Township)¹

This paper explores modular building as a response to two apparent and specific needs for housing in Pennsylvania:

- Modest housing for an aging population – emerging demographics are driving a strong need for high quality, low maintenance housing that is modest in size and cost.
- Demand for housing related to the natural gas industry - The rapid expansion of the natural gas industry because of drilling in Marcellus Shale formation is causing unprecedented growth in a region unaccustomed to growth.

The combination of these two needs represent an opportunity for meaningful Smart Growth. A carefully considered and rigorous infill housing program using prefabricated modules can provide lasting value and lead towards a sustainable future for the commonwealth now and beyond current trends. Such a program must challenge the way we fund, contract for and deliver subsidized housing. Inherent compatibility with economic development, smart growth, and “local” initiatives should give housing funds unprecedented leverage.

SMART GROWTH OPPORTUNITY

Existing small and medium-sized towns with their mix of uses, walkable fabric, concentration of infrastructure and services offer a remarkably achievable vision of sustainable living. Because rural collective identity is often tied inextricably to historic patterns of development and land use - historic routes or patterns of commerce – towns tend to retain their status as drivers of regional identity. On the fringes of the northeast corridor many such towns have, for a generation, seen loss of population and dispersion of their services. As a result their practical status as efficient centers for rural areas is greatly diminished. This proposal suggests how small scale infill development and renovation can make for practical and sustainable revitalization of Pennsylvania’s small towns.

The logic of small town Emphasis:

- Current disinvestment means buy-low development options and a combination of infill and rehab/use opportunities.
- Mix of uses and types provides opportunity for mixed income and walkable development. Vibrant small towns reduce reliance on private automobiles.
- Existing infrastructure and relatively dense configuration is inherently efficient.

Though often disinvested, small towns’ problems seem to be less intractable than those of larger communities and their premonitory status as centers of rural life make the benefits of development in existing towns self-evident. In a New York Times Magazine editorial, author Michael Pollan lays out a compelling argument related to food policy that can easily be applied to small-town revitalization – “Reregionalizing”.² Enduring revitalization of local and regional economies is a cause with great appeal to conservatives and liberals alike. The Smart Growth advantages of the small town focus are consistent with the Commonwealth of Pennsylvania Keystone Principles for Growth, Investment & Resource Conservation. Adopted by Pennsylvania’s Economic Development Cabinet in 2005, the Principles & Criteria provide general goals and objectives for economic development and resource conservation and measures for projects to accomplish these goals, prioritizing redevelopment. The report’s “Be Fair” standard recognizes that projects must be evaluated based on their specific context... “what might work in an urban area might not work in a rural area”.³

The Keystone Principles provide *preferential criteria* in the interest of expanding housing opportunities; specifically supporting “the construction and rehabilitation of housing of all types to meet the needs of people of all incomes and abilities”.⁴ To ensure this support of local projects planning and policy changes are necessary. Specifically:

- Comprehensive planning and zoning/design guidelines should be considered to support infill/rehab/mixed-use/mixed income housing development;
- Infrastructural augmentation to support local networks is required;

And, because financial responsibility often falls on the smallest of municipalities,

- Subsidies, tax incentives, and perhaps Transfer of Development Rights Programs should be employed to support localized smart growth development.

Marcellus Shale and Housing Trust Fund

The Housing Alliance of Pennsylvania has set its sight on the Marcellus Shale impact fee to assist in meeting these housing needs and filling the financial gap. They outlined a plan that sets priorities for accomplishing regional housing needs, especially those in the natural gas impact areas. Their plan calls for the strategic placement of projects that will meet diverse housing needs while preserving the rural nature of the region.

“In many ways, the housing needs in the Marcellus Shale region are different from those we have faced before. Our first recommendation is to think creatively. While the development of new housing is part of the solution to the tight housing market, it is not the only solution. Programs such as rental assistance, rental rehab, and the rehab and adaptive reuse of existing structures should also be considered.”⁵

It is noted by the Housing Alliance of Pennsylvania that Act 13 Marcellus Shale Impact Fee funds can be employed to address “housing affordability and blight at the same time” creating more homes and revitalizing small towns. Accessibility is also a need recognized in their proposal, linking a dwindling supply of affordable homes with the difficulty of people with mobility issues to find accessible homes.⁶

Perhaps the housing trust fund can finance the development of comprehensive planning for replicable housing methods.

The modular housing “Kit of Parts” described below is to be the intellectual infrastructure that facilitates the efficient use of manufactured housing for small (scattered site infill and rehab) projects to achieve high energy performance and high quality housing with the promise of replication in the context of Smart Growth consistent with those outlined in the Keystone Principles.

PRESENTING A MODEL FOR MODULAR INFILL DEVELOPMENT

Infill development augments existing fabric. That means small projects, usually one or two houses at a time. Because it builds upon existing infrastructure, infill development is inherently green. But rarely do we see small green affordable (subsidized or not) housing projects. A significant reason is size, small projects cannot bear the soft costs required by a team lead integrative design process or the specific design response associated with the unique and often historically sensitive context of existing towns. The presentation of The Union County Housing Authority’s Energy Efficient Housing Project (EEHP) (a model for green affordable infill housing) begins to suggest an approach. The EEHP’s first new-build project - a duplex - was designed to attain the best cost to energy savings ratio achievable for a very modest budget.

The building saves 46% on energy costs compared to a home that just meets minimum EnergyStar standards. It is comprised significantly of local and recycled materials, and costs little more than might be expected in the market (\$108 / S.F.). It was fabricated in one of the region’s many (now under-used) modular housing plants. The duplex is a result of an ambitious process for projects intended for low-to-medium density context. Through modular building, it is clear that this highly efficient model can be adapted to quickly and efficiently fit a variety of infill conditions through the development of a Kit of Parts (KOP). This KOP describes a carefully designed set of modules (based in part on the EEHP duplex) that can be combined and site adapted. Because the modular manufacturing process provides for mass-customization, the houses benefit from both the economy of scale and integrative design process associated with high-performance and context sensitive design.

Union County EEHP

Four homes were completed in the initial phase of the EEHP, the aforementioned duplex, and the renovation and energy-efficient retrofit of two existing homes. The homes are designed specifically for income-eligible Prime-Time buyers (age 55 and older). All four homes are verified as “green” (EnergyStar and National Association of Home Builder’s Green Building certified), average 1,100 square feet and are located in existing communities on previously developed building lots. The total project cost was \$690,900 and was funded in part through a \$500,000 HOME grant from the Pennsylvania Department of Community and Economic Development. It is the Union County Housing Authority’s mission to provide safe, decent, sanitary, affordable housing to income eligible residents. It is also important to do this in a way that provides long-term benefit to the county and commonwealth. The EEHP effort includes an ongoing outreach, education and research endeavors to assure the performance of the projects and that they are replicable as a model.

The benefits of a dense (relatively anyway) mix of people and uses are well documented. The EEHP is intended to help reverse the trend for marginalization of existing infrastructure and to capitalize on (and fix) sustainable patterns present in existing fabric by providing support measures and meaningful enhancement of Pennsylvania’s small towns. The massing and design of the duplex is intended to fit into the context of the adjacent residences. Existing lot configuration and zoning regulations where respected; the front of both homes face Market Street and the rear access and parking is provided from the alley behind the homes. Though contextual, the sun-collecting roof (the homes are “solar-ready”), a trellis, rain garden and recycled content siding announce the homes’ green status to the large volume of traffic on Market Street.

The homes are designed to be “Visitable” by all people and each home is designed to be easily adaptable to universal accessibility standards. All storm water is controlled on site and does not put pressure on existing infrastructure. Rainwater off the roof is collected and contained by the rain gardens. All landscaping is

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designed to be low maintenance, and the plant species are both water and drought tolerant. All four projects (the Duplex and the two retrofit homes) make use of locally produced and /or recycled and recyclable materials, energy and water efficient appliances and fixtures, and healthy finishes and adhesives.

The Smart Growth and energy efficiency principles showcased in the EEHP homes reduce land and resource consumption and conserve fiscal resources. The following criteria were important considerations with regard to selection and development of the project sites and are consistent with suitable land use strategies set forth by the Keystone Principles:

- Projects' locations support the walkable existing community and business district by providing infill housing / rehabilitation of existing housing and maintaining population within the core community.
- The program provides an example of small Smart Growth development; progressive local, regional, and state land use planning and implementation is strengthened. Small projects are essential for healthy mixed-use and historical communities.
- The project encourages future development near existing infrastructure by providing a contextually appropriate and competitive model for infill development.
- Traffic congestion, air and water pollution are reduced through reinforcement of walkable conditions resulting in reduction of energy use.
- Future implementation of renewable energy (solar) is provided for.
- On-site storm water management is planned.
- The projects provide affordable housing that is ADA adaptable and accommodates aging in place for an increasing aging demographic.
- Infill, retrofit and walkable development helps to protect historic, natural, agricultural, and recreational resources.
- The program conserves natural resources through green building including new construction and renovation.

EEHP Process / Construction / Delivery

The project team was lead by two separately contracted groups, the architectural team and an energy consultant. Prior to contracting with the design team a project advisory board, representing expertise and experience relevant to the project, was assembled. This advisory board participated in an initial project charrette to establish project goals and priorities. The architectural team worked closely with the energy consultant throughout the design for feedback on performance (assessed through energy modeling) and for recommendations on construction and HVAC methods. This energy consultant also oversaw verification related to energy performance for the NAHB certification.

The duplex was designed with modular housing conventions in mind and both conventional and modular builders bid on the project. A

modular builder won the bid with a significantly lower construction cost. The condensed construction time facilitated by modular building allowed for more careful product oversight and monitoring of the process for continual verification of energy-efficiency measures and details. For this project modular construction was ideal, especially with neighbors within steps of the site, because the on-site construction time overall was significantly reduced (the finished modules of the duplex were set in a day.

While the renovation work was delivered in a more traditional manner, it was necessary for the project team to work carefully with the general contractor to assure that the aggressive performance goals were met. It is critical for the delivery of such affordable green projects that small contractors be well versed in the tenets of energy efficient construction.

KIT-OF-PARTS

The KOP concept builds on the valuable lessons learned during the initial stages of the EEHP. A yet unmet goal of the EEHP is its replication. This concept is intended to remedy that. In addition to embracing the manufacturing process the KOP concept seeks to leverage public investment by identifying tools for wide-spread application.

Public investment in the design of fabrication-ready building modules allows for the cost of integrative green design to be spread over many small projects. The KOP is intended as the core building blocks of public bid packages. A 'Standard geometric template' would conform to the common constraints typical of our small towns, modest houses and (efficient) modular construction. Application would not be universal but if planned properly it could be reasonably ubiquitous. Further, adherence to such geometrical constraints goes a long way to making houses context sensitive and is more reliable and cheaper than the frequently ham-handed application of faux historical materials.

Fabrication documents for the KOP would be developed to tight manufacturing standards and tolerances. They would include a level of coordination unprecedented in the design of individual affordable houses. Because the KOP would be technologically and spatially simple, cutting edge software and digital fabrication is not needed. KOP should be reductive, elegant and definitively low-tech; most materials and systems will be "off the shelf". Mass customization would occur during the (site adaption) individual application of the parts and through the integration of local materials.

In addition to context sensitive new houses, the KOP has application for existing houses. Modules would be designed to facilitate high performance mechanical and plumbing cores, accessibility, (code compliant) egress, single floor living and division of houses into multiple units. Existing historical housing is frequently in need of just this sort of updating. It is our hope that the KOP would have similar advantages for retrofitting existing houses as it would relative to site built new construction; Certainly the reduced construc-

tion time would minimize disruption for residents. Because older houses frequently perform much more poorly than current energy code the energy savings realized through this careful retrofit can be very significant. Other benefits include the embodied energy saved, neighborhood revitalization, and historic preservation.

BENEFITS/ CONSTRAINTS OF MODULAR CONSTRUCTION

Manufactured Home Builders are fond of saying that “if it can be site-built it can be built modular.” This is likely true but modular houses are most efficient if they embrace the modest dimensions dictated by shipping constraints. Happily what is needed most are modest residences. An important lesson from the EEHP’s duplex demonstrated that design that is responsive to the constraints of efficient modular construction can be extremely cost-effective. As a result the bid price from the lone modular builder more than 20% less than the bids by contractors proposing to site-build.

It is critical for high-performance houses (particularly modest houses) that construction be carefully observed by the design team. Because factory based construction occurs over the space of a week or so, this intense observation is possible. Such attention is much more difficult and expensive in a site-built project that takes months to complete. In our limited experience the quality of construction in modular plants is often lower than that typical of site-built projects but the intense observation protocol does much to mitigate this problem; repetition would as well.

ROLE OF THE ARCHITECT

The retail value of design services for the EEHP are hard to determine precisely but our unscientific analysis suggest that they would exceed 40% of the value of the construction cost. This is not replicable. The KOP will help by removing the most expensive part of the design process. This would seem to limit the architect’s scope but the reality is that architects typically would have no role at all in such small projects (it is generally not required by AHJs) and it is almost unheard of that their scope would include full design services (the EEHP is an obvious exception). With the strategy suggested herein, the architect’s role is critically important to the effective use of the kit-of-parts. It would include: 1) site analysis to determine whether the KOP is appropriate for a given site or sites, 2) modular configuration, design and coordination for site adaptation, 3) integration of local materials and “materials of opportunity” (4) Project administration and 5) green certification.

CONCLUSIONS (and challenges)

The benefits of small town (re)development in terms of Smart Growth are obvious; a vibrant small town has the potential to be a very desirable place to live. Likewise modular construction for projects that are publically bid and anchored by fabrication-ready designs for recombinant modules and materials promise a realistic way to deliver high performance, context sensitive housing. How-

ever there are a few challenges that make the implementation of this program far from a forgone conclusion.

Market

People and businesses have been steadily abandoning small town centers for a generation or more in favor of auto-centric living. Thus it may take some effort to change people’s perception. Given this, the transformation needs to be decisive; it cannot be allowed to take too long to approach critical mass. This may suggest a town-by-town approach.

A New Way of Doing Things

This bold and perhaps risky public investment runs counter to prevailing trends of to pro-privatization⁷ and project specific “bricks and sticks” (not planning) funding.

It is true that the process pushes building construction towards the long-predicted manufacturing model but does it in a low-tech and unsexy manor. What’s more it requires change in established public building procurement protocol.

A Bigger Plan

This proposal is in its infancy. The authors assumptions about the cost effectiveness of the manufacturing process, the transformation of the procurement process and the role of the architect are based upon limited and incomplete experience and need to be studied and elaborated upon. This cannot happen in a meaningful way without direct public support for research and development. Likewise meaningful and material public policy support must aggressively support Smart Growth in the interest of the revitalization of small town fabric.

The prospective benefits of this approach seem obvious. Likewise it is obvious that the time is over for short-term and linear solutions to energy and economic sustainability.

It is only logical that public investment in housing should have enduring benefit to the public. If this proposal is viable, (rural) public housing authorities and not-for-profits should be able to better meet their core mission by adding and renovating highly efficient houses, one at a time, in established small towns.

ENDNOTES

1. David Thompson, “Laying down the law on the housing crisis,” *Sun Gazette*, January 29, 2011, <http://www.sungazette.com/page/content.detail/id/559559/Laying-down-the-law-on-the-housing-crisis.html?nav=5011>
2. Michael Pollan, “Farmer in Chief,” *The New York Times*, October 12, 2008, <http://www.nytimes.com/2008/10/12/magazine/12policy-t.html?pagewanted=all>
3. Commonwealth of Pennsylvania, *Keystone Principles For Growth, Investment & Resource Conservation*, 2005, www.portal.state.pa.us

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4. Pennsylvania Interagency Land Use Team, *Keystone Principles, brochure, 01 January 2010*, http://www.newpa.com/sites/default/files/uploads/Keystone-Principles-brochure_rev91.pdf
5. Housing Alliance of Pennsylvania, "How should housing funds from impact fee be targeted,?" May 4, 2012, <http://www.housingalliancepa.org/news/201205/612>
6. IBID
7. This concept and some of it's affects are discussed in: Nicolai Ourossoff, "Reinventing America's Cities: The Time Is Now," *The New York Times*, March 29, 2009, <http://www.nytimes.com/2009/03/29/arts/design/29ouro.html?pagewanted=all>