Making the Side Yard House; A Passive Mass Housing Model

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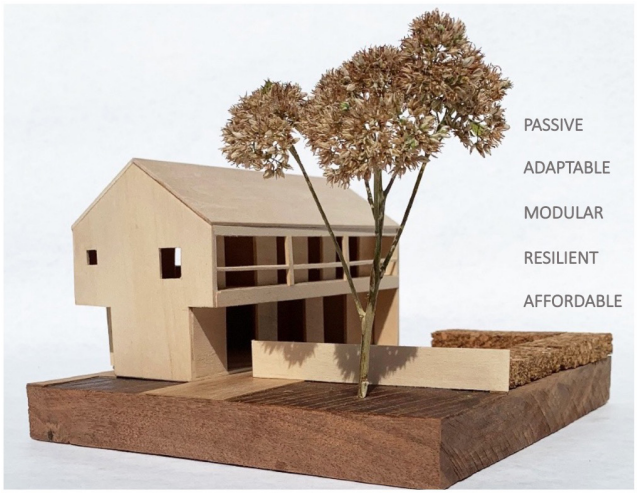

Figure 1. House Model by Author

Figure 2. Hybrid House Model Rendering by Marzea Akter

BACKGROUND URBAN PLANNING RESEARCH

We currently face a major housing crisis, yet housing design and construction has barely responded. Approximately 98% of single-family house construction is still developer driven and the vast majority are energy inefficient, unsustainable to build and unaffordable by missing-middle home buyers who cannot afford skyrocketing real estate prices.[1] To address climate change and social/economic disparities, the Side Yard House was developed as a new proposal for mass detached housing that, largely through a reproportioning of the house to the land, can produce a more Passive, Adaptable, Modular, Resilient and Affordable home that incorporates qualities of both urban and suburban environments. The common planning concept for all variations of houses involves re-proportioning the lot from a long rectangular backyard to a square side-yard model home while maintaining existing area and density. Instead of a backyard that is accessible to few, this arrangement, similar to the Charleston House typology, creates a sunny, large, green space on the south side that serves many functions. The long southern façade with its shaded "gallery" provides an optimal layout for multiple solar

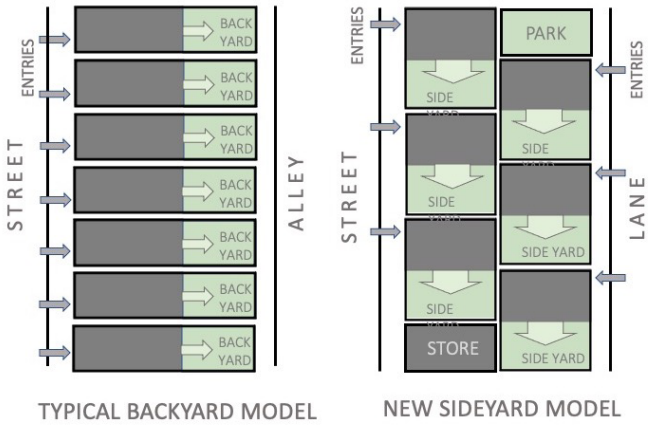

Figure 3. Side Yard House Concept Diagram by Author

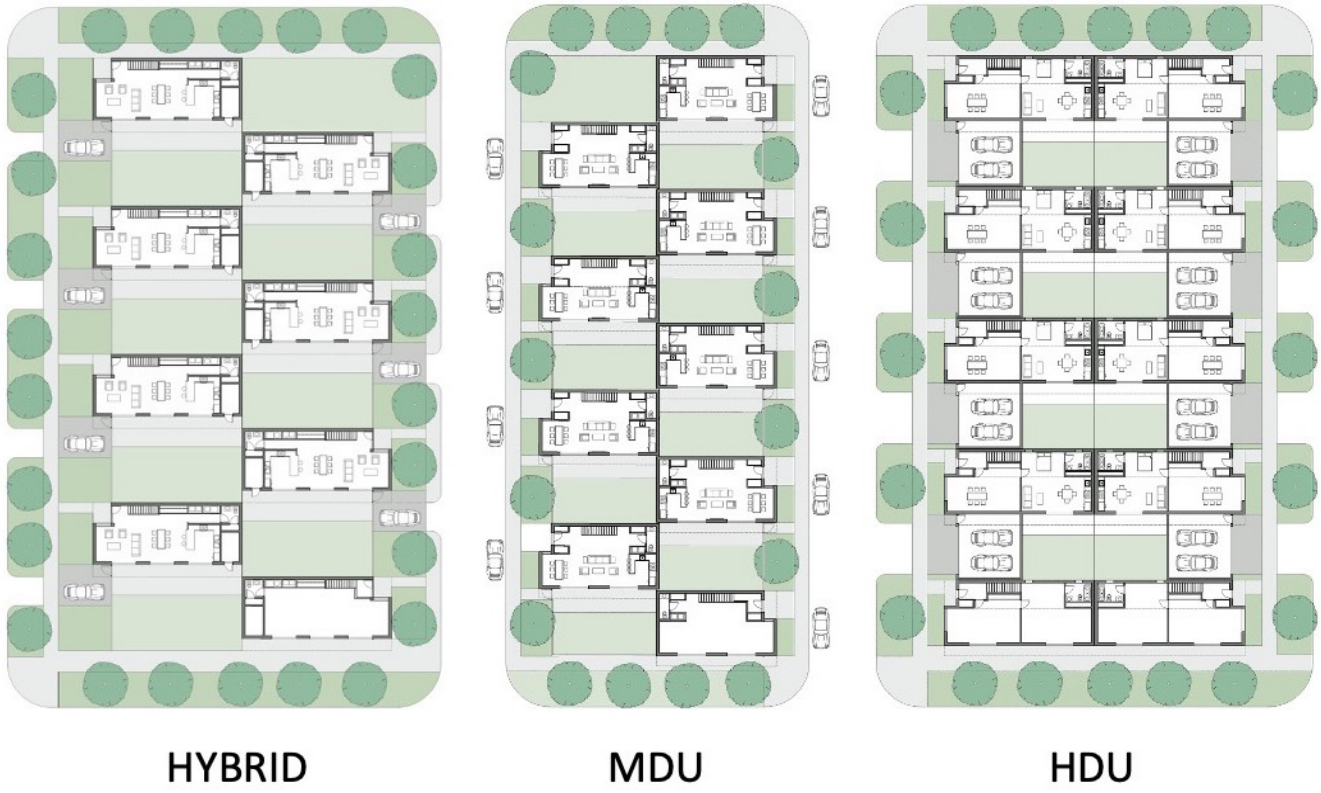

Figure 4. Urban Models Block Planning Options by Author

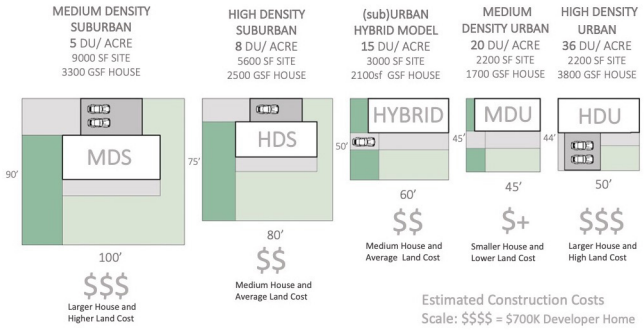

Figure 5. Range of Model Types by Author

strategies like passive solar heating, natural daylighting, and PV power production that when combined with a Passive House highly insulated envelope, greatly increases energy efficiency and resiliency over standard construction. The side-yard provides a private healthy green environment, reduces heat island effect, increases passive cooling and can be a protected place of refuge during future pandemics. Past research on this project has been conducted at the urban planning scale to investigate the home's adaptability to a range of urban and suburban settings. A detailed description of how the typology was tested using Detroit as a model city can be found in an article in The Plan Journal[2], and some images are included here for context, but this project focuses on current developments to test the construction feasibility of a single house.

PASSIVE ENERGY STRATEGIES

Any new housing model should stive to be as carbon neutral as possible so the Side Yard House would incorporate Passive House (Passivhaus) principles to the greatest extent feasible. An initial energy analysis using Sefaira software and ASHRAE criteria showed, after several steps, the 2030 Challenge target of 13 kBTU/ft2/yr was reachable. Daylighting analysis demonstrated well-lit living areas and sufficient ambient light in remaining spaces to minimize artificial lighting. Specific strategies include:

Efficient Envelope – The house incorporates an R-60 Heavily Insulated, Tightly Sealed Envelope & Windows and a Heat Exchanger in Attic.
Solar Gain – As a Sun Tempered Home, the majority of glazing is on the south Wall with reduced glazing on North, East and West Walls. Thickened/ Insulated Concrete Floor Slab as Thermal Mass
Sun Shading – The gallery and roof overhangs block the high angled summer sun to reduce AC load
Natural Cooling - The long, thin house shape promotes

natural ventilation cooling while the minimally fenestrated north side deflects winter wind around the building
Daylighting – The thin building, skylights and clerestories provide natural daylight into all rooms reducing need for artificial lighting and its electric and cooling loads.
Photovoltaic Power – The long, sloped south-facing roof is optimal for photovoltaic power generation and battery storage (a 400 sf panel space provides enough power to supply a 7 kW system for this size house) and increases the home's resiliency in times of power outage.
Open Green Space – The vegetated side-yard space reduces heat island effect, increases natural ventilation cooling, provides direct access to fresh air and serves as a area of refuge in times of isolation.

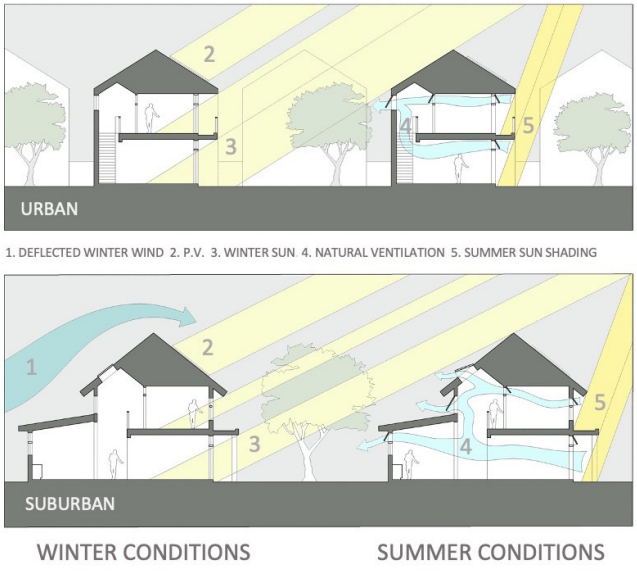

Figure 6. Passive Energy Strategy Sections by Author

SIDE YARD HOUSE CONSTRUCTION

New research has focused on the construction details to investigate how this house model could be built both affordably and sustainably. This design follows Passivhaus principles so construction typically costs more than standard due to additional insulating materials required. Preliminary calculations using the PHIUS Initial Cost Saving Premium and Source Energy Saving Estimator predict a House of this size in Detroit would cost $14 more per square foot, or about 6-10%, to build. At the same time, rising construction costs are making new construction unaffordable to all except the wealthy. The long, narrow proportions of the Side-Yard House that work well with passive energy strategies also work well with modular construction dimensions, so the house models were designed using methods of prefabrication and

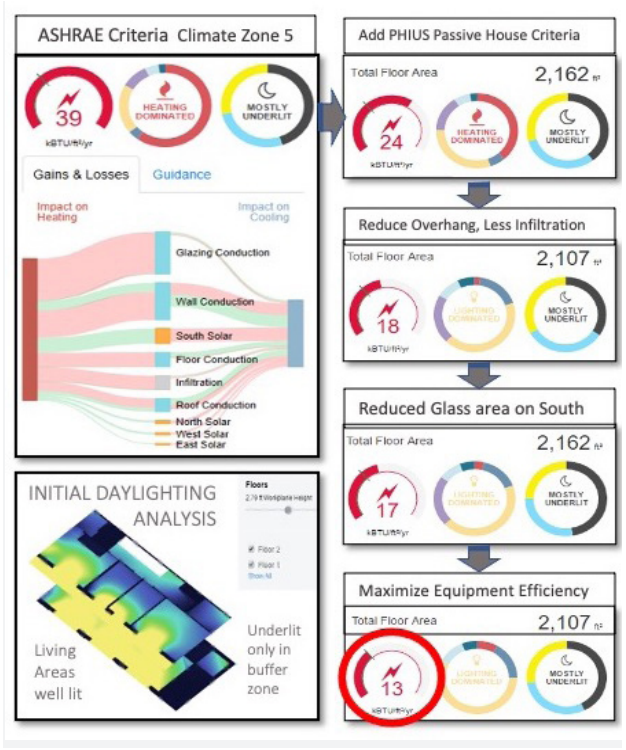

Figure 7. Initial Sefaira Energy Analysis by Sal Armetta

modular construction to keep labor costs down and offset the increased cost of an energy efficient home. Typically, a modular home costs 10-20% less than a stick-built home which would easily cover the 6-10% increase for Passive House.[3] Future reduced energy costs would continue those savings. Prices would not be as low as traditional subsidized housing but should be in range of the missing-middle housing buyer market, who have an adequate income yet cannot afford much of the new housing produced today. Land and construction prices vary greatly between regions so exact results still need to be tested.

Mass Timber CLT

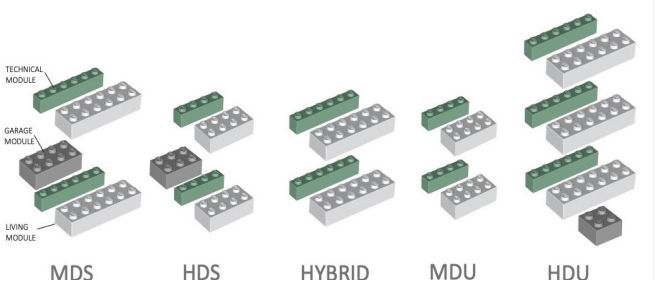

Figure 8. Module Combination Diagram by Author

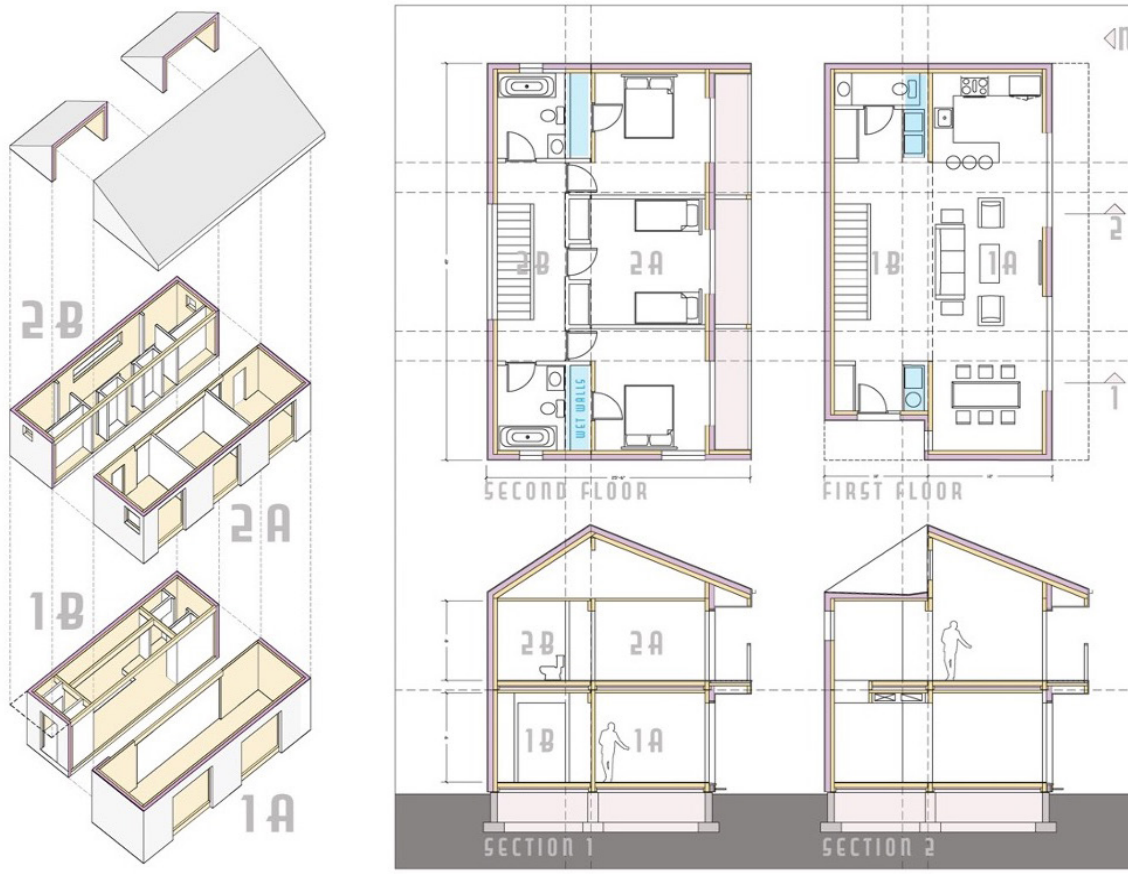

Figure 10. Module Arrangment by Author

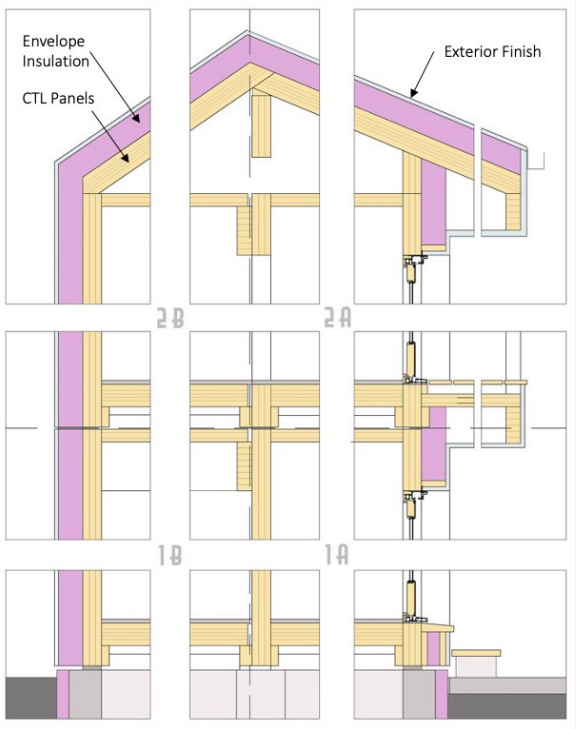

Figure 9. CLT Details by Author

A sustainable, energy-efficient home should also employ low-carbon methods of construction so the chosen building system is mass timber CLT (Cross Laminated Timber) construction rather than standard light wood framing typically used for prefabrication. This system has been used extensively in Europe, especially for multi-unit housing, but has limited exposure in the US. Dimensions of the Side-Yard House work well with CLT spanning capacity and transportation requirements of the modular orthogonal boxes. The bulk of the house consists of 4 modules sized to fit a standard flat-bed truck without being so large as to require special permission to transport. The 2 larger south modules contain the living spaces while the 2 smaller technical “wet” pods contain the mechanical equipment/chases and act as a north buffer. The roof and long balcony are flatpack CLT slabs to be erected on site meaning the entire house could be shipped on a total of 5 trucks and installed quickly by crane. The construction details were created following manufacturers CLT construction details[4] and the proposed methods were reviewed by modular construction consultants to verify feasibility.

ENDNOTES

1. Daniel Parolek, *Missing Middle Housing*, Island Press, 2020
2. Craig Griffen, "*(sub)URBAN Hybrid Housing; Rethinking the City with Healthy, Sustainable Housing*", The Plan Journal, Volume 5.2, 2021, Bologna, Italy
3. Karen Gardner, *Prices of Modular Vs. Stick Built Homes*, https://budgeting.thenest.com/prefab-housing-disadvantages-24540.html
4. Building Systems by Stora Enso, Stora Enso, Division Wood Products, Version 4.0, December 2016