House in a House

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Abstract

There is a significant amount of existing domestic housing stock in the United States that is ready to be insulated and retrofitted for improved energy performance. These existing houses can be upgraded to be more climate responsive extending their efficient occupancy for many decades to come. Instead of replacing or demolishing existing dwellings, they should be retrofitted so the environment is not burdened with inefficient houses. This concept limits the deterioration of neighborhoods, landfills are not overwhelmed with waste, and ultimately reduces greenhouse gas emissions. This paper is a case study that demonstrates the strategies incorporated to make a dwelling more climate responsive. The upgrade includes a rainscreen in conjunction with a crisscrossing lattice system mounted on a sub-façade, plus the addition of an interconnected passive ventilation system at the roof ridge. This paper examines the techniques utilized to install the rainscreen and how this system mitigates heat gain from solar radiation on the sub-façade, roof, and insulation. The idea is to construct and live in a house in a house.

Keywords: Sub-façade, rainscreen, heat mitigation, ventilation box, passive cooling

1. Introduction

The project uses existing technologies that can be applied in an innovative, economical and to some degree, when compared to existing methods, more efficient way. The concept is to externally refurbish existing dwellings; making already constructed houses climate responsive with passive cooling. The question is how to execute the retrofit in a cost-efficient manner that addresses both winter and summer conditions.

Fig. 1: Refurbished north façade – House in a House

The problem in refurbishing existing dwellings with new insulation is, in most cases, limited to the existing 2x4 wall framing system. Instead of creating access to the old 2x4 structure, the existing dwelling in the case study was wrapped with a new 2x10 insulating structure. Homeowners that have excessive heating loads might want to retrofit and add insulation to their house, but often fear the expenses associated with an approach that in most cases is intrusive and cumbersome. The house in a house idea eliminates this problem.

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In the case study presented here is a dwelling from 1919, wrapped in a modern structure that was completed in 2019. In this project, known as the Cloud House, new extends old. In this approach the environment is not burdened with old dwellings simply being tossed away, instead existing dwellings are given new resiliency, reinvigorating existing neighborhoods while reducing greenhouse gas emissions.

2. Passive cooling

This case study is presented in twelve steps that illustrate how one can easily apply passive heating and passive cooling to an existing domestic dwelling. Most figures are extracted from evidence-based deployment in the field.

One: The Cloud House is situated in Fargo, North Dakota. The north façade received a new brise soleil that was executed in cedar (see figure 1). A brise soleil is excellent for ventilation and providing shadow. The dimension of each cedar element is 1 x 2's, not stacked tightly, but mounted with a negative space that allows for wind to pass through. A brise soleil should be set on sleepers with fine mesh applied to the surface facing the sub-façade.

Fig. 2: Original dwelling and refurbished dwelling

Two: The case study house originally had a stucco façade and was not executed with any insulation in the walls. The building is located in a climate with +80 degrees Fahrenheit temperatures in the summer and -40 degrees Fahrenheit in the winter. The building was wrapped and retrofitted with a new structure that contains insulation and a new rainscreen that prioritizes passive cooling in its design (see figure 2). The addition to the Cloud House includes a brise soleil on the south façade, similar to the one on mounted on the north façade (see figure 1).

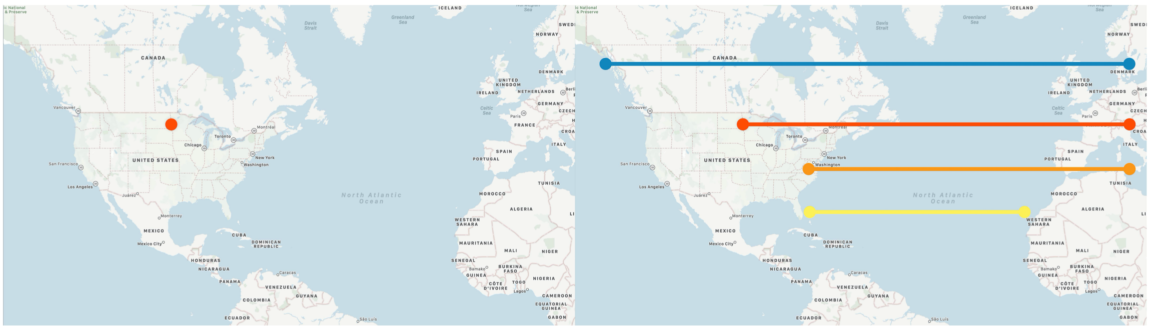

Fig. 3: Fargo, North Dakota and sunlight in relation to other areas

Three: In Figure 3, note that Fargo, North Dakota, is slightly north of Venice, Italy, Washington DC is at the same latitude as Palermo, Sicily, Miami is at the same latitude as Western Sahara, and the panhandle of Alaska is at the same latitude as Copenhagen, Denmark. The entire lower 48 states could learn from design solutions that many Mediterranean cultures developed when designing in relation to sunlight.

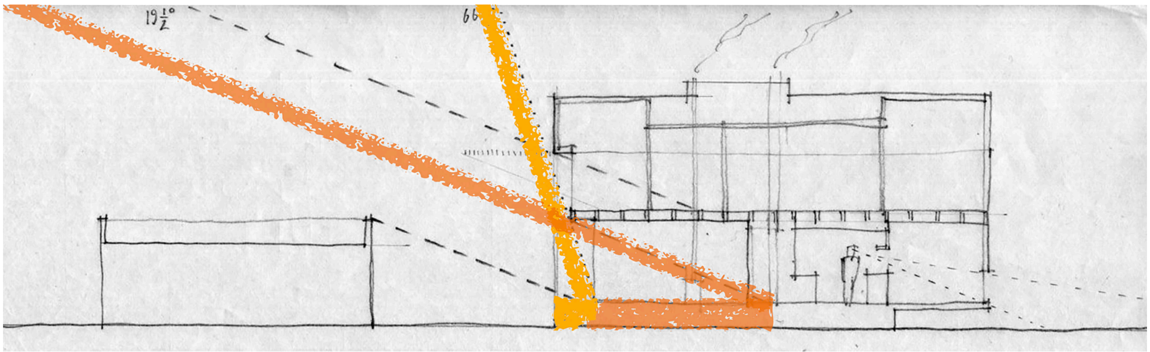

Fig. 4: Sketch regarding sunlight in summer and winter

Four: Early sketches of the Cloud House design account for the noon sun position on the 21st of June and noon sun position for the 21st of December (see figure 4). Sunlight should be considered and studied by architects and engineers when designing and working together. Designing and operating technical equipment for climate-controlled-interiors should include passive heating and passive cooling solutions as well. This sketch explores the geometry between sun and earth and how to invite sunlight into a building during winter and excluding direct sunlight from interior spaces during summer.

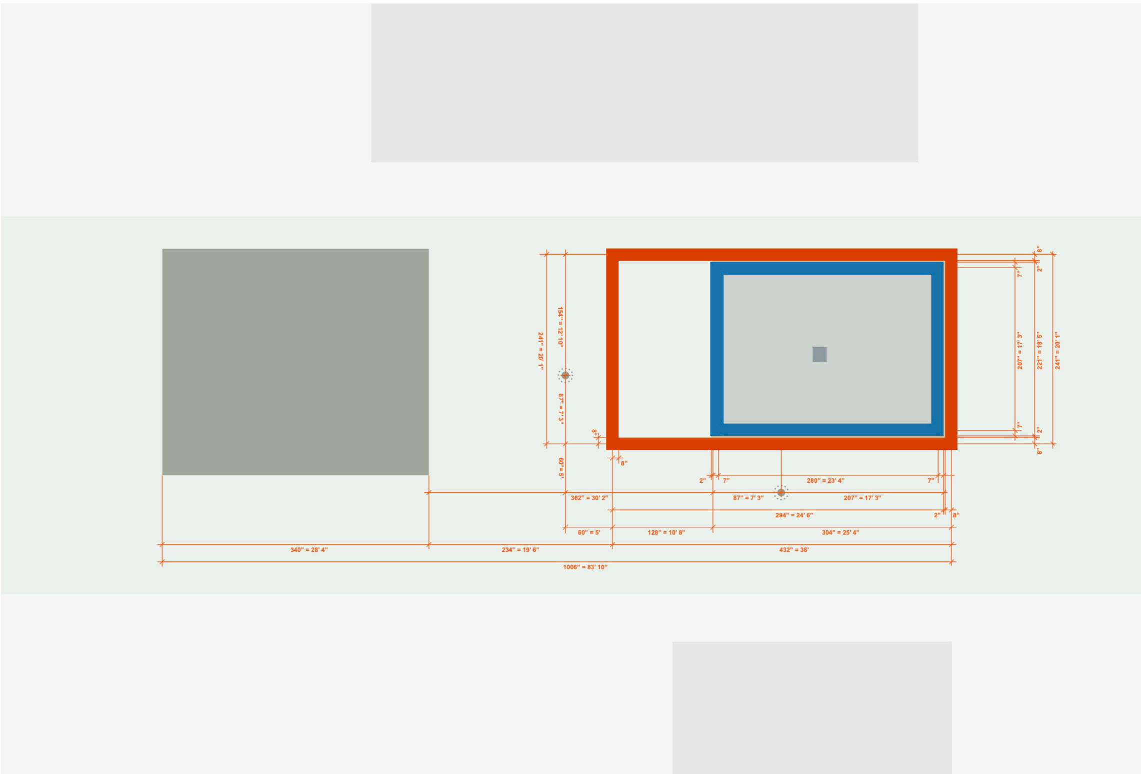

Fig. 5: Idea for a house in a house

Five: The plan in figure 5 is the essence of this concept for how to preserve and refurbish an existing dwelling with the house in a house approach. Almost any existing dwelling can be modified by expanding a new outer foundation in any direction. Zoning setback or urban context must be taken into consideration in any new design or alterations. The plan outlines the existing foundation in blue color and outlines a new foundation in red. The old foundation is framed by the new foundation creating a house in a house. Figure 5 also displays a garage to the left of the house, in dark gray. Neighboring houses, in light gray, can be seen outside the property indicated with a light green color. North is to the right.

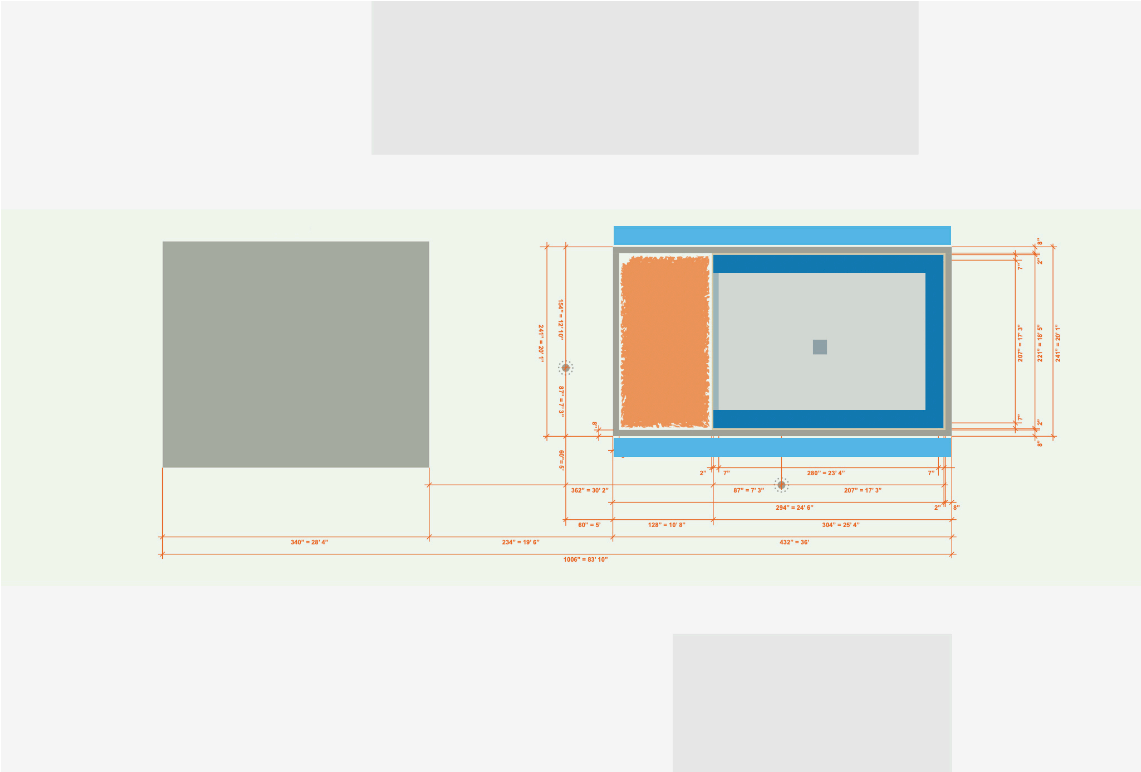

Fig. 6: Ventilation between existing dwelling and new structure including passive cooling behind rainscreen

Six: The blue frame in figure 6 indicates ventilation between existing dwelling and the new surrounding structure. There must be an air gap between the old and the new structure, so no mold or fungus can develop behind the new vapor barrier. The orange color represents the floor heated by the winter sun. The light blue lines indicate passive cooling and ventilation between new rain screen or siding and the new sub-façade/OSB-board and insulation. The light blue lines represent passive cooling that will be further explored in the following figures.

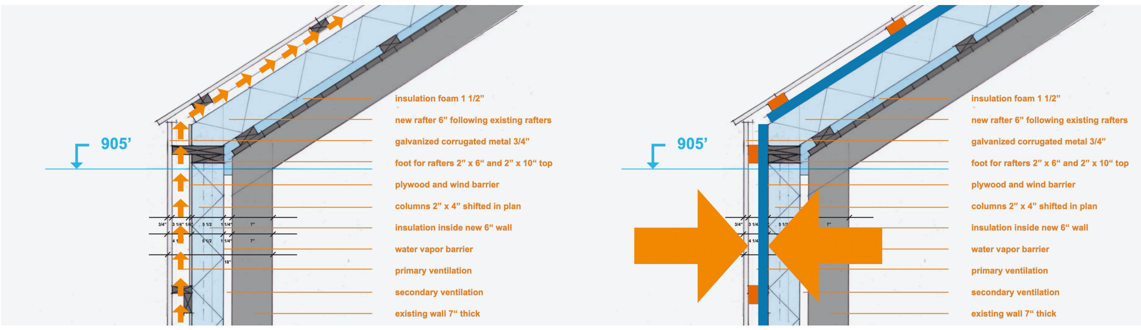

Fig. 7: Detail façade and roof and crisscrossing sleepers

Seven: The small orange arrows in figure 7 on the left, indicates the passive airflow between the new structure and sublayer OSB-board and floating rain screen. The open crisscrossing latticework of the 2x4's between OSB-board and new rain screen are highlighted in color between the two large arrows in figure 7 on the right. Dark blue is vertical 2x4's and orange rectangles horizontal 2x4's. The gray represents the existing dwelling. Notice that there also is a ventilation gap between existing dwelling and new structure in the vertical area. The roof of the dwelling from 1919 was constructed with an attic, therefore it was possible to fully insulate all areas in the new roof structure, as long as existing attic can remain ventilated. Insert this detail of façade, roof and crisscrossing sleepers and latticework in figure 7 into the orange circle in figure 8.

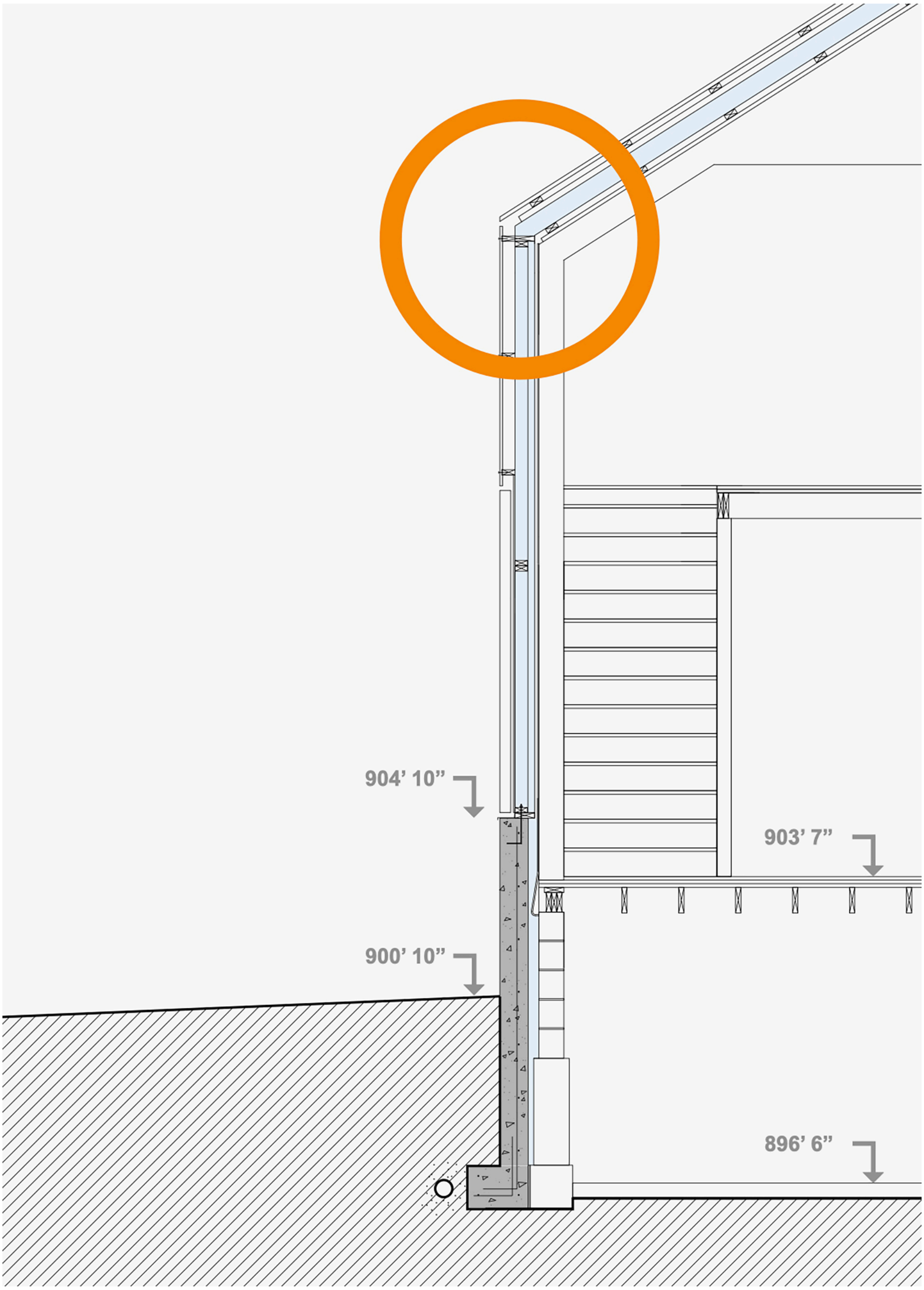

Fig. 8: Section of façade and roof

Eight: Figure 8 highlights a detail on how to mount rainscreen and roof, both floating on crisscrossing sleepers and latticework. The new structure is indicated in a very light blue color. The new rain gutter is missing in this drawing; refer to partly installed gutter as seen in figure 10 instead.

Fig. 9: Completing the crisscrossing lattice system for ventilation on façade

Nine: A layer of the 2x4 crisscrossing lattice system has been mounted on top of the sub-façade (figure 9, left). This is a simple and efficient solution to generate passive cooling behind a rainscreen. Notice that the large arrow in figure 9 points at the very first horizontal 2x4 that was mounted for the crisscrossing lattice system. The white lines indicate all the horizontal 2x4's that complete the crisscrossing lattice system that carry the rain screen. Simply mount any rain screen to a crisscrossing lattice system, in this case Galvalume was selected for the façade, and tie into a large ventilation box on ridge cap, and by doing so, create a cost-effective passive cooling system.

Fig. 10: Completing the crisscrossing lattice system for ventilation on roof

Ten: Almost all dwellings have a ventilation ridge, it is not a new idea, but they are rather simple and small in proportion. There are only very few design options for a ventilated ridge cap that targets residential buildings. The large ventilation ridge box not only collects all ventilation air behind the rainscreen, but also collects various other installations centrally, such as smokestack and pipes, eliminating perforation of roof or façades.

Fig. 11: Galvalume, crisscrossing lattice system, weather-resistant barrier

Eleven: A small sample of the brise soleil can be seen in the very right corner of the south façade in figure 11. When the brise soleil has been mounted on sleepers on top of the weather-resistant barrier that is protecting the sub-façade, it will help develop air convection initiating passive cooling. The brise soleil is constructed with a very fine mesh between sleepers and weather-resistant barrier preventing insects from entering the ventilation space. Notice the crisscrossing lattice system behind the ladder on the very left in figure 11, still exposed in this photograph, being applied a Galvalume siding that will complete the east and west façades. An efficient passive ventilation was made possible by combining the brise soleil with ventilation along all edges of the Galvalume and the ventilation box on the ridge.

Fig. 12: Passive cooling

Twelve: The façades, executed in wood on south and executed in metal on east and west, perform simultaneously and in unison regarding cooling (see figure 12). The orange arrow indicates how excessive hot air, generated behind the Galvalume, exits the ventilation box. The white arrows highlight the eastern area of the south façade; however, the arrows should be mirrored on the south façade, and applied to the north façade as well.

3. Cool aesthetics

The idea of a house in a house was first introduced to me when working on various design projects for architect Oswald Mathias Ungers in Berlin. The theoretical approach is full of temptations, but without deployment in the field there would not be any strategy, reflection, or feedback. The objective in this paper, to apply a rainscreen on a crisscrossing substructure generating passive cooling, emerged from an idea that originated from a very different problem. The ventilation box was primarily an aesthetic solution. It was first designed to merge all pipes that vent the interior of the Cloud House. I wondered why roofscapes on dwellings are often poorly designed, or why so many architects would design a roof as a single membrane, only to see the rainscreen or roof be compromised by a number of penetrations? From a technical point a roof should never be compromised by installations that emerge from below; resulting in a potential leak. In the design of the Cloud House the lifespan of the roof is longer, as no surface of the roof has been compromised by poking large holes anywhere. The only compromise was to fasten the corrugated Galvalume to the crisscrossing substructure (figure 7, 9, 10, 12, 13 and 14). An unexpected benefit for the new ventilation box was that it could serve as a vehicle for passive cooling. When executed, it was easy to see why the house in a house approach would not be theoretical, or just an idea, but pragmatic. However, it is maybe a philosophical question instead: Should all existing dwellings be revitalized so we can live better tomorrow? The refurbishment of any project is to honor what is. It is an opportunity to alter and adjust what was set in motion decades or centuries ago. The future invites us to recognize that nature is not abundant, but limited to site, situation, seasons, and resources, encouraging architects to collaborate with engineers and experts to find a path to reshape current dwellings in a cost-efficient way. The house in a house is an idea, and an approach, for how to upgrade any dwelling in almost any location, however, from a professional point of view, it is especially joyful embracing areas of extreme exposure such as summer and winter on the Great Plains in North Dakota.

Fig. 13: The retrofitted dwelling seen from the northeast corner

Fig. 14: Upgraded south façade – House in a House

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