THE AMERICAN NORTHEAST AS A BIOREGION FOR REGENERATIVE CONSTRUCTION

Kaja Kühl

youarethecity

This research is an effort to map the existing ecosystem of stakeholders and resources involved in regenerative building practices in the American Northeast. Combining desktop research, interviews, field visits and design drawings, it illustrates the many stages of the supply chain – from farms, forests and coastal landscapes to the interior of our homes. It seeks to tell stories of opportunities to uplift a growing regional network of advocacy and action to once again build with biomass.

with contributions by Anoushae Eirabie

Table of Content

The Atlas For Regenerative Construction in the American Northeast is supported by *Independent Projects*, a grant partnership of the New York State Council on the Arts and The Architectural League of New York.
This program is made possible with public funds from the New York State Council on the Arts, with the support of the Office of the Governor and the New York State legislature.

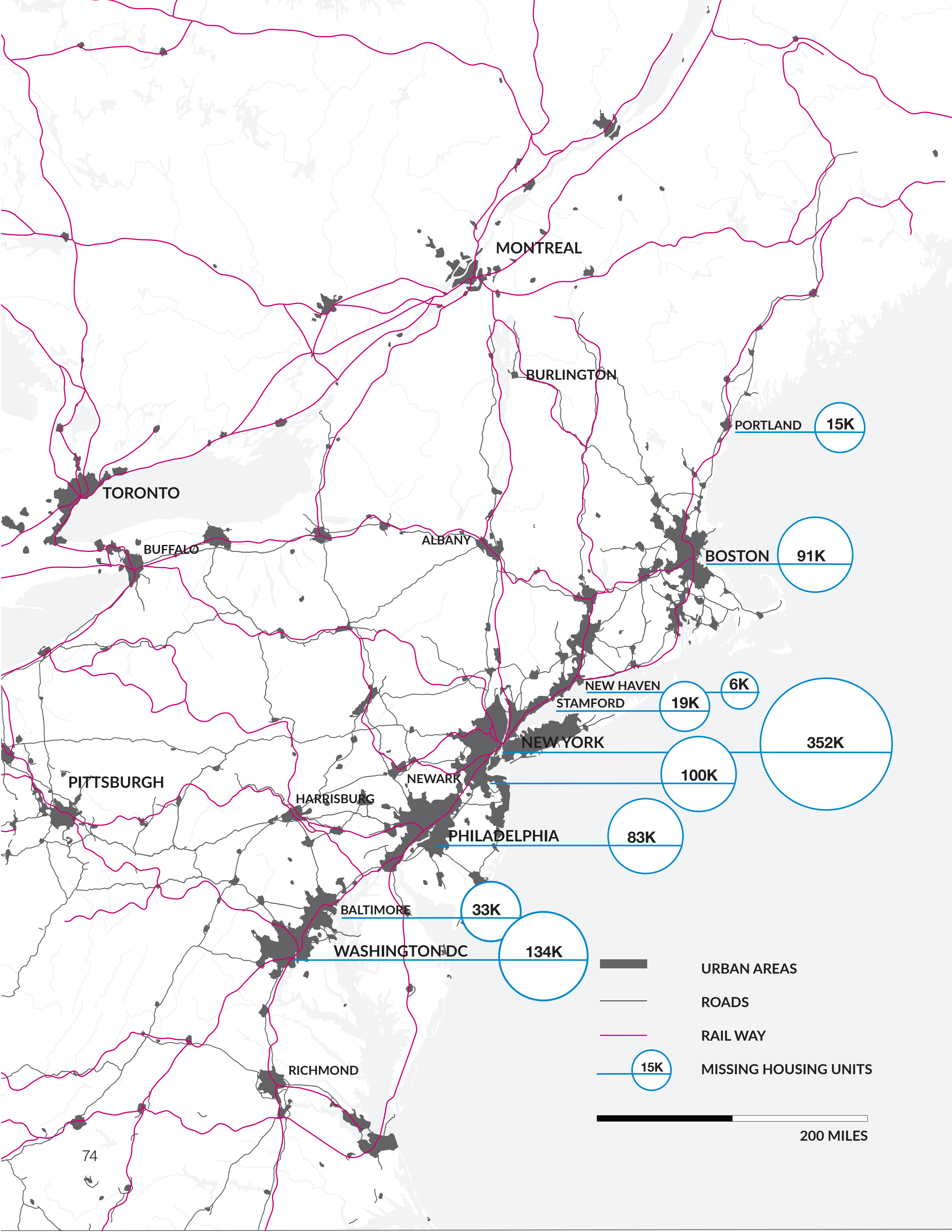
HOUSING AS CARBON STORAGE

3

Retrofitting, Accessory Dwelling Units or “Missing Middle” housing can be stepping stones to larger scales of multi-family housing and commercial applications, expanding the repertoire of biobased carbon-storing buildings within the urban fabric and move beyond the examples one-off single-family and weekend homes.

Years of underproduction since the 2008 recession have caused a housing shortage in the US of an estimated 4.5 million homes now missing. High interest rates since the COVID-19 pandemic and increasing costs for construction materials and labor have exacerbated this crisis, pricing many new households out of the owner and rental markets.[1]
A 2024 report on housing underproduction, *Up for Growth*, estimated the shortfall of new housing units in the Northeastern states to be greater than 846,000 in 2022.[2] Metropolitan areas within the Boston-Washington corridor account for the majority of underproduction, falling short more than 780,000 units, between 1% and 6% of a metropolitan area’s total housing stock. Unlike in previous decades, these shortages are not unique to major cities but also occur in suburban neighborhoods and rural areas.

While cities in the Northeast region need all types of housing as well as drastic policy interventions to ensure that housing is affordable, this report focuses on a few opportunities specific to the scale of one to four-family homes that we believe can be built with biobased materials today and can shape housing demand in the near future. They operate within the existing fabric of


MONTREAL
BURLINGTON
PORTLAND
15K
TORONTO
BUFFALO
ALBANY
BOSTON
91K
NEW HAVEN
6K
STAMFORD
19K
NEW YORK
352K
100K
PITTSBURGH
NEWARK
HARRISBURG
PHILADELPHIA
83K
BALTIMORE
33K
WASHINGTON DC
134K
URBAN AREAS
ROADS
RAIL WAY
15K
MISSING HOUSING UNITS
RICHMOND
200 MILES

cities and towns and address needs related to the aging building stocks and changing household compositions in the region, while also showing that additional housing does not need to take up more land.

The two prototypes discussed in this report are examples of relevant building typologies in the Northeast region and its need to scale up housing production and renovation. While each building project is unique, the drawings on the following pages prototypes offer opportunities to learn for creating buildings under similar conditions. Their relatively small sizes also recognize current limitations in building codes. Hemp and straw, for example, are both adopted into international residential building code as appendices, but only for structures less than 25 ft in height.[3] That said, until individual states or municipalities adopt the appendices more broadly, most projects using biobased materials today are approved using a provision of the residential building code that gives local code officials authority to approve materials not in the code.[4]

This provision reads as follows:

“An alternative material, design or method of construction shall be approved where the code official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.”

While each of the discussed prototypes is small in size (and, therefore, impact), collectively, biobased building projects can achieve significant carbon storage driven almost entirely by private individual property owners working—at least for now—largely without the help of direct government programs or subsidies.

There is no doubt that even greater scale can be achieved through government regulation or incentives aimed at encouraging multi-family housing developers to increase their use of biobased materials, be it through embodied carbon regulation and carbon markets, public health requirements, or support for biobased start-ups that can bring down the costs of materials. In the meantime, the following prototypes illustrate what owner-occupants, architects, and builders can do today.

As one of the first regions to be occupied by

Map: Housing underproduction in metropolitan areas in the Northeast in 2022. Data from Up for Growth

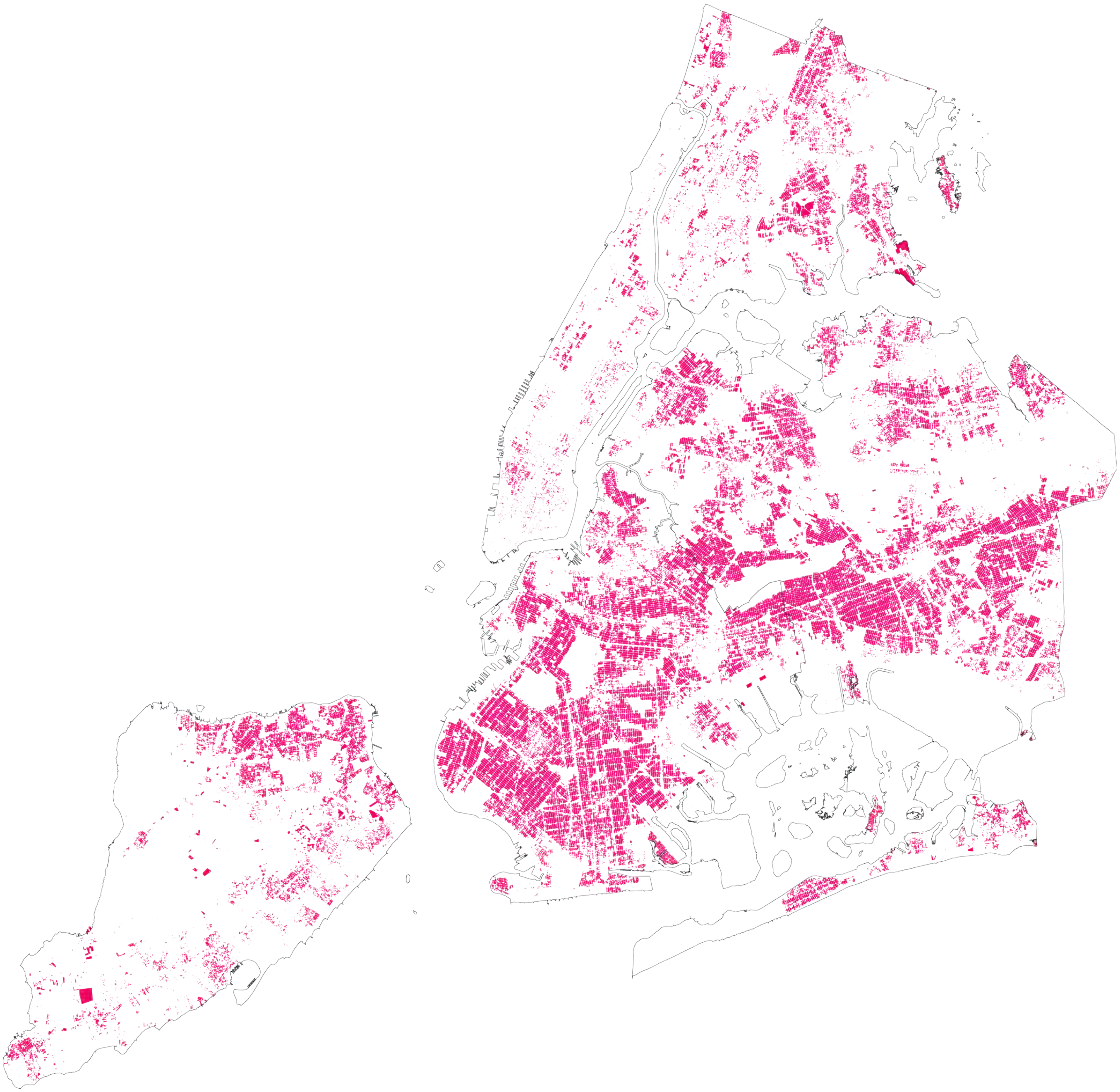
Prototype A Townhouse Retrofit

Prioritizing biobased carbon storing materials for envelope improvements ensures that the emission reductions in energy retrofits for heating and cooling do not come at the expense of upfront embodied emissions in the form of fossil fuel-based insulation.

European settlers, the housing stock in many small and large cities in the Northeast region is significantly older than in other parts of the country. In New York City alone, there are nearly half a million residential buildings of four stories or less that were built over 90 years ago. When these buildings were built, minimal insulation was installed. Today, potential renovations of these buildings often have to comply with stringent standards of historic preservation or zoning guidelines, making it difficult to add thick layers of exterior insulation.

In addition to building new housing, the Northeast region has enormous potential to renovate its existing housing stock, both in bringing abandoned structures back onto the market and improving energy efficiency by connecting more households to clean energy sources. Extending the life of old buildings can keep the carbon that was sequestered 200 years ago and shipped in the form of logs down the Hudson River and stored in these buildings for at least another 100 years. Prioritizing biobased carbon storing materials for building envelope improvements also ensures that emission reductions in energy for heating and cooling do not come at the expense of upfront embodied emissions in the form of fossil fuel-based insulation (at an R-value for passive house standards, a typical spray foam insulation emits approximately 80 kgCO2 per square meter, while hemp lime insulation sequesters 40 kgCO2).

Equally important to storing carbon,



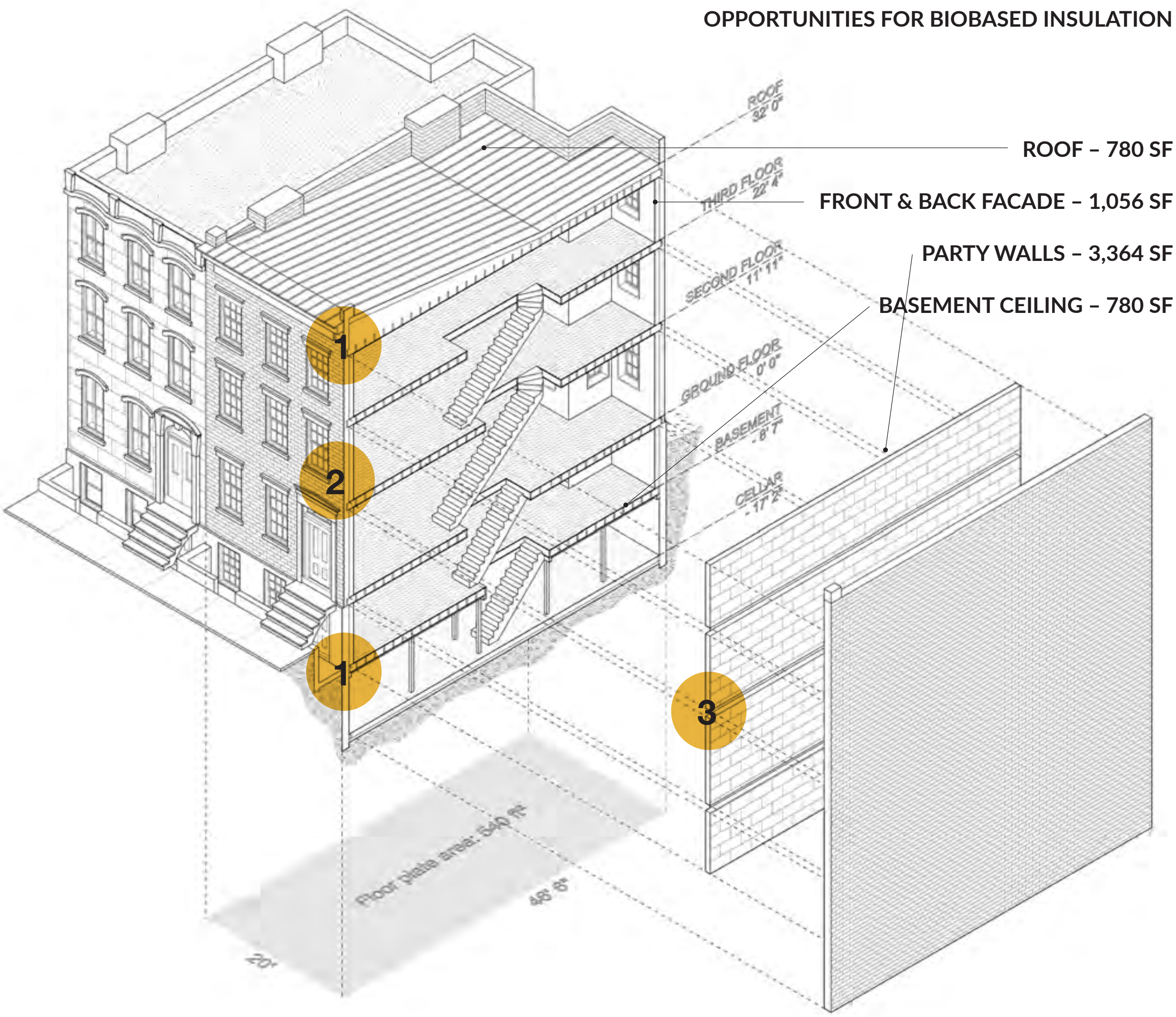
Map: Residential homes 4 stories or less in New York City
built before 1930

however, is the opportunity to return to healthy material practices that benefit both occupants and workers. Improvements to energy efficiency in homes should not have to sacrifice the health of residents and installers.

The Pratt Center for Community Development studied barriers to energy retrofits in New York City's townhouses for more than a decade and concluded that "rather than considering every building as a unique case requiring an intensive, individualized retrofit process, a simplified model designed around building stock similarities could greatly increase the number of retrofits in NYC."[5] It found that offering a standardized package of measures and prioritizing health and safety could help many low and moderate-income homeowners to undergo the renovation process.

The example described in this research builds on the Pratt Center's strategy, emphasizing how interior biobased insulation

Image: Energy retrofit with hemp blocks of the top floor of a townhouse in New York City,
Image Credit: Gabriel Vergara

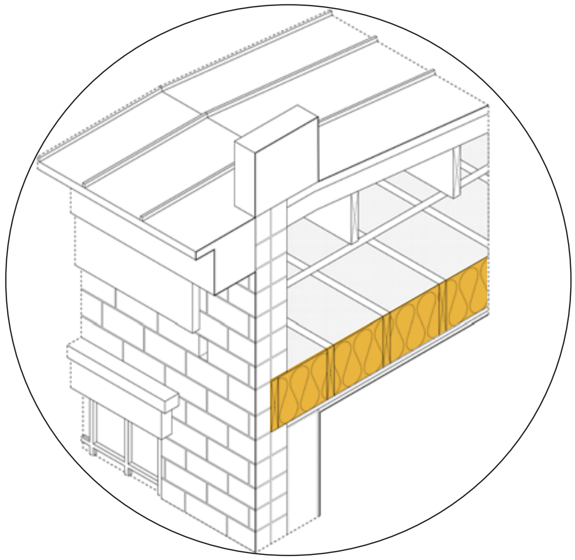


can improve energy efficiency and the health of residents while maximizing the potential to store carbon within the constraints of an existing building.

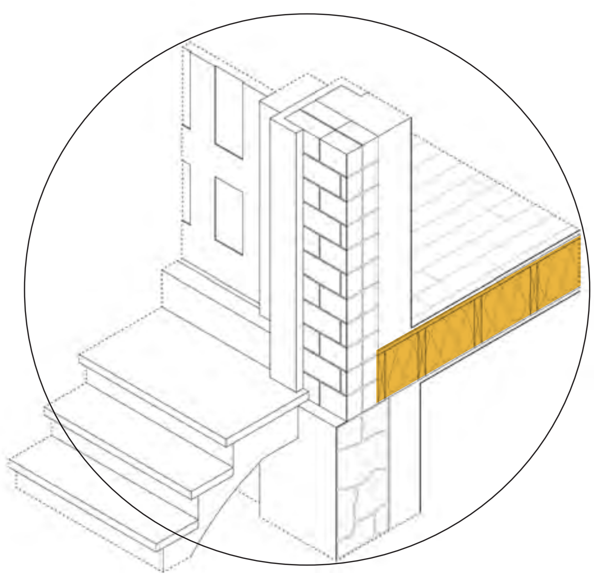
This example illustrates a 20x46 ft four-story townhouse and its ability to store between two and five metric tons of CO2 in its wall and floors. The total amount depends on the scope of renovation. For a typical energy retrofit similar to the pilots performed during the Pratt Center study with residents living in the building during renovation, the scope might include air sealing windows, doors and roof hatches as well as insulating the roof and the floor under the lowest inhabited space – typically the ceiling of the cellar (1).

In this comparison of stored/embodied carbon for different cavity insulation materials in 780sf of roof at R 44 and 780sf of basement at R 30, the difference between

1 CAVITY INSULATION IN ROOF AND BASEMENT CEILING

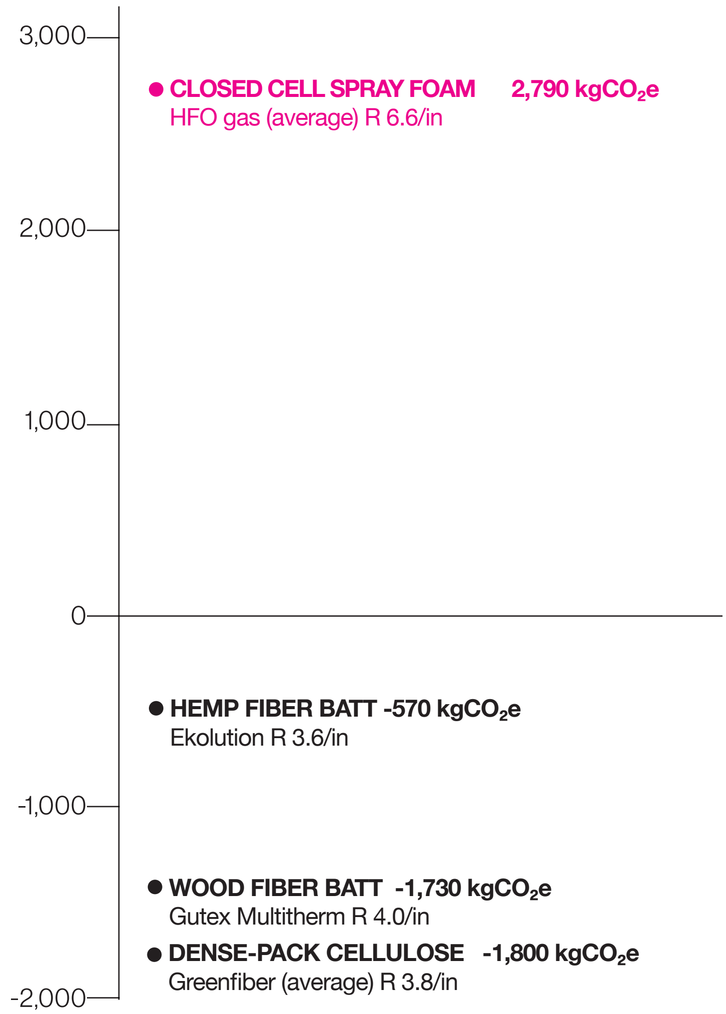


Roof cavity insulation at an average of R 44 (12 inch)



Cavity insulation underneath the lowest occupied floor at an average R 30 (8 inch)

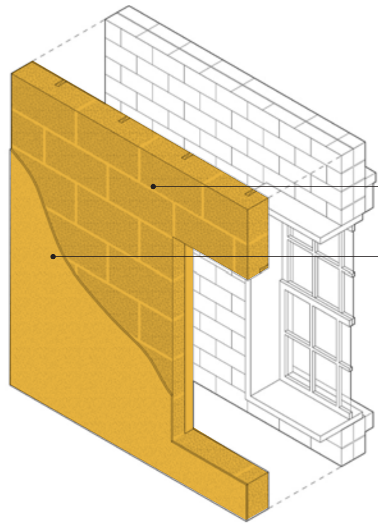
a worst-case scenario of using closed cell spray foam and using dense-pack cellulose is 4.5 metric tons of CO_2e, the equivalent of of what 4.5 acres of forest sequester in a year. Additionally, adding biobased insulation to the



Comparison of stored/embodied carbon for different cavity insulation materials for 780sf of roof at R 44 and 780sf of basement at R 30.

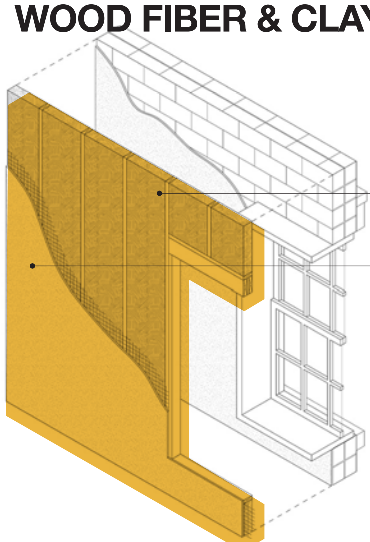
2 INSULATING INTERIOR OF FRONT AND BACK FACADE

HEMP & CLAY



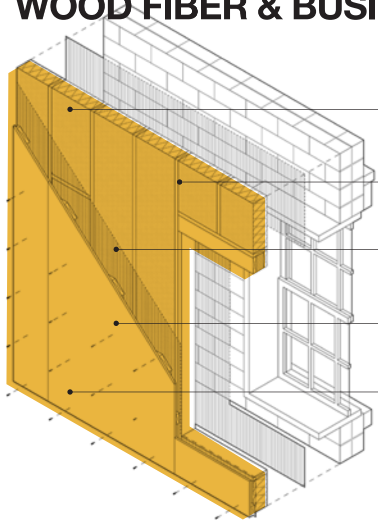
HEMP BLOCKS 6” Isohemp R 2.0/in	-543 $kgCO_2e$
CLAY PLASTER site mixed, 9/16”	86 $kgCO_2e$
TOTAL CARBON STORED	**-457 $kgCO_2e$**

WOOD FIBER & CLAY



WOOD FIBER BOARD Gutex Multitherm R 3.6/in	-1,667 $kgCO_2e$
CLAY PLASTER site mixed, 9/16”	86 $kgCO_2e$
TOTAL CARBON STORED	**-1,581 $kgCO_2e$**

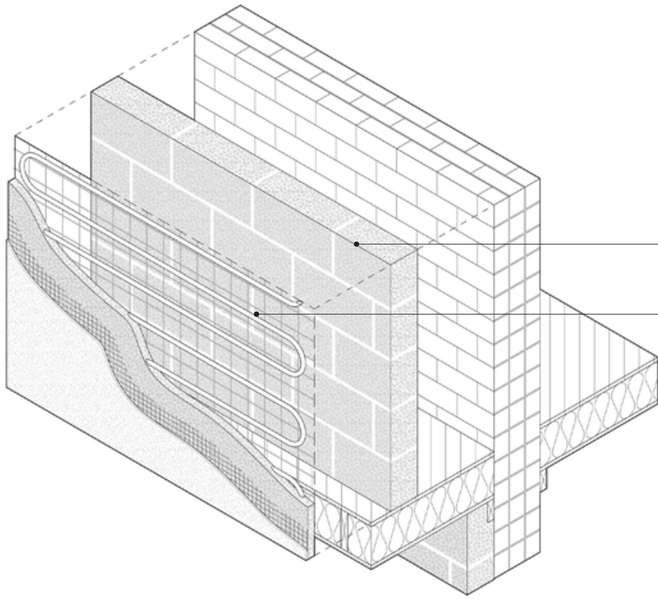
WOOD FIBER & BUSINESS-AS-USUAL ASSEMBLY



WOOD FIBER BATT Gutex Thermoflex R 4.0/in	-594 $kgCO_2e$
2x4 LUMBER	138 $kgCO_2e$
SHEET BARRIER Rothoblass Clima Control 80	72 $kgCO_2e$
DRYWALL 5/8” Type X ind. average	293 $kgCO_2e$
CLAY PLASTER site mixed, 9/16”	86 $kgCO_2e$
TOTAL CARBON STORED	**-5 $kgCO_2e$**

3

PARTY WALLS, & INTERIOR WALLS



HEMP BLOCKS 8" Isohemp R 2.0/in	-2,300 $kgCO_2e$
CLAY PLASTER site mixed, 1/2"	300 $kgCO_2e$
TOTAL CARBON STORED	-2,000 $kgCO_2e$

Party wall insulation with integrated wall heating and natural plaster as air barrier.

exterior walls will not only reduce energy cost, but can significantly improve indoor air quality (2). As part of a larger gut renovation (and a larger budget), additional carbon storage and indoor climate improvements can be made by choosing biobased materials also for insulation in floors, party walls and interior walls (3).

Biobased cavity insulation can be installed in the same way petrochemical products are installed –either as batts or blown material. They offer a cost-competitive one-to-one replacement.

Hemp blocks or panels and wood fiber boards on the other hand offer an opportunity to rethink and simplify wall assemblies. In combination with natural plasters, they create a vapor-open, but airtight wall using fewer layers than conventional wall assemblies. They improve indoor air quality, attenuate sound and can integrate wall heating systems within the plaster layer. In addition, hempcrete continues to absorb carbon during its life span due to the slow carbonization process of the lime increasing its carbon storage potential over time. Many European examples integrate wall heating systems, improving energy efficiency and indoor air quality even further.

As of this writing (Summer 2025), hemp blocks and wood fiber boards can be acquired through distributors based in the

HempBLOCK distributed through HempBLOCK USA based IN Lewes DE

Wood fiber batt manufactured by TimberHP in Maine.

region, but are not manufactured here. Future carbon storage potential of these materials can be improved significantly, if manufactured locally and distances between farm or forest and processing are short or raw material can be transported in bulk via rail or barge.

While the total carbon storage in one renovation might seem moderate, it should be noted that a business-as-usual approach that uses spray-foam insulation in roof cavities and mineral wool together with drywall, framing and sheet barriers for walls, would likely result in 3-5 metric tons of embodied carbon emitted cancelling out several years if not decades of savings in operational carbon, especially when combined with on-site renewables.

- Architects and homeowners must make

Cellulose, blow-in insulation material, widely available at hardware stores

Considerations for Architects, Homeowners and Policymakers

compromises between the maximum R-value, the thickness of the wall, and the loss of living space. Stringent energy codes that require high R-values do not account for the added benefit of thermal mass or the efficiency of lime plaster acting as an air barrier. Anecdotal evidence, however, suggests that energy efficiency (measured in reduced energy costs) is much better in hemp lime buildings than its pure R-value suggests.

- In addition, historic tax credit rules often limit the allowable wall thickness, forcing architects and homeowners to prioritize historic “looks” of buildings over traditional building materials and methods.

Wall heating on hemp blocks,
Image: Bausteinwerke Schöntaler

- Electrical conduits and outlets can be carved into the hempcrete or can run through a small gap between the existing wall and the hempcrete. This may require advanced planning and coordination with subcontractors, but eliminates the need for service cavities and additioanl drywall.
- Similarly, blocking can ensure that cabinets or heavy objects can be installed later.
- Hemp lime offers important additional indoor air quality benefits when combined with natural plaster. It also adds to the already existing thermal mass of a brick wall, which makes it particularly beneficial in the Northeast region, where temperature differences between night and day contribute to regulating comfort.
- While most hemp lime blocks in the US still have to go through further testing, some European products have a two-hour fire rating for party walls. Wood fiver boards have 90-minute fire rating.

According to a New York Times analysis in

Image: Terra 600, Burlington, VT designed and built by New Frameworks is a 600 sf ADU in the backyard of a single family home. Straw panels were prefabricated at New Frameworks' facilty and then transported and installed. Image Credit: New Frameworks

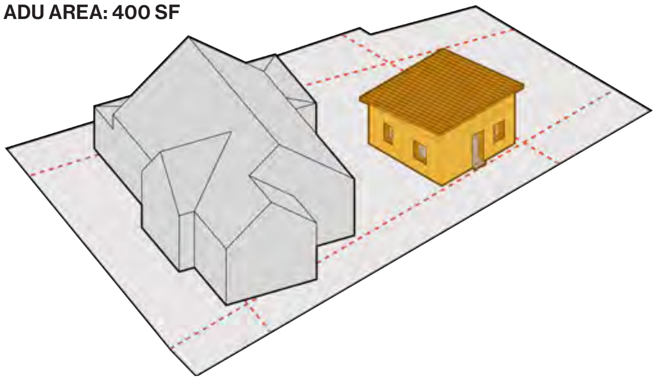
Prototype B Accesory Dwelling Unit

2019, 75% of the land in the US is zoned for residential use that allow only single-family detached dwellings.[6] This is seen as the greatest barrier to adding housing, and increasingly, jurisdictions across the US are encouraging the construction of accessory dwelling units (ADUs) in backyards, driveways, or as attachments to the primary unit as one possible way to address the housing and affordability crisis. There are several reasons why homeowners might choose to build ADUs, such as facilitating aging in place, accommodating multigenerational living, or generating extra household income. Market researchers predict that the global market for ADUs will double to $39 billion by 2033, with about 60% of that market share in the US.[7] California is currently leading this market, with approximately 23,000 new ADU permits approved annually.

Local regulations, including owner-occupancy requirements, off-street parking requirements, and conditional or discretionary reviews for ADU permits, are considered the greatest barriers to the proliferation of ADUs. Only 14 states have broadly legalized ADUs in an attempt to unify rules and set standards. Most importantly, these states have done this to prevent individual municipalities from banning ADU's as a strategy to increase the housing supply.[8]
In the Northeast, Vermont, Massachusetts, Connecticut, New Hampshire, Maine and Rhode Island have created ADU policies within the last five years, broadly legalizing ADUs. Massachusetts passed a pro-ADU law in 2025 and expects 8,000 to 10,000 ADUs to be built within the next five years.[9]
Local regulations still govern bulk, access, parking, and sprinkler requirements. In an attempt to help residents navigate these rules, the City of Boston has published an illustrated Accessory Dwelling Unit Guidebook.[10] New York City is working on similar assistance to homeowners after it passed its "City of Yes" zoning reform in 2024.[11] While currently, New York, New Jersey, Pennsylvania, and Maryland, states with some of the most severe housing challenges, have not passed state-wide laws superseding local regulations, many local jurisdictions in these states have regulations permitting them, and states are working on providing more streamlined governance and support.

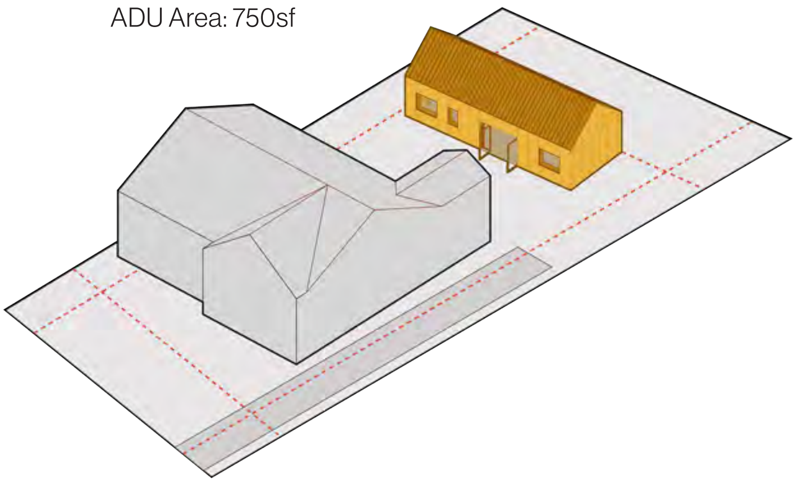
In this context we speculate that designers

LOT AREA: 7490 SF
ADU AREA: 400 SF



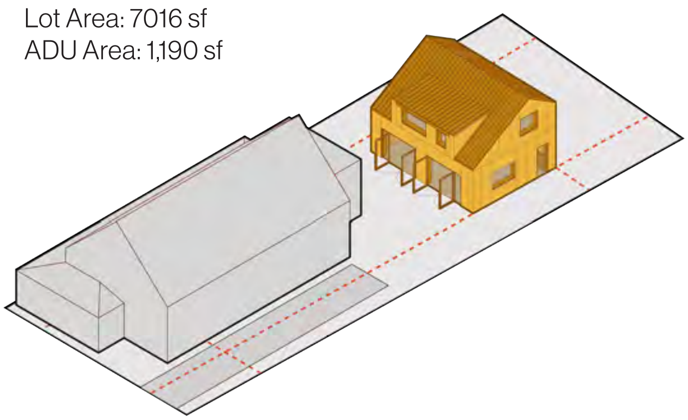
CARBON STORAGE: 6.3 METRIC TONS

Lot Area: 11664 sf
ADU Area: 750sf



CARBON STORAGE: 7.3 METRIC TONS

Lot Area: 7016 sf
ADU Area: 1,190 sf



CARBON STORAGE: 9.7 METRIC TONS

and builders working with biobased materials are well-positioned to occupy a large share of the prospective market in locations encouraging gentle population density increases through ADUs. 50% of ADUs globally are modular or prefabricated units. Similar to the previous example of townhouse renovations, ADUs are often not built by experienced developers and architects but by individual property owners who may have limited understanding of building codes and technical material performance. At the same time, these owners are likely to be very involved in decision-making and may have concerns about aesthetic, health, and cost factors, as well as disruptions to their own lives during the construction on their property. In order to accelerate the building of ADUs from biobased materials at scale, a catalogue of prefabricated panelized design options that simplify the building process can serve as a useful pathway.

New Frameworks, profiled in the previous chapters, already offers several models of "casitas," which are pre-designed and prefabricated in their workshop and then installed on site in a relatively short time frame.

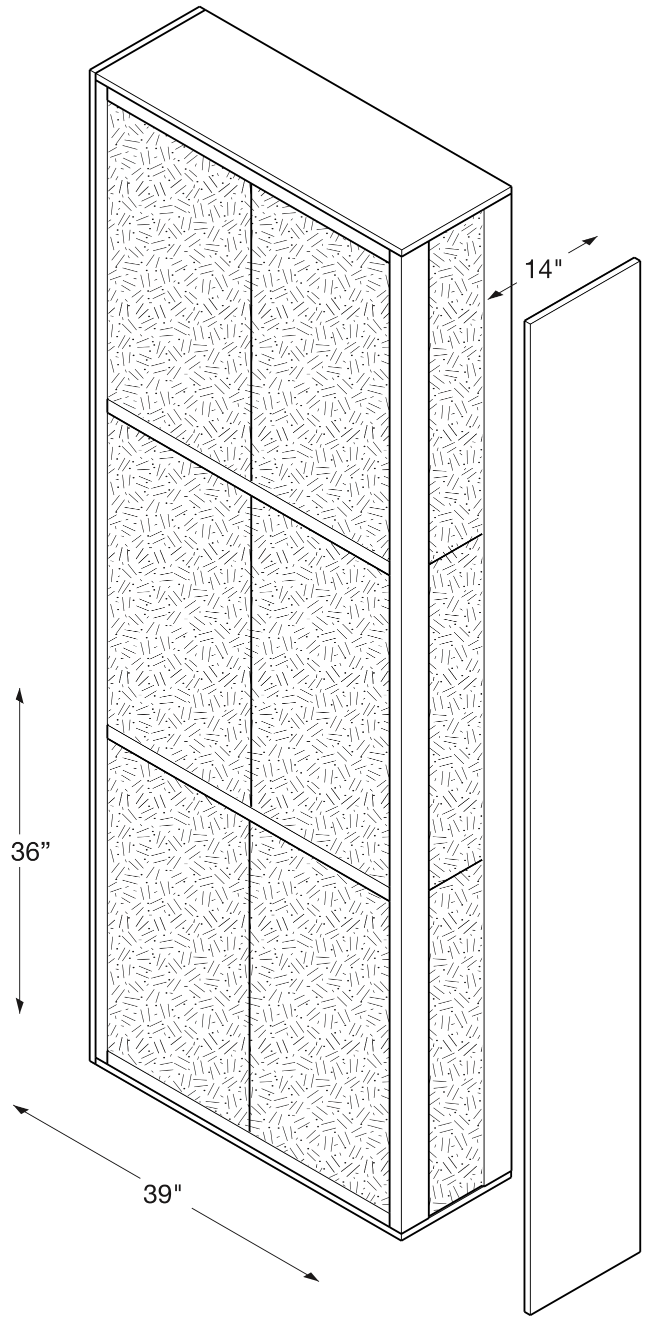
Image: Suburban fabric in Brookline, MA
Above: Sample lots of different size and geometry

Through New Frameworks' Seed Collaborative network, these designs can now also be supplied by a growing network of straw panel design-build firms across the Northeast region. Croft, a straw panel manufacturer based in Maine, offers "Croft Kits"[12], schematic designs at different scales that illustrate design and finish options for a prospective client. This kind of pre-design work is an upfront cost these manufacturers currently carry to motivate demand for their products. Expanding the catalogue of options for homeowners to choose from regarding size, shape, and cost can be a valuable way of scaling up demand and a call to action for architects to contribute possible design solutions.

Structural straw panels made by New Frameworks follow a simple design metric. Typically, they are two bales wide, one bale thick and a multiple of three feet high (The more bales can stay intact as they come out of the baler at the farm the better for compression strength). Cross bracing with 2x4 every 36 inches helps to keep the straw in place and also allows for future installment of cabinets or other heavy objects on the finished wall. Other manufacturers use different assemblies, but the basic premise to design around the size of the straw bale is similar and results in walls that are between 12 and 16 inches thick and panel sizes that can be easily transported and installed.

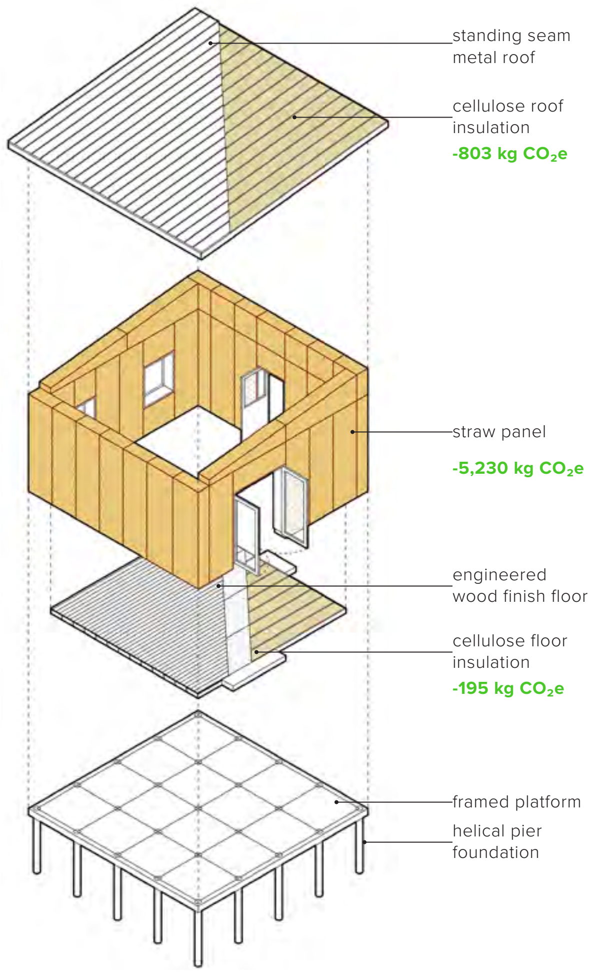
The three ADU versions in this chapter illustrate different size units that can be designed using these dimensional parameters as a foundation for design. As of this writing, only Ecococon, manufactured in Lithuania and imported to the Northeast by New York-based *Build with Nature* has a third party EPD that estimates its global warming potential at -7kg CO_2e per square foot for an R-35 wall that is 40cm (15.7"). New Frameworks estimates its own at -5kg CO_2 per square foot.

Image: Work table for straw panel fabrication at New Frameworks

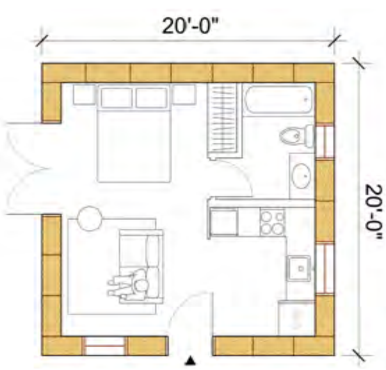


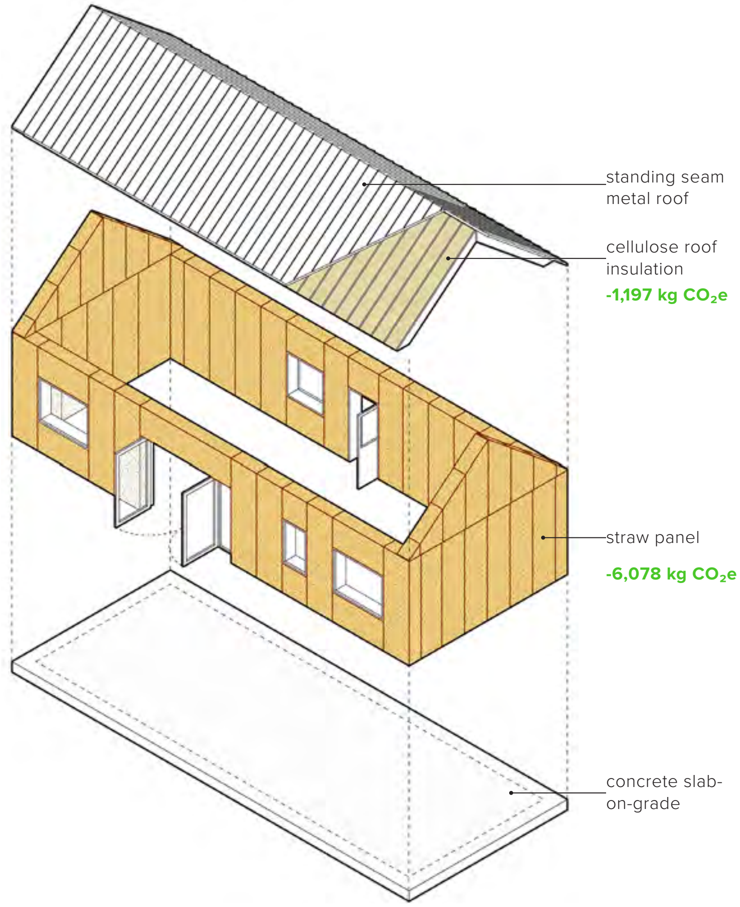
The prototypical lots represent sizes and geometries in Brookline, Massachusetts and conform with local regulations for minimum distances to lot lines, buildings as well as access requirements. These rules may vary throughout the Northeast.

The three versions illustrated here would store 6.3, 7.3 and 10 metric tons of carbon respectively in just the straw panel walls. Roof panels – constructed similarly– can be filled with dense pack wood fiber or cellulose to reduce weight and store an additional 1.5 to 2.2 metric tons. Net emissions – the complete A1-A3 emissions for each unit may vary based on finishes, foundations and additional materials chosen in the design of an ADU. As the examples on the following pages illustrate, when utilizing helical piers as foundation as an alternative to concrete, it is possible for the project to become a net carbon storage.
At the anticipated rate of 10,000 new ADU's units to be built in Massachusetts alone over the next five years these small additions to the existing residential fabric can store 100,000 metric tons of carbon, the equivalent of 20,000 homes' electricity use for one year.

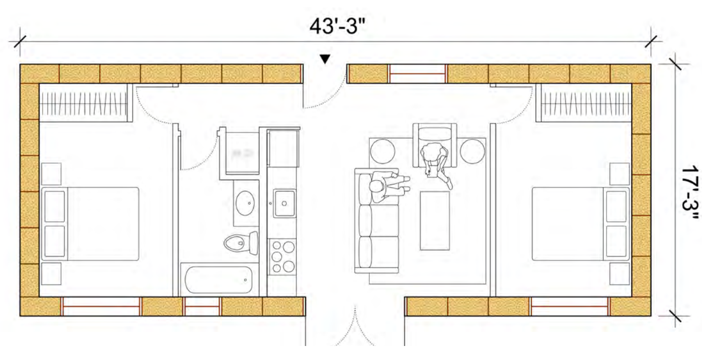


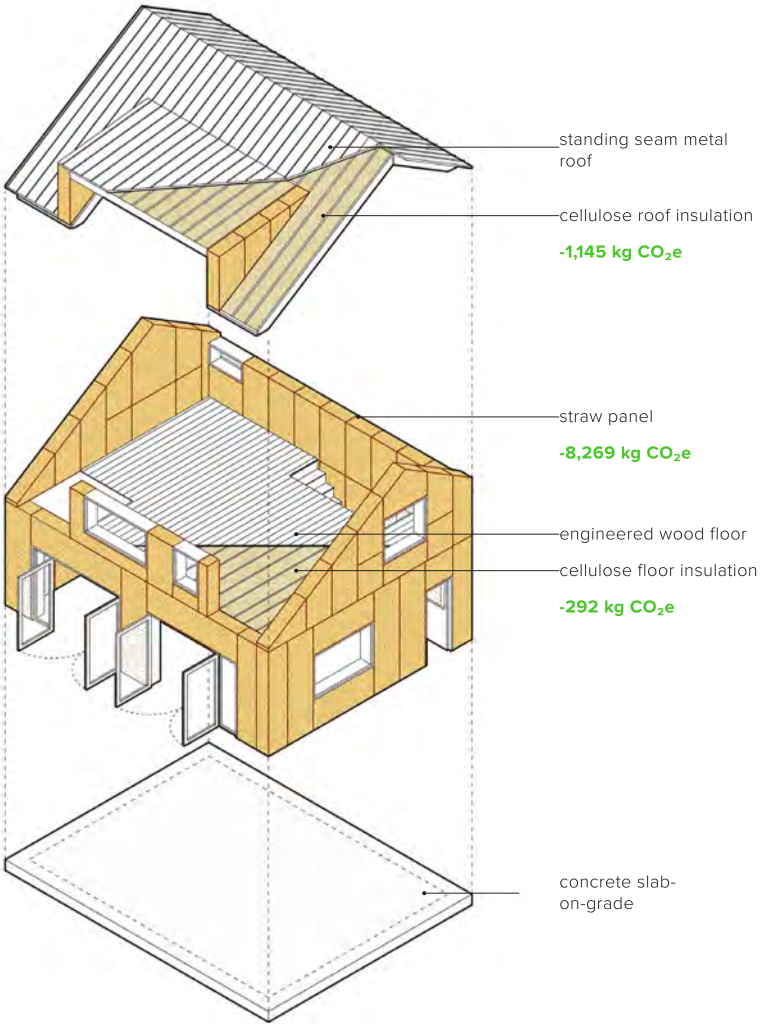
400 sf
1bed, 1 bath
-6,228 kg CO_2e



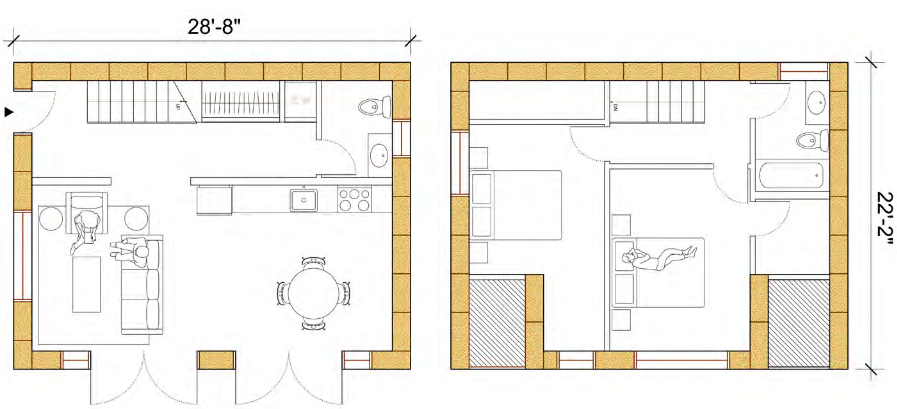


748 sf
2bed, 1 bath
-7,275 kg CO_2e





1190 sf
2bed, 2 bath
-9,706 kg CO_2e



Ecococon panels on site for install

Considerations for Architects, Homeowners and Policymakers

- The 14–18" thick walls present a challenge for small or narrow sites but also offer opportunities to utilize this depth for shading windows or creating deep window seats.

- Site access is often the greatest challenge. Developing designs made from panels that can be transported on hand trucks and installed with small equipment is vital to being able to widely utilize these prefabricated options.

- Pre-design is a significant cost that straw panel manufacturers invest in, but a relatively small and manageable design challenge for students and young architects. Developing design competitions that produce replicable solutions is one way that the architecture community and local governments can engage with the challenge of biobased ADUs.

- Similarly, partnerships between units of local government and not-for-profit organizations can promote the adoption of prefabricated biobased ADUs. New York State's Plus One[13] concept partners local governments with community developers to support low and middle-income households in the construction of ADUs. Providing a series of pre-design options using biobased materials could strengthen this program.

- Concrete foundations are responsible for the greatest amount of embodied emissions in residential construction. Minimizing this amount through the use of helical piers can result in a net-carbon negative project, meaning the building stores more carbon than was emitted during construction.

Scaling Carbon Storage

It should be noted that for the purpose of this report, we did not perform whole life cycle analysis, but instead focused on estimating the embodied carbon in certain building elements as a proxy for the amount of carbon stored. While zero carbon construction for an entire building is possible in some instances, here we are interested in the potential carbon storage in comparison to business-as-usual construction practices.
If we were to set a goal of storing a minimum of 10 metric tons of carbon in every new housing unit built, the 840,000 missing units in the Northeast would collectively store 8.4 million metric tons of carbon, the equivalent of what 8 million acres of forest sequester in a year.

Unless otherwise noted we used BEAM by Builders for Climate Action, a tool for estimating embodied carbon in small projects, for carbon storage potential calculations in each of the prototypes. Unlike other tools, BEAM includes Environmental Product Declarations (EPDs) and averages for biobased materials and developed a methodology for accounting for carbon storage. There is currently no standard process for accounting for carbon storage in life cycle assessments in North America.

At the end of its useful life, a product can be composted or burned as biofuel, and at this point, all stored carbon is released into the atmosphere again. For this reason, most life cycle assessments for biogenic materials consider this process a “wash”, also referred to as the 0/0 method or static LCA. BEAM, however, uses a dynamic LCA method, also referred to as -1/+1 accounting, where the biogenic carbon stored in the plant is counted as negative embodied carbon and calculated against emissions that occur in the manufacturing process. For most of the materials mentioned in this report, the biogenic carbon is greater than the A1–A3 emissions caused by producing the material. Biogenic carbon is recorded in two ways in this calculation tool. First, it should be noted that many European EPDs break down global warming potential (GWP) into three subsets:

- “GWP-fossil” refers to the GWP of fossil fuels,
- “GWP-biogenic” refers to the biogenic GWP, and
- “GWPluluc” = refers to the GWP of land use and land use change.

For many biogenic products, the combined GWP total is negative for the product stage A1–A3. This calculation often also includes the release of CO_2 from the disposal of packaging, even though this would only occur at stage A5 at the construction site. When such information is not available, BEAM uses the Phyllis Database, a database containing information on the composition of biomass, macro and micro-algae, and feedstocks for biogas production.[14] For many plants, 50% of their biomass is carbon. In other words, half of the weight of a straw bale is made up of carbon. To stay conservative, BEAM applies a 10% reduction across the board to this method of accounting.

Efforts are underway to develop Product Category Rules (PCR) to streamline the accounting method for biogenic carbon in agricultural fiber. This would allow third-party issuers of EPDs to account for biogenic carbon and include their EPDs in carbon accounting tools and would facilitate the development of EPDs for manufacturers of biobased products.

It should be noted that BEAM and other tools estimate embodied carbon. While they strive for accuracy, they should be valued for helping architects, builders, and policymakers make better-informed decisions rather than for their ability to produce exact numbers. Note also that none of the carbon storage or emission calculations in this chapter include A4 – Transportation to the construction site. Given that many of the materials mentioned are not yet available in the Northeast, it is worth reiterating that the mode of transportation is more important than the distance alone, as illustrated in Chapter 2. Products shipped from Europe on a container ship to the US East Coast are associated with lower transportation emissions than products trucked from the US Midwest to the Northeast region.

Notes

1 Makinizi Hoover, *The State of Housing in America*, US Chamber of Commerce, March 2025 www.uschamber.com/economy/the-state-of-housing-in-america, accessed July 2025

2 David Garcia, Anjali Kolachalam, Leah MacArthur, Michael Wilkerson, Ph.D. 2024 *Housing Underproduction in 2024*, Up for Growth, 2025

3 2024 International Residential Code Appendix BL https://codes.iccsafe.org/content/IRC2024P2/appendix-bl-hemp-lime-hempcrete-construction

4 2024 International Residential Code 104.11*Alternative materials, design and methods of construction, and equipment, https://codes.iccsafe.org/s/IEBC2021P1/* chapter-1-scope-and-administration/IEBC2021P1-Ch01-Sec104.11

5 Rebekah Morris and Jen Becker, *EnergyFit NYC Final Report*, Pratt Center for Community Development, 2018 https://prattcenter.net/uploads/0420/1587936953509575/Energyfit_Final_Report_for_web.pdf

6 Emily Badger and Quoctrung Bui, *Cities start to question an American Ideal: A House with a Yard on every Lot*, New York Times, 2019 https://www.nytimes.com/interactive/2019/06/18/upshot/cities-across-america-question-single-family-zoning.html

7 Global Growth Insights, *Accessory Dwelling Unit (ADU) Market*, June 2025 https://www.globalgrowthinsights.com/market-reports/accessory-dwelling-unit-adu-market-102182

8 Emily Hamilton and Abigail Houseal, *A Taxonomy of Accessory Dwelling Unit Laws 2024*, Mercatus Center Housing Policy Briefs 2024 https://www.mercatus.org/research/policy-briefs/taxonomy-state-accessory-dwelling-unit-laws-2024

9 *Massachusetts Healthy Aging Collaborative News* February 2025 https://mahealthyagingcollaborative.org/accessory-dwelling-units-officially-allowed-statewide/

10 City of Boston, *Accessory Dwelling Unit Guidebook*, 2025, https://www.boston.gov/departments/housing/accessory-dwelling-units-adus-boston

11 City of New York ADU for You Program, launched Summer 2025 https://www.nyc.gov/site/hpd/services-and-information/adu-for-you.page

12 https://www.croft.haus/croft-kits

13 New York State Homes and Community Renewal Plus One ADU program https://hcr.ny.gov/adu

14 Phyllis2, database for (treated) biomass, algae, feedstocks for biogas production and biochar, TNO Biobased and Circular Technologies https://phyllis.nl/

Image: Townhouse retrofit in Brooklyn NY using biobased materials for the envelope. Design vonDalwig with youarethecity, Image: Alan Tancey