RMI

Building with Biomass: A New American Harvest

How manufacturing building products from domestically sourced upcycled biomass can create more jobs and affordable healthy housing

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Authors and Acknowledgments

Authors

Aurimas Bukauskas
Tracy Huynh
Chris Magwood
Victor Olgyay

Authors listed in alphabetical order. All authors from RMI unless otherwise noted.

Additional Contributors

Adeline Leung, RMI Intern, 2024

Contacts

Victor Olgyay, volgyay@rmi.org
Chris Magwood, cmagwood@rmi.org

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About RMI

RMI is an independent nonprofit, founded in 1982 as Rocky Mountain Institute, that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and NGOs to identify and scale energy system interventions that will cut climate pollution at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; Abuja, Nigeria; and Beijing.

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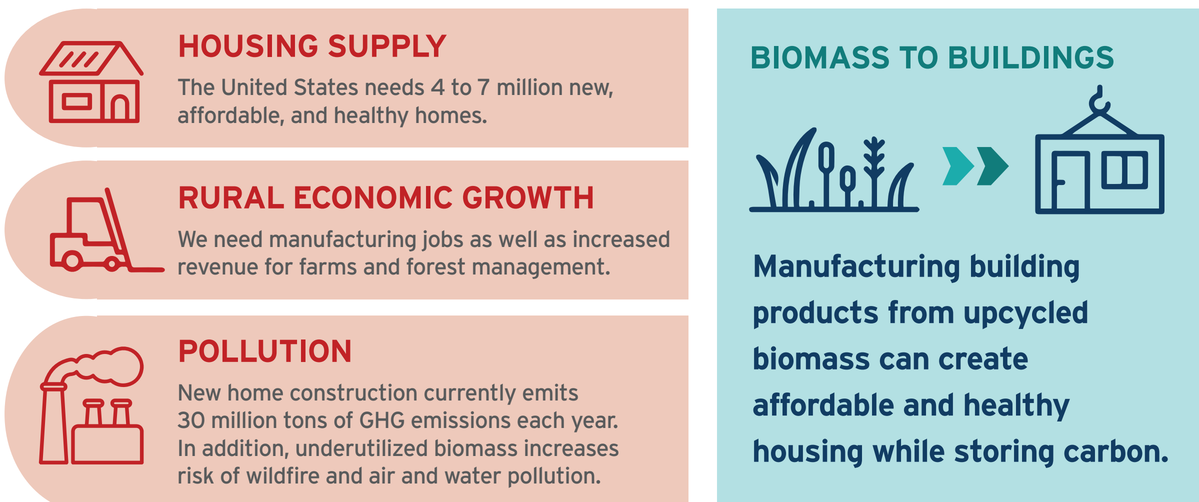
Executive Summary

There is widespread agreement that the United States needs significantly more healthy affordable housing, higher-quality jobs, and clean air, water, and soils. A worsening and unpredictable climate compounds these issues and demands immediate action to reduce emissions and remove carbon dioxide from the atmosphere. What if we could help solve all of these issues at once? This study explores a cross-cutting solution with surprising effectiveness and scale: **manufacturing building products from upcycled biomass to turn undervalued by-products into valuable carbon-storing products for home builders across the United States.**

Exhibit 1 Biomass to buildings, a cross-cutting solution



RMI Graphic. Source: RMI Analysis

Upcycled biomass — what we call the **"new American harvest"** — can durably store millions of tons of carbon, meet growing housing demand, and boost local economies by transforming low-value biomass into valuable, sustainable building products.

Exhibit 2 Key Elements of the New American Harvest

1. **PAY FARMERS, FORESTERS,** recyclers, and waste handlers for bio-based residues that are undervalued and underused.
2. **USE BIO-BASED FEEDSTOCKS** to manufacture a wide range of healthy building products, such as insulation, flooring, cladding, and partitions.
3. **SCALE UP THE MANUFACTURING** of building materials to support increases in affordable housing stock and job creation across the country.
4. **AVERT MILLIONS OF TONS** of embodied carbon emissions from new home construction and durably store millions of tons of carbon in bio-based building products.

RMI Graphic. Source: RMI Analysis

Building products made from upcycled biomass are already being commercially manufactured in the United States and, to a greater extent, in other parts of the world. The market readiness of these bio-based building products far exceeds the market and technological readiness of typical carbon dioxide removal (CDR) solutions; and both large production builders and custom home builders are eager to use these products. Since 2024, more than 50 US builder companies and nearly 100 Home Energy Rating System (HERS) raters and consultants, as well as more than 250 individuals have joined RMI's **HomebuildersCAN** program with the explicit intent to tackle embodied carbon — the emissions associated with the life cycle of buildings and their materials.

Key Findings

This report details our methodology and findings, showing how the multilayered benefits of upcycled biomass can drive broad support and market uptake — from home builders, manufacturers, and waste handlers to farmers, foresters, and policymakers. It offers comprehensive solutions, backed by high-level quantification, to inspire a roadmap for scaling this new American harvest.

Exhibit 3 By upcycling underused biomass into building products, by 2050:

100M metric tons of CO_2e could be stored profitably in new residential buildings over the next 25 years in a low-adoption scenario.

$79B of new domestic manufacturing opportunities could be created, generating 42,000 new jobs in domestic manufacturing industries.

400M tons of underused biomass from our farms, forests, and landfills could be converted into healthy, affordable products to supply growing housing demand.

RMI Graphic. Source: RMI Analysis

Introduction: An Economic and Climate Revolution

Photo courtesy Bensonwood

The United States is facing a housing shortage, a push for new manufacturing jobs, and the urgent need to cut greenhouse gas (GHG) emissions. This report highlights a rare triple-win solution to tackle all three areas: Upcycling the millions of tons of undervalued biomass into affordable and climate-smart building products. Our analysis quantifies the benefits of this strategy and explains the necessary steps to unlock substantial progress to provide affordable and healthy materials for millions of new homes.

Capitalizing on this opportunity requires us to draw links between four well-understood action areas that have not previously been seen as connected:

- Reducing the 55 million tons of embodied carbon emissions generated annually from the construction of new homes to meet US climate targets[1]
- Encouraging an American manufacturing renaissance to drive local economies and good jobs — especially in rural areas[2] — and establishing strong regional supply chains to support increased residential construction
- Unleashing innovative solutions to confront the shortage of homes in the United States, with estimated deficits ranging from 1.5 to 7.3 million units[3]
- Finding a productive use for the 1.1 billion tons of underused biomass produced in the United States every year, which has little or no current market value and some of which poses significant environmental hazards[4]

If we were to align these needs and opportunities, the benefits could be immense. To determine the scale of the positive impacts we combined three distinct analyses:

1. **Life-cycle analysis** (LCA) of new home construction with conventional and bio-based building products to understand the scale of positive climate outcomes for US homes.
2. **Economic analysis** of the amount of new manufacturing capacity required to meet the needs of increasing use of bio-based building products and the associated jobs and economic growth.
3. **Quantity analysis** of available low-value biomass produced in the United States to understand the types and volumes of feedstocks available to support production of bio-based building products.

In this report, we present case studies of affordable new homes built with the types of biomaterials featured in our modeling alongside examples of recently established manufacturing facilities for such products across the United States.

Additionally, the team surveyed the impacts of this approach on several co-benefits that may speed up adoption of bio-based building products, including:

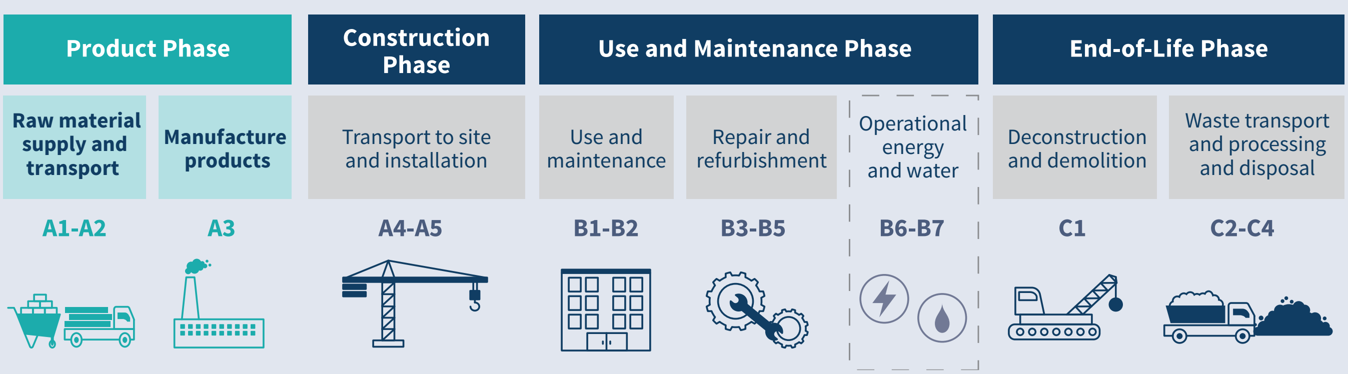
- More new affordable homes built with bio-based building products
- Health benefits of new homes built with bio-based building products
- Reduced waste burdens from use of undervalued biomass

By providing a reasonable estimate of the positive effects of transitioning toward greater use of bio-based building products, we hope to inspire further research and action to bring about this “new American harvest.”

Box 1 **What is embodied carbon?**

The term *embodied carbon* refers to the greenhouse gas emissions that arise over the life cycle of a product or building, from initial harvesting of raw materials through manufacturing, transportation, installation, use, and disposal. Quantification of embodied carbon is achieved through a life-cycle analysis (LCA) conducted according to international standards.[5] For this study, we analyze the embodied carbon and biogenic carbon storage arising during the product phase (life cycle modules A1-A3).

Exhibit 4 **Embodied carbon across a product or building life cycle**



RMI Graphic. Source: RMI Analysis

Climate Impacts of Bio-Based Products in Housing

Efforts are underway across the US construction industry to measure and reduce embodied carbon in buildings. Initial estimates put embodied carbon from new low-rise home construction between 55 and 80 million tons (Mt) annually,[6] equivalent to the entire economies of nations like Norway (42 Mt), Hungary (51 Mt), and Austria (66 Mt).[7] One leading way to reduce embodied carbon is to use bio-based building products that store more carbon in their raw materials than is emitted in manufacturing the product, resulting in carbon storage over the functional lifespan of the product.[8] Carbon stored in durable, long-lasting building products can reduce the amount of carbon dioxide in the atmosphere and the associated overheating of the planet[9] (see Box 4: *Valuing Durable Carbon Storage in Building Products*).

Bio-based building products

In this study, we analyze the embodied carbon impact of substituting typical building products with bio-based products. Four criteria guided the selection of products used in the model homes:

1. Products must be currently available in a major market.

2. Products must meet applicable prescriptive and/or performance requirements in the current version of the International Residential Code. Examples of buildings using the product must exist in a jurisdiction with modern building codes (the United States, Canada, EU, UK, or Australia).

3. Third-party verified Environmental Product Declarations (EPDs) must exist for products used in this study. EPD data on global warming potential (GWP) is used to estimate emissions and carbon storage.

4. Products must use biomass feedstocks that are currently available at scale and underutilized in the United States (see *Biomass Feedstock Availability*).

These selection criteria led to the inclusion of a wide range of bio-based building products in our models. Incumbent products such as cellulose insulation and linoleum flooring are applied alongside products with significant historical precedent (such as straw, flax, hemp, and reeds) and a variety of recycled fibers including cardboard, paper, and textile waste (see Exhibit 5).

Exhibit 5 **Products for model buildings by assembly**

BUILDING ASSEMBLY	CONVENTIONAL PRODUCT TYPES	BIO-BASED PRODUCT TYPES WITH EPDs	BIO-BASED PRODUCT TYPES WITH NO EPDs
Foundation	• Typical concrete	• Biochar concrete aggregate	• Microalgae cement • Net shell aggregate • Mineralized bio-aggregate
Cavity insulation (exterior walls, roof and floor)	• Fiberglass batt	• Cellulose batt • Wood fiber batt • Hemp fiber batt • Grass batt • Hempcrete • Straw	• Mycelium insulation • Seaweed batt • Flax fiber batt • Sheep wool batt • Rice hull insulation
Flooring	• Rigid core vinyl flooring (LVT) • Ceramic tile	• Bio-based carpet • Engineered wood* • Linoleum (liquid applied) • Hempwood	• Mycelium tiles • Bio-cement tiles
Structural sheathing (walls, roof)	• Oriented strand board (OSB)	• Gypsum/cellulose panels • Recycled drinking box panels • Straw board panels • Paper sludge panels	• Reed grass board • Corn board • Wood wool board
Continuous insulation (exterior walls)	• EPS foam board	• Wood fiber board • Compressed straw board	• Hemp fiber board • Corn stover board • Eelgrass board • Hempcrete board
Exterior wall cladding	• Brick • Fiber cement	• Engineered wood • Fiber cement	• Seaweed brick • Mineralized bio-aggregate
Interior partitions	• Wood stud framing • Drywall (gypsum board)	• Recycled cardboard studs • Compressed straw board	• Corn cob board • Clay fiber board • Hemp board • Flax core panels
Interior finishes (walls and ceilings)	• Drywall (gypsum board)	• Straw board panels • Paper sludge panels	• Eelgrass board • Wood wool board • Corn cob board • Clay fiber board

* RMI's selection of timber-based products is limited to engineered wood floor and cladding based on our decision to only include timber feedstocks available from forest thinning (removed to reduce the likelihood of forest fires) and urban tree removal. See Box 3: Why Not Include Wood Framing and Sheathing for more details. As much of this timber feedstock is not composed of large-diameter, straight trees we predict the most likely use for this wood fiber is in products that use chipped or shredded fiber. It is possible that a wider variety of products could be made from this feedstock (see Timber Age case study) which could add to the carbon storage benefits we estimate.

Many available bio-based building products met three of the four selection criteria for inclusion but were not included in the analysis because they lacked valid EPD data to enable quantification of emissions and storage potential. Exhibit 5 includes a column for bio-based products without EPDs to show the broader variety of product types being manufactured today. While not exhaustive, this list of alternatives is included to demonstrate that the range of bio-based products extends well beyond those evaluated in this study, pointing to a larger pool of both feedstocks (see Exhibit 17) and product types and suggesting that the results of this study could be conservative.

We also excluded products for which the feedstocks are not grown in sufficient quantity in the United States, such as cork and bamboo, though these types of products are currently imported into the United States and could further enhance the results.

A wide range of bio-based building products are already being commercially manufactured in the United States and, to a greater extent, in other parts of the world. The technology and manufacturing know-how to achieve a bio-based transformation in construction products is largely market ready today. This degree of technological readiness sets this proposal apart from most carbon dioxide removal (CDR) solutions, which often require further development before reaching the market.

Model buildings

This report focuses on new single-family home construction because this building type represents more than 60% of all newly constructed floor area in the United States.[10] Single-family homes have long provided innovative manufacturers with a lower-risk entry point into the market, as custom home builders are often open to experimenting with new products, which can then be market-validated and more widely adopted. Many of the bio-based products in this study are following that path, but if they were also used in multi-family housing and low-rise commercial construction, their impact could be even greater than our estimates.

Forty single-family house models were created in the Building Emissions Accounting for Materials (BEAM) life-cycle assessment software,[11] using the geometry and specifications from the US Department of Energy's (DOE) Prototype Building Models single-family detached base prototype.[12] The DOE Prototype Building Model is a two-story home of 2,382 ft^2 (221.3 m^2) of conditioned floor area. For consistency, the one- and three-story models were created with the same total conditioned floor area. See Appendix A for a complete list of models.

We modeled two versions of each of the 40 house types:

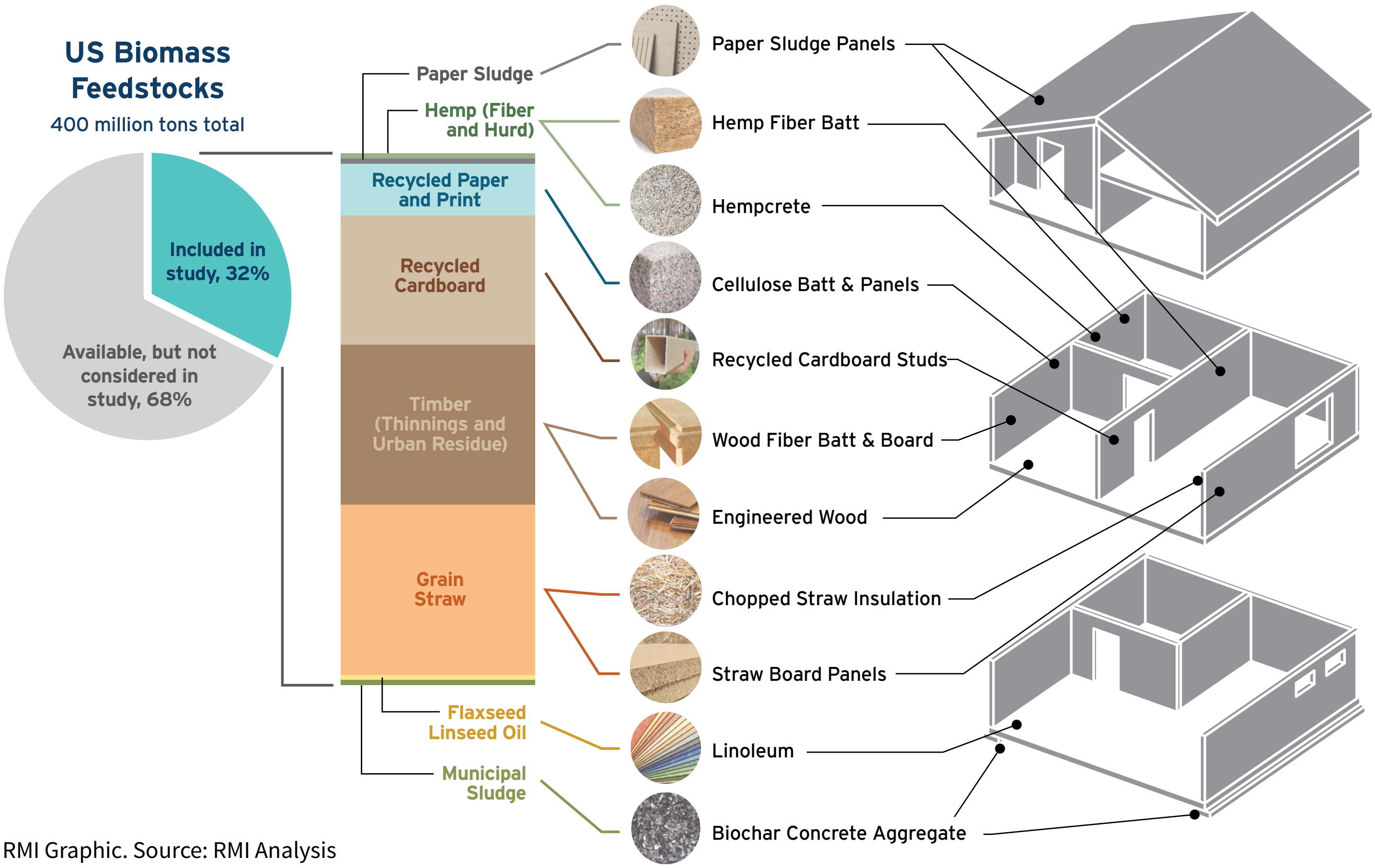
1. A business-as-usual baseline, using a typical selection of building products (see Exhibit 5)

2. A version using a mix of building products with net carbon storage in life cycle modules A1-A3 (where biogenic carbon contained in the product is greater than the emissions generated to create the product) according to the BEAM tool (see Exhibit 5 and the Box 4: *Valuing Durable Carbon Storage in Building Products*).

All product substitutions were based on meeting comparable performance requirements such as thermal value and structural capacity.

Exhibit 6 **Types of building products from biomass feedstocks**

Biomass feedstock quantities, the products derived from them and the placement of products in a typical home.



RMI Graphic. Source: RMI Analysis

For each BEAM model, results were calculated for total gross emissions and total net storage. Additionally, gross emissions and net emissions were divided by the conditioned floor area to create an embodied carbon intensity result. Results from individual models were proportionally weighted according to the percentage of the total data set represented by each model when calculating totals.

Box 2 **Can a real house be built this way?**

Zero House by Endeavour Centre is one of many real-world examples that validate the potential of constructing homes with a high proportion of bio-based products.[13] This home used six of the bio-based product types included in this study (cellulose, hemp and straw insulation, recycled drinking box sheathing panels, wood fiberboard continuous insulation, and engineered wood flooring) and two additional bio-based products (cork flooring and continuous insulation). A BEAM model for the house estimates 15,977 kg carbon dioxide equivalent (CO_2e) gross emissions and 14,067 kg CO_2 net storage.[i] The net emission intensity is 5 lb CO_2e/ft^2 of conditioned floor area, a reduction of 85% from this study's baseline model and close to the level of performance of our speculative carbon-storing model. This level of carbon storage in a code-compliant home today is encouraging evidence that these products are feasible options.

The project was built to meet net-zero energy requirements, ensuring that its carbon footprint from operational energy is minimized along with its embodied carbon.

Zero House also addresses one of the key concerns regarding temporary carbon storage in buildings: What happens to stored carbon at the end of the lifespan of a product or home? The project developers used a design-for-disassembly strategy enabling every component of the building to be removed and reused rather than disposed into a landfill and re-releasing carbon. Building for disassembly can greatly extend the period over which carbon is stored.





Zero House incorporates eight of the bio-based products identified in Exhibit 5 to achieve a net embodied carbon that is close to the results of the models in this report. Courtesy of Endeavour Centre.

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i We calculate all greenhouse gas emissions from a residence in units of carbon dioxide equivalent (CO_2e). However, only carbon dioxide (CO_2) is absorbed and stored by plants.

Climate impact results

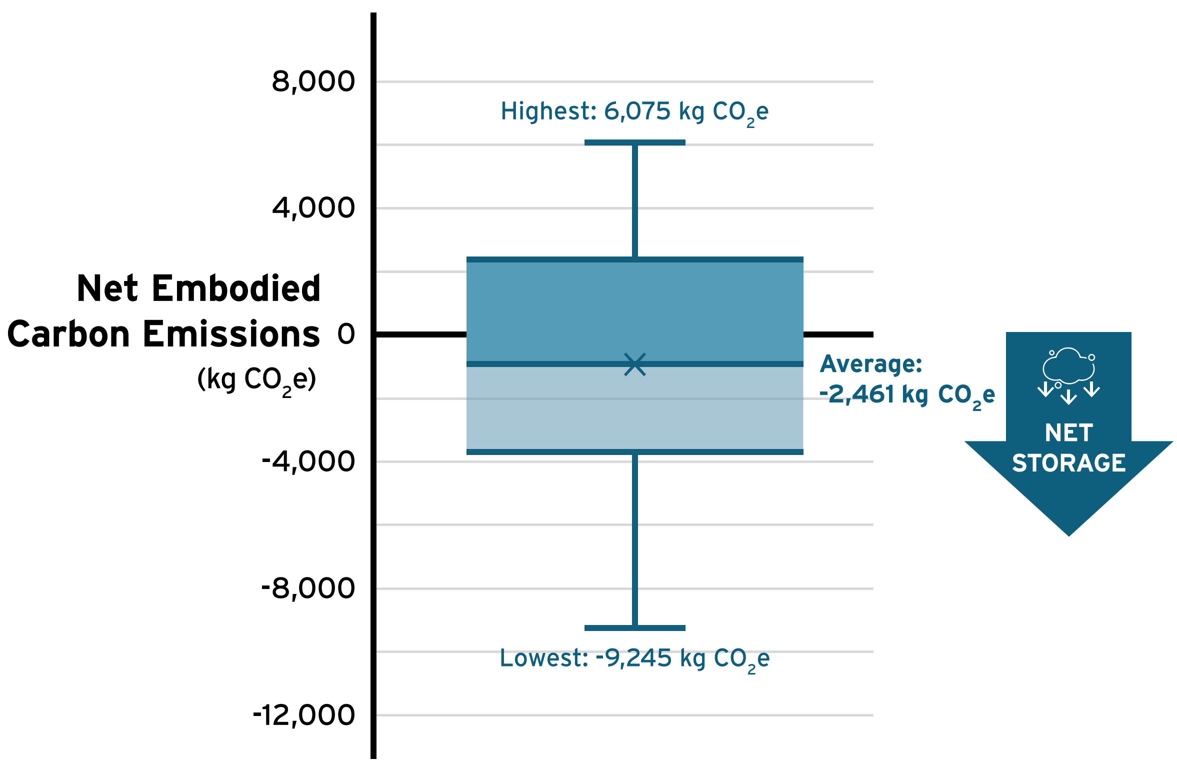
There is a meaningful difference between the business-as-usual and carbon-storing models, with the average gross embodied carbon emissions differing by 6%, with BAU at 36,220 kg CO_2e (79,850 lb CO_2e) and carbon-storing at 34,100 kg CO_2e (75,180 lb CO_2e).

Taking carbon storage into account, the difference becomes profound. The average for the carbon-storing models shows a 107% reduction in net emissions, tipping the models into net storage territory at –2,461 kg CO_2e (-5,425 lb CO_2e).

These whole-building results are divided by the conditioned floor area of each model to produce an emissions intensity. The average intensity of BAU homes is 178 kg CO_2e/m^2 (33.5 lb CO_2e/ft^2) compared to the average negative intensity of the carbon-storing models at –2.5 kg CO_2e/m^2 (-0.5 lb/ft^2).

On average, taking carbon storage into account (which leads to negative emissions), carbon-storing models reduce embodied carbon by 107% over business-as-usual models.

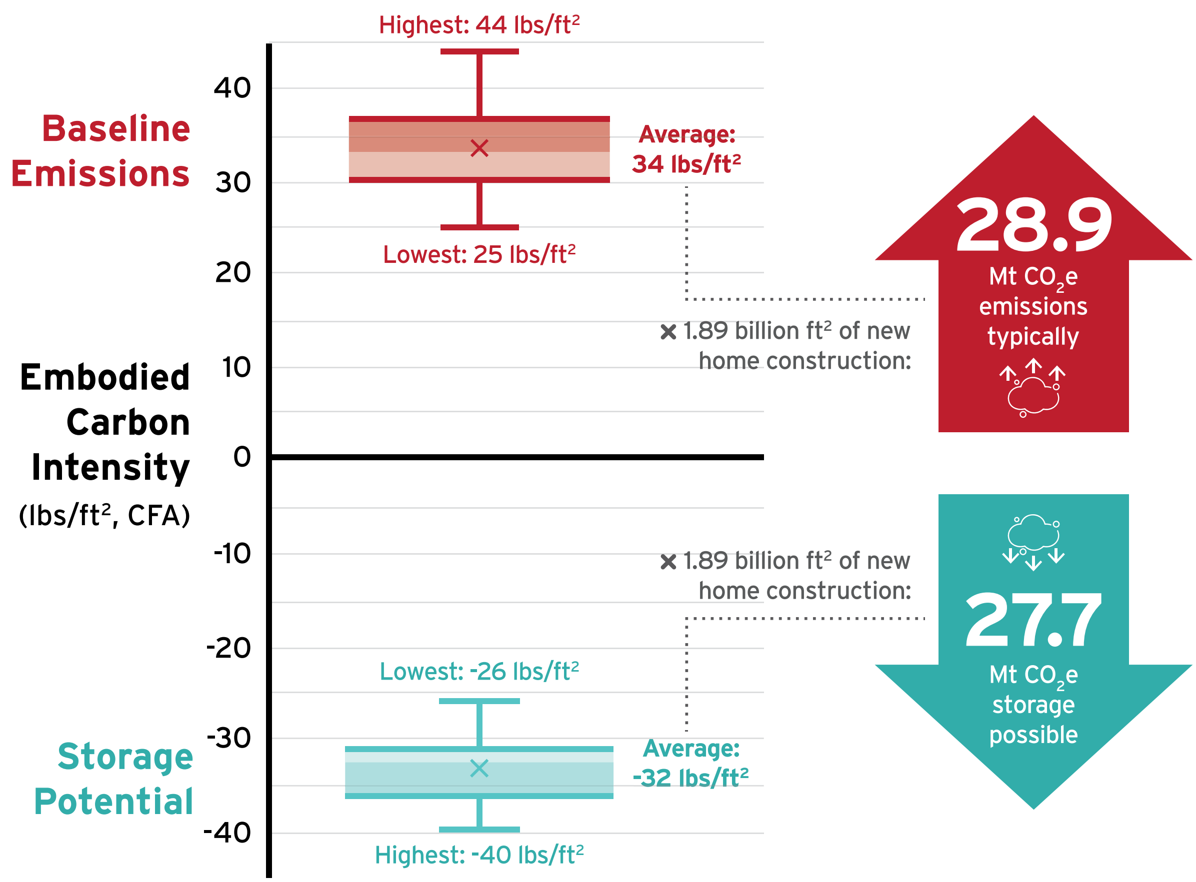
Exhibit 7 Net embodied carbon emissions from carbon-storing models



RMI Graphic. Source: RMI Analysis

To approximate the embodied emissions and storage impacts across all new home construction, the weighted intensity results were multiplied by the estimated 1.9 billion square feet of new home construction in 2023.[14] For the baseline results, that would equate to 28.9 million tons (Mt) of CO_2e emissions. For the carbon-storing results, 27.7 Mt of net novel carbon dioxide removal would occur from the use of bio-based building products. A net total of 0.44 Mt of CO_2 could be stored across all new home construction annually, suggesting a feasible pathway for the homebuilding sector to reach carbon neutrality.

Exhibit 8 Total emissions results from baseline models and total storage results from carbon-storing models



RMI Graphic. Source: RMI Analysis

Impact by material type/category

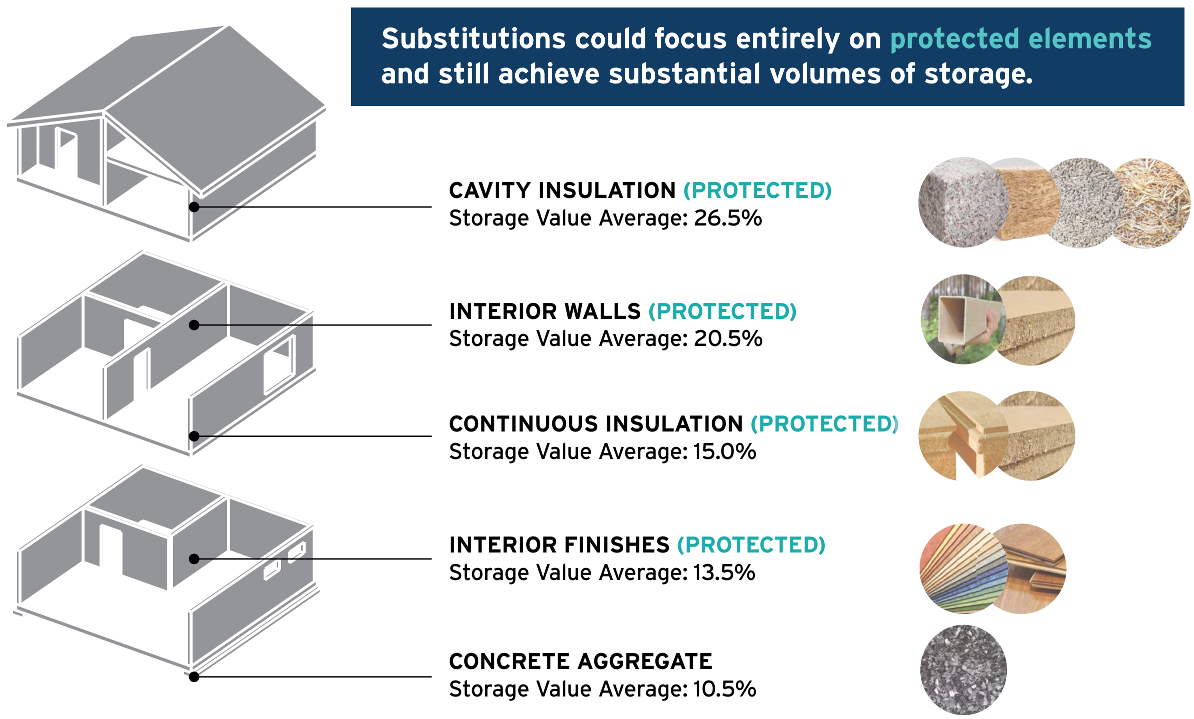
The model buildings used to assess carbon storage potential include a variety of carbon-storing products used as insulation, cladding, flooring, concrete aggregate, interior partitions, and wall and ceiling finishes. Cavity insulation for walls and roofs represents the largest storage opportunity with 26.5% of the overall storage potential.

Nearly three-quarters (74.5%) of all the storage potential comes from products that are used inside the building's primary enclosure, where they are protected from outdoor environmental conditions. This is important to note as the durability of bio-based products when subjected to moisture and temperature fluctuations remains one of the leading concerns about this type of product substitution. These results indicate that substitutions could focus entirely on protected elements and still achieve substantial volumes of storage.

The fact that many of the bio-based products with significant net carbon storage are "hidden" in the house means that homeowner expectations regarding aesthetic implications need not impact decisions to use these types of products.

Exhibit 9

Average percentage of a building's overall storage potential from different product categories



RMI Graphic. Source: RMI Analysis

Projecting the growth of bio-based building products

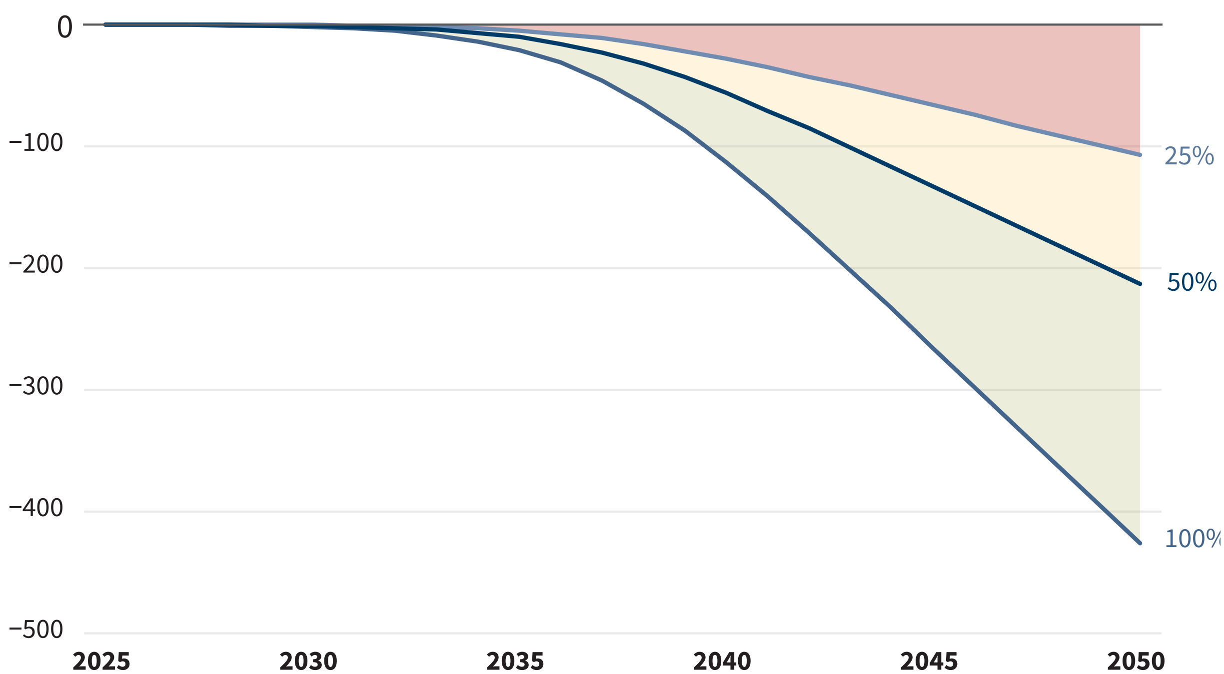
The results in this report assume 100% adoption of a wide range of bio-based building products. However, market penetration of bio-based building products is very low today and would need to accelerate substantially to reach the levels of carbon storage we have projected. To examine how our models might play out, we examined three adoption scenarios: 25%, 50%, and 100% adoption of bio-based products by 2050. Adoption was modeled assuming that a given percentage of new residential floor area is assigned the average embodied carbon and carbon storage of all bio-based home models studied in this report, weighted by their proportion of floor area in current annual new US single-family home construction.

Adoption was modeled using a logistic growth equation (**or S-Curve** — see Appendix D) to reflect the fact that industry-wide technology adoption typically proceeds non-linearly. Adoption is slowed initially by market forces, such as economies of scale, lobbying power, and complementary technologies that disproportionately advantage market incumbents. As these challenges are overcome and these benefits accrue instead to new innovations, adoption can grow rapidly, ultimately slowing as markets become saturated with the new technology. In each scenario, adoption grows from near 0% in 2025 to roughly 12.5%, 25%, or 50% in 2037 (the midpoint year) and 25%, 50%, or 100% in 2050.

Using these three adoption scenarios, we calculated the cumulative carbon storage that could be achieved between now and 2050. Even in the most pessimistic scenario, a total of roughly 100 Mt of carbon could be stored in new residential buildings over the next 25 years. This would be over 160 times the amount of carbon dioxide removal achieved in the market to date.[ii]

Exhibit 10 Cumulative carbon storage

Cumulative carbon storage associated with 25%, 50%, and 100% bio-based material adoption scenarios, in millions of tons of carbon dioxide-equivalent.



RMI Graphic. Source: RMI Analysis

If uptake of bio-based building products were to reach 50%, over 200 million tons of emissions could be stored by 2050. **At the current market price for CDR from biomass, which ranges from $92–$111 per ton, this could translate to a potential financial value of $18.4–$22.2 billion.**[iii]

ii From CDR.fyi assessment of 640 kilotons of carbon dioxide removals sold and delivered on March 10, 2025, **https://www.cdr.fyi/**.

iii Average selling price of CDR worldwide in 2022 and 2023, by method, March 10, 2025, **https://www.statista.com/statistics/1415800/carbon-removal-prices-by-method-worldwide/**.

Product cost implications

Cost impacts are a leading concern with a shift to new construction technologies and products. A transition to more bio-based building products is unlikely to succeed if it drives up costs at a time when housing affordability is a leading concern.

A comparison of costs for conventional products and the bio-based replacements shows that many bio-based products are at or near cost parity today, despite most of these products not yet having reached the economies of scale of the incumbent products.

Exhibit 11 Cost comparison of conventional and bio-based building products

BUILDING ASSEMBLY	CONVENTIONAL PRODUCT TYPES	COST*	BIO-BASED PRODUCT TYPES	COST†
Cavity insulation (exterior walls, roof and floor)	Fiberglass batt	$1.06/ft^2 @ R19	**Cellulose batt**	**$2.11/ft^2 @ R20**
	Mineral wool batt	$2.18/ft^2 @ R21	**Wood fiber batt**	**$1.73/ft^2 @ R20**
			Hemp fiber batt	**$1.79/ft^2 @ R20**
			Grass batt	N/A
			Hempcrete	N/A
			Straw (chopped)	**$2.11/ft^2 @ R20**
Flooring	Rigid core vinyl flooring	$1.99–3.79/ft^2	**Bio-based carpet**	**$1.28–2.66/ft^2**
	Ceramic tile	$0.89–11.14/ft^2	**Engineered wood**	**$2.84–5.49/ft^2**
			Linoleum (liquid applied)	N/A
			Hempwood	$5.99–11.99/ft^2
Structural sheathing (walls, roof)	Oriented strand board (OSB)	$0.44–1.17/ft^2 @ 7/16″	**Gypsum/ cellulose panels**	**$1.27/ft^2‡ @ ½″**
			Recycled drinking box panels	N/A
			Straw board panels	**$0.55/ft^2‡ @ 19/32″**
			Paper sludge panels	$5.85/ft^2‡ @ ½″
Continuous insulation (exterior walls)	EPS foam board	$0.70–1.01/ft^2 @ R5	**Wood fiber board**	**$1.22/ft^2 @ R5**
	XPS foam board	$1.09/ft^2 @ R5	Compressed straw board	$2.29/ft^2‡ @ R5
Exterior wall cladding	Brick	$3.33–$5.22/ft^2	**Engineered wood**	**$2.74–4.30/ft^2**
Interior partitions	Wood stud framing	$0.38/ft	Recycled cardboard studs	N/A
Interior finishes (walls and ceilings)	Drywall (gypsum board)	$0.49–0.53/ft^2	**Straw board panels**	**$0.55/ft^2‡ @ 19/32″**
			Paper sludge panels	$5.85/ft^2‡ @ ½″

Green is comparable cost. Yellow is less than 20% cost increase.

Notes: * Average product cost comes from building supply websites.
† Product cost comes from distributor websites and/or is supplied by product manufacturers.
‡ Price is converted to US dollars from currency in country of production.

In every product category there is at least one bio-based option that is at or near cost parity with incumbent products, suggesting that a home designed to maximize US-manufactured bio-based building products could be built without increasing the cost.

Installation costs were not considered because the selected bio-based products have similar installation requirements to the mainstream incumbents, suggesting that labor costs and the need for additional training should not be a critical cost factor.

The range of products included in this study do not represent the full cost of construction for new homes. Although the use of these products will not necessarily drive up the cost of housing, neither will they lower it. Assuming relatively neutral cost differences for these products, overall cost savings would, for the near term at least, need to be found in other aspects of home pricing.

Box 3 **Why not include wood framing and sheathing?**

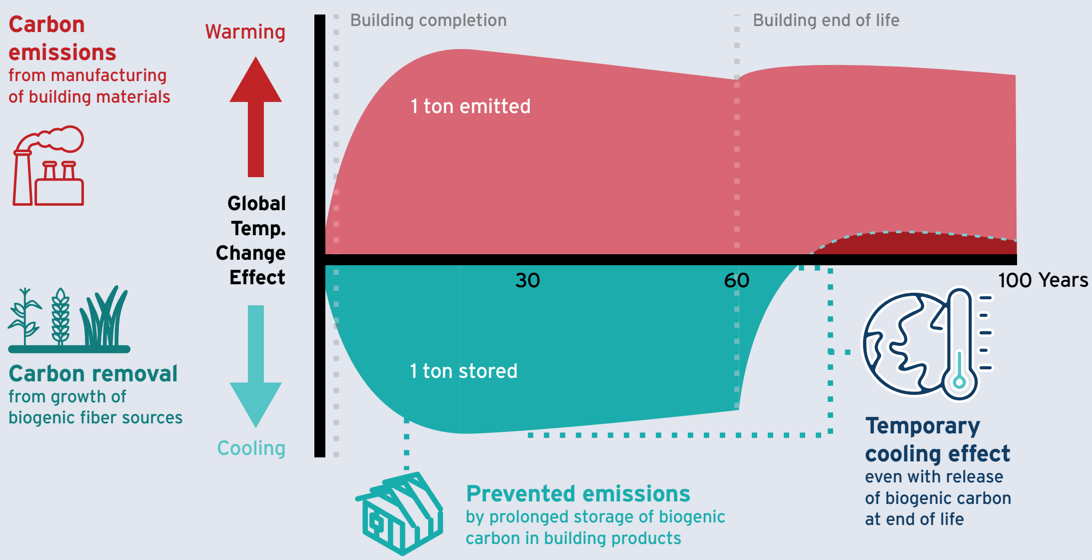
Although timber is a bio-based building product, we did not include carbon storage values for products made from existing supply chains in our analysis. In North America, timber products are already widely used for framing, structural sheathing, cladding, and flooring. In this study, we seek to identify bio-based building products that offer additional carbon storage to the business-as-usual scenario. With 23,097 of 24,227 models in the housing census dataset (95% of total homes) already wood framed (wall, roof, and floor structure), there is limited additional carbon storage value to be added.

Box 4 **Valuing durable carbon storage in building products**

Our climate analysis quantifies the amounts of physical biogenic carbon contained in bio-based building products (gross carbon content) and the net carbon balance of products after subtracting emissions that occur during harvesting and manufacturing (net carbon storage) as of the time they are installed in a new building.

In LCA, uptake of biogenic carbon into a product is shown as a negative emission and any release of stored carbon back to the atmosphere (from decay, decomposition, and/or combustion) at the end of the product's useful life is shown as a positive emission. This accounting procedure has led to the notion that bio-based products are, at best, carbon-neutral since –1 kilogram of biogenic carbon uptake captured in a product must result in +1 kilogram of carbon released to the atmosphere. This static LCA approach is an accurate way of tracing the physical flow of carbon through a product system, but it ignores both the absolute and relative climate benefits of biogenic carbon storage.[15]

Exhibit 12 **By using building materials that remove carbon, the emissions at the end of a building's life are much lower than if they happened at day one**



Note: This graph is generated by modeling 1 ton of carbon emitted and 1 ton of carbon removed using the Temporal Climate Impacts tool developed by the University of Bath.

RMI Graphic. Source: RMI Analysis

BOX 4, CONTINUED ON NEXT PAGE

Efforts to ascribe a measurable climate benefit to durable carbon storage in long-lived building products consistently show that this type of multi-decade storage is positive. However, there are disagreements on how best to measure the benefit. There are four approaches to quantifying the climate benefits of biogenic carbon storage:

- **Dynamic LCA** (DLCA) studies can be classified into three main types: dynamic system boundary, dynamic inventory, and dynamic modeling/characterization. These classifications capture temporal changes, accurately reflect real-time variations, and apply time-varying impact factors throughout the LCA process.[16] For biogenic carbon storage, DLCA studies can help quantify the climate impact of CO_2 removal over the anticipated lifespan of a bio-based product.

- **GWPbio** is a metric-based alternative to DLCA that considers the interface between biomass growth and emissions and the global carbon cycle. The results and the characterization factors produced can determine the climate change benefits or impacts associated with the storage of biomass in the anthroposphere, and the subsequent release of biogenic CO_2 with the radiative forcing integrated in a fixed time window.[17]

- **Ton-year accounting** quantifies the temporal value of storing carbon that has been actively sequestered or removed from the atmosphere, establishing a time period over which sequestered carbon should be stored to counteract the radiative forcing effect of carbon emissions, based on the residence time and decay pattern of atmospheric CO_2. Ton-year accounting suggests this equivalence time to be approximately 55 years.[18]

- **Spatiotemporal dynamic LCA** incorporates time- and space-dependent variations, classified into four types: dynamic foreground elementary flows, dynamic background system, dynamic characterization factors, and dynamic weighting factors to support reasonable environment management policies.[19]

All these approaches to determining the climate value of stored biogenic carbon point to the benefits of achieving this storage using annually renewable crops and forestry waste, the focus of our feedstock selection in this study. The climate benefit is twofold: the prevention of emissions from biomass decomposition or incineration and the replacement of biomass feedstocks with new crops. “The faster the biogenic materials regrow, the faster the CO_2 is removed from the atmosphere, and the sooner the net cooling effect can occur.”[20]

This study does not attempt to ascribe a particular climate value to the millions of tons of biogenic carbon storage potential we have identified; however, **by any of the dynamic assessment measures identified here, the benefit to the climate of quickly and affordably storing over 100–400 million tons of carbon by 2050 would be a leading mitigator of climate change.**

Economic Impacts of Bio-Based Building Product Manufacturing

This report makes the case that the manufacturing of bio-based building products can provide significant and well-distributed economic opportunities across the United States. The makeup of the current market for building products is already large and spread relatively evenly across the country. The National Association of Home Builders (NAHB) found that over 93% of all products used in new single-family and multifamily home construction in 2020 were domestically manufactured and were valued at $88.8 billion.[21] Of that total, 30 states had at least a $1 billion share and another 6 states had between $0.5 and $1 billion.

With an estimated pent-up demand for 1.5 to 7.3 million units and current annual housing starts averaging near 1 million units,[22] meeting increased housing production will require boosting domestic manufacturing of building products. New bio-based manufacturing opportunities need not come at the expense of capacity for incumbents.

An increase in bio-based building product manufacturing would align with recent US federal initiatives to promote domestic manufacturing. There is bipartisan support for policies to stimulate manufacturing to restore the sector and offset the decline in manufacturing jobs from a peak of 19.5 million in 1979 to 12.7 million jobs in 2022.[23,iv] This was a decrease of 35% over the same period that US population increased by roughly 50%.

Biomaterials bring jobs home

All the bio-based building products modeled in this study have at least one manufacturing facility currently in production. However, there is greater production capacity in other parts of the world (particularly the European Union and Australia) than in the United States for all but one product type. In addition, 7 of 20 products have no manufacturers in the United States despite the domestic existence of ample, low-cost feedstocks to support manufacturing (see Exhibit 13).

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iv At the 2025 World Economic Forum, President Trump stated, "Under the Trump administration, there will be no better place on Earth to create jobs, build factories, or grow a company than right here in the good old USA," **https://www.whitehouse.gov/remarks/2025/01/remarks-by-president-trump-at-the-world-economic-forum/**.

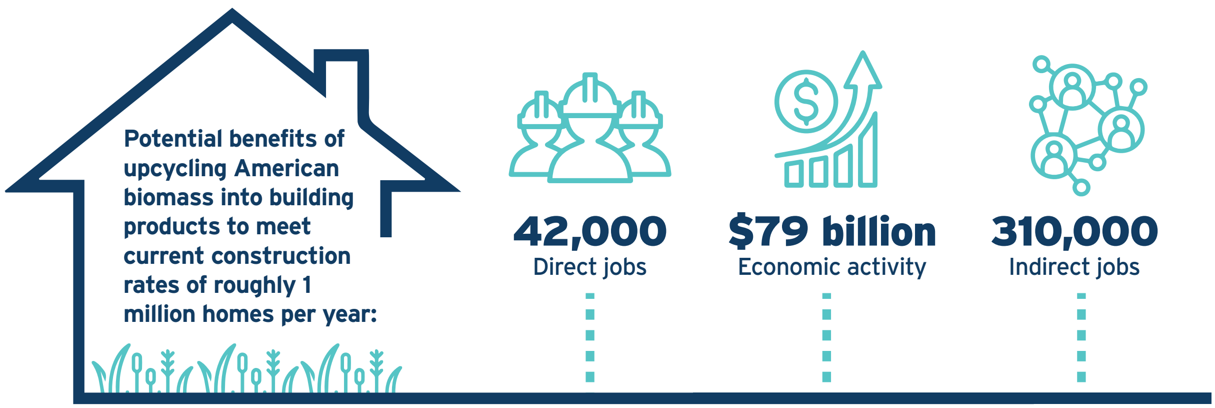
Exhibit 13 US and international manufacturers of bio-based products

BUILDING ASSEMBLY	BIO-BASED PRODUCT TYPES	US manufacturers	International manufacturers*
Foundation	Biochar concrete aggregate	1	6
Cavity insulation (exterior walls, roof and floor)	Cellulose batt	1	4
	Wood fiber batt	1	6
	Hemp fiber batt	1	7
	Grass batt	0	1
	Hempcrete	1	8
	Straw (chopped)	0	3
Flooring	Bio-based carpet	1	1
	Engineered wood	8†	25+
	Linoleum (liquid applied)	0	2
	Hempwood	1	0
Structural sheathing & interior finishes	Gypsum/cellulose panels	0	2
	Recycled drinking box panels	1	4
	Straw board panels	1‡	6
	Paper sludge panels	0	2
Continuous insulation (exterior walls)	Wood fiber board	3	8
	Compressed straw board	0	6
Exterior wall cladding	Engineered wood	12+	12+
	Fiber cement	1	6
Interior partitions	Recycled cardboard studs	0	1

Notes: * Based on internet search results.
† Number of manufacturers in the National Wood Flooring Association only.
‡ Not yet in production.

The combination of growing but underserved demand, abundant raw material feedstocks (see *Biomass Feedstock Availability*), and government support point toward significant opportunities for domestic manufacturers of bio-based building products. Our analysis indicates the scale of the opportunity. For every job in durable goods manufacturing, an estimated additional 2.9 jobs are created through manufacturer purchasing and a further 4.5 jobs are created through employee spending and tax revenue.[24] Every dollar of final sales of durable goods generates roughly 1.5 dollars in economic activity.[v] Upcycling low-value American biomass into building products made entirely by large manufacturers to meet current construction rates of roughly 1 million homes per year could be associated with an estimated 42,000 direct jobs in clean manufacturing, approximately 310,000 indirect jobs (supplier and induced jobs), and over $79 billion in economic activity. If construction activity were to increase to meet the demands of the current housing shortage, this economic activity and job creation would also increase.

Exhibit 14 **Economic opportunity of upcycling American biomass into building products**



RMI Graphic. Source: RMI Analysis

A manufacturing resurgence to revitalize communities

Evidence of a resurgence in bio-based building products can be found in the number of manufacturers established across the country over the past five years (see Exhibit 15). These manufacturers are widely distributed across the United States, suggesting that the benefits of growing a domestic bio-based materials industry could provide economic benefits that are well-distributed across the country. Several of these manufacturers create products included in this study, but a larger number do not yet have the EPD data required for inclusion despite making products from regional biomass that likely offer similar net-carbon storage benefits.

v The value-added multiplier is calculated using Bureau of Economic Affairs data. See Appendix B for detailed methodology.

Case Study: TimberHP

Madison, Maine

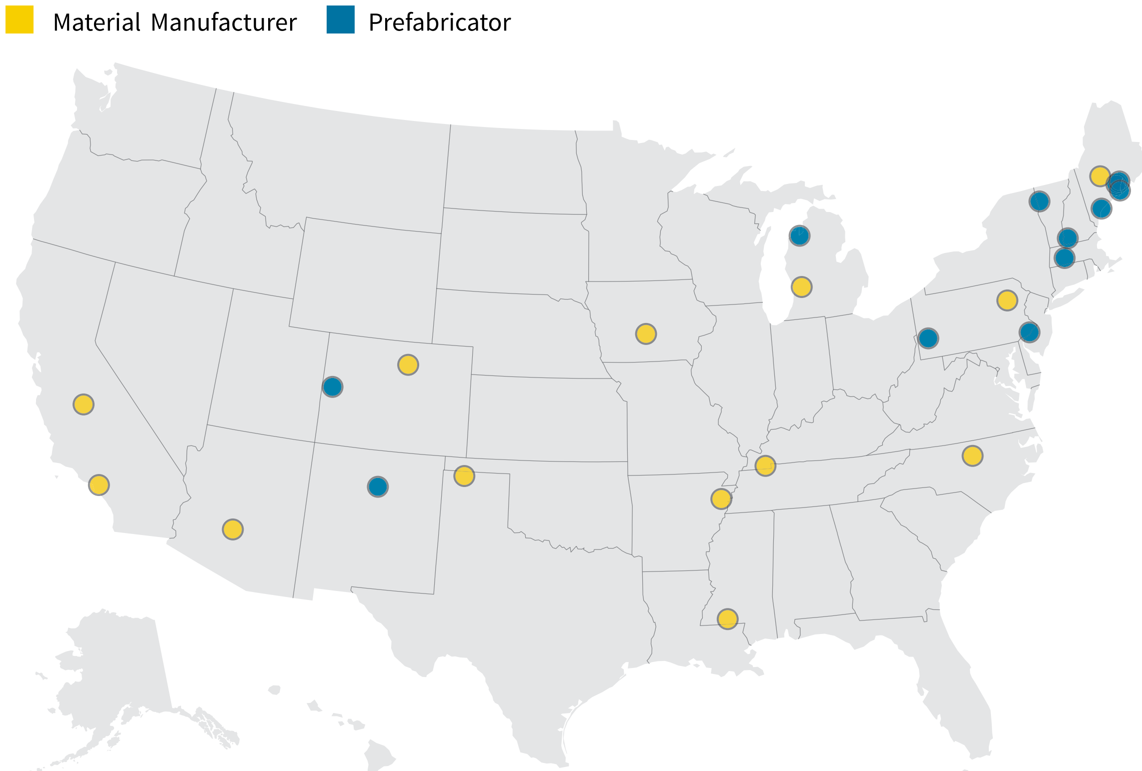
Through much of the 20th century, Maine was one of the largest paper-producing states in the country. Since the 1980s, however, Maine has lost 17 of its formerly 20 paper mills due to reduced demand for paper and increasing competition, resulting in the loss of over 4,000 jobs in rural parts of the state,[25] and posing economic challenges to local sawmilling businesses, which depend on the sale of wood fiber waste to maintain profitability.

After the Madison paper mill closed in 2016, resulting in the loss of 214 jobs,[26] Go Lab purchased the facility in 2019, and has now established the United States' first fully operational wood fiber insulation manufacturing facility, planning to create as many as 134 jobs and selling $160 million in insulation annually to the region. The TimberHP factory makes use of the existing paper mill industrial site, including the on-site 27-megawatt hydro-electric power station. The manufacturing technology and product line sold by TimberHP is already well-established in Europe, substantially de-risking this investment. A portion of TimberHP's equipment was purchased used from a European-based wood fiber insulation manufacturer, further reducing capital costs.

TimberHP's factory is housed in a former paper mill in Madison, Maine. Courtesy of TimberHP.

TimberHP's batt insulation product being installed in a wall assembly. Courtesy of TimberHP.

Exhibit 15 Selected bio-based material manufacturers and prefabricators in the United States



RMI Graphic. Source: RMI Analysis

A number of bio-based manufacturers have demonstrated the commercial viability of domestic and regional mass production of biomaterials. Plantd in North Carolina has repurposed an 80,000-square-foot former tobacco facility in Oxford to produce panels from fast-growing perennial grass, partnering with local farmers.[27] Hempitecture has established a 33,000 square foot manufacturing facility in Jerome, Idaho, to produce thermal insulation from industrial hemp, aiming to support local agriculture and plans to expand operations to New York to meet growing demand.[28] Further examples are provided in the case studies beginning on the next page.

Less can be more: Small-scale manufacturers

Large-scale manufacturing facilities tend to dominate the building products market, but in some instances small-scale bio-based manufacturing may be more appropriate. Where feedstock supplies are disbursed or variable, community-scale bio-based manufacturing businesses can start and stop operations more quickly with lower capital risk. Due to their reduced land, energy, and logistics requirements, small-scale businesses have more options for facility siting and may experience fewer permitting barriers. Small-scale manufacturing can also occur on-farm or near the forest, enabling workers to spend off-season hours engaged in value-added production using residue feedstocks generated on site. In some instances, small-scale businesses can help to de-risk technologies and business models and create an enabling environment for medium- and large-scale biomaterials businesses to become established in a region.

Case Study: Timber Age Systems

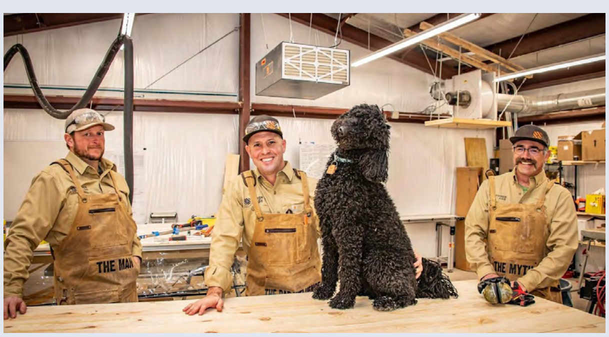
Durango, Colorado

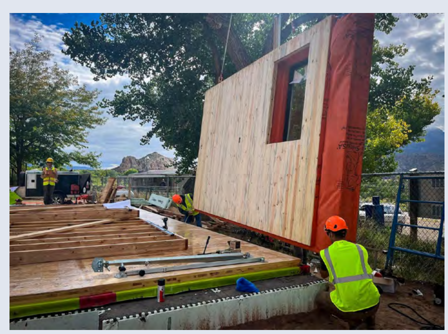
Timber Age Systems is a community-scale manufacturer of prefabricated housing based in Durango, Colorado, founded with an ethos of using locally sourced, undervalued timber in high-performance housing in local communities. Timber Age System's flagship product, the Timber Age Modular Building System (TAMBS) is a type of mass timber panel suitable for wall, roof and floor construction specifically for the low-rise residential market.

Timber Age works closely with local foresters to utilize Ponderosa Pine harvested as part of wildfire mitigation treatments in fire-prone forests. TAMBS uses lamella (thin strips) cut from these timbers and glued together to form cross-laminated timber (CLT) structural panels.

Timber Age is going beyond manufacturing for their local market by championing a repeatable low capital-cost micro-factory design which is right sized for locally available timber resources from sustainable forest management wherever they exist. This micro-factory approach allows for new facilities to ramp up quickly with a high degree of quality because the equipment used is cheaper, quicker to install, and easier to operate. Timber Age also intends to use the standardized nature of their micro-factories to streamline certification in ways which are comparable to larger, bespoke facilities. Timber Age Systems currently employs 13 people, and eventually hopes to create as many as 100 jobs across the Colorado / the Rocky Mountain Region.

*Ponderosa pine logs **harvested in a wildfire mitigation project** funded by the Colorado State Forest Service near Durango, Colorado. Courtesy of Timber Age Systems*





Timber Age Modular Building System (TAMBS) panels made from cross-laminated timber. Courtesy of Timber Age Systems

Case Study: New Frameworks

Essex Junction, Vermont

New Frameworks is a worker-owned design, build and prefabrication cooperative focused on using healthy, locally sourced biomaterials in their products. New Frameworks has transitioned from a design-build firm supplying custom homes to a manufacturer of straw structural insulated panels (S-SIPs) and prefabricated homes. The company highlights that over 75 percent of their materials are grown and sourced within 50 miles of their facility. They maintain close working relationships with the farmers and foresters that supply these raw materials.

The company uses a worker cooperative operating model which shares profits and benefits among its co-owners (some of whom were formerly workers on Vermont farms) and an egalitarian governance structure.

Faced with growing demand for their panels and kit homes, New Frameworks chose to expand capacity not by enlarging their own facility but by starting their Seed Collaborative in which other companies or individuals can learn how to start their own S-SIP and kit home production facility. Annual cohorts of trainees are involved in extensive training in all facets of production and business development from the New Frameworks team for one year and access collaborative support from the whole cohort for an additional two years.

Their current plan is to evolve into a shared-services, producers cooperative to leverage resources for small, local and regional producers. In this way, a network of small manufacturers can remain closely tied to their local supply chains and customers but can also respond to surges in demand or larger-scale projects by contributing panels from several manufacturers to the same project. Additional benefits include co-marketing efforts, research and resource-sharing, and collaborative innovation in prefabrication processes.

Prefabrication of structural insulated straw panels. Courtesy of New Frameworks.

Installation of prefabricated straw panels. Courtesy of New Frameworks.

Prefabricated and modular manufacturing with bio-based building products

One leading pathway for the rapid uptake of bio-based building products in the US housing market is via prefabricated building elements. This sector of the market is anticipated to grow from approximately $36 billion in 2024 to nearly $60 billion by 2032.[29] For new manufacturers of bio-based building products, adoption by prefabrication companies offer many advantages over direct sales to site builders:

- Business-to-business sales reduce reliance on retail sales distributors and outlets, a typical pain-point for new building product manufacturers.
- Product installation and training requirements can be addressed for a small number of workers, rather than requiring generalized training across the sector.
- Products are installed in controlled conditions.

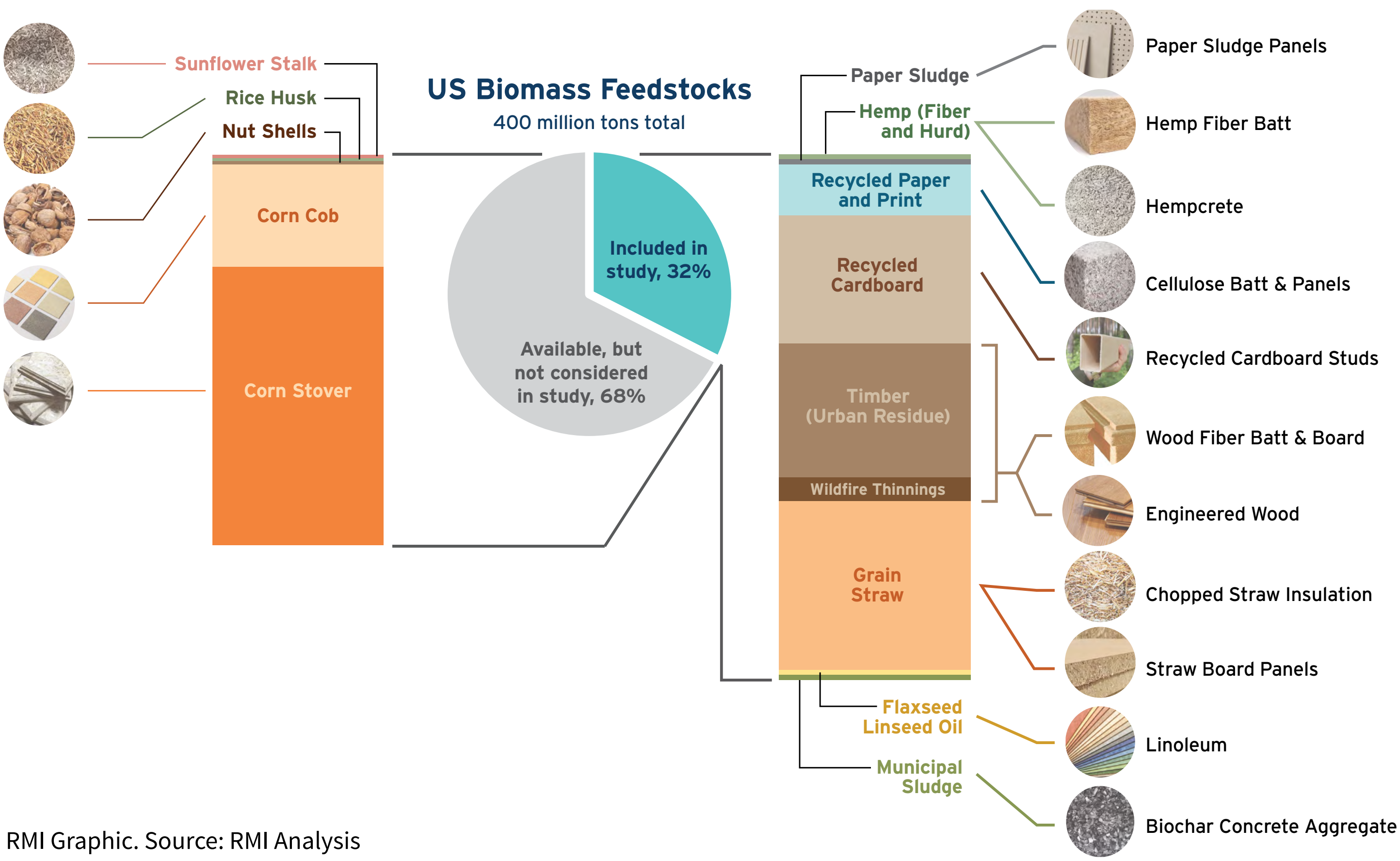
Across the United States, numerous manufacturers of prefabricated components for houses often focus on the high-performance housing market, attracting customers who are seeking improved energy and resource efficiency, reduced climate impacts, and improved occupant health outcomes, which are often the differentiators for bio-based building products.

Biomass Feedstock Availability

The potential success of the new American harvest requires a viable supply of under-valued biomass feedstocks to provide raw materials for building products. We focused on feedstocks that require no additional land use changes to be available for manufacturing of building products because the biomass comes from land that is already in use for agriculture, forestry, or from recycling of discarded consumer products. This reduces the likelihood of unintended consequences that might arise from promoting large-scale adoption of new crops, such as deforestation or displacement of food crops.

Using data from the US Department of Agriculture (USDA),[30] we identified available quantities of by-products from agricultural crops that have proven uses in building products and forestry-related residues from wildfire thinning and urban street tree residues.[31] Data from the US Environmental Protection Agency (EPA) was used to assess quantities of waste-stream feedstocks such as discarded paper, cardboard, drinking cartons, and sewage sludge.[32] Exhibit 16 summarizes these findings.

Exhibit 16 Sources of biomass feedstocks in the United States with demonstrated uses in building products



RMI Graphic. Source: RMI Analysis

In analyzing whether there is enough available feedstock to potentially supply a substantial uptake into building product manufacturing, we had to consider factors beyond the national totals of gross quantities of feedstocks. These include competition for feedstocks (especially for bioenergy uses, as identified in the US Department of Energy's "Billion Ton Report" that assesses many of the same feedstocks[33]), regional availability, and price fluctuations likely to accompany increases in demand.

Broadly, we find the quantities of low-value biomass suitable for building products are large enough to support manufacturing at a sector-wide scale. The available quantities of timber (from wildfire thinning and urban tree recovery), recycled cardboard, and paper/newsprint all far exceed the volumes needed to build 100% of new homes with the associated product types. Available stocks of grain straw (41 million tons) could build a half million new homes as per our models, or about 50% of all new home construction today.

Straw is the feedstock incorporated in the most product types in this study, including cavity and board insulation, interior walls, and wall and ceiling panels. Current straw stocks could support a major transition in each applicable product category but not 100% uptake in every category. However, we identify large stocks of corn stover (195 million tons), corn cob (70 million tons), rice hulls (2 million tons) and sunflower stalk (0.75 million tons) that can be used in similar product types and collectively would exceed even an ambitious 100% uptake target.

On the other hand, biochar made from municipal sludge could only supply 10% of new homes and the quantities of hemp fiber and hurd produced today fall well short of being able to supply more than a small percentage of new homes. These shortfalls are related to the relatively recent introduction of hemp as a legal crop in the United States and biochar production as a new industrial process. Production of these feedstocks continue to scale up every year in response to growing demand,[vi] largely driven by uses for building products.

Numerous innovative feedstocks were not quantified for this analysis because data was unavailable for performing LCA and quantifying production volumes. However, these feedstocks could play an integral role in the new American harvest because they represent emerging types of biomaterials, none of which are directly tied to land-use needs that might create competition with existing food and forestry production. These include:

- **Algae.** Lab-grown algae is used as a cement and aggregate replacement in the manufacture of concrete and concrete masonry units. Development is led by Prometheus Materials,[34] which has begun commercialization of a range of products applicable to home construction.

- **Seaweed.** Several companies globally use seaweed collected from beaches in the production of insulation and panel products.[35] Seaweed farming is beginning to provide feedstocks for production of seaweed bricks and blocks,[36] suitable for structural and cladding uses.

- **Microbes**. Tiles and bricks grown from microbe cultures have been developed by BioMason,[37] and are entering manufacturing in the United States and Europe.

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vi Hemp production increased 18% from 2023 to 2024 (**https://hempgazette.com/news/2023-hemp-report-hg2194/**) and biochar production is anticipated to increase by 11.8% per year (**https://www.grandviewresearch.com/industry-analysis/us-biochar-market**).

- **Mycelium.** Mycelium composite products for flooring and sound attenuation have recently been introduced in Europe.[38] Insulation products are under development from several companies, and a structural version of mycelium composites has been introduced by Okomwrks for use as framing and structural wall panels.[39]

It remains to be seen which, if any, of these novel bio-based feedstocks might grow to represent a significant proportion of the building product market, but all of them have desirable properties and start-up manufacturers in the early phases of moving into building product markets. Should any or all of these find success, the proportion of building products that could be sustainably sourced from biomass could be far larger than our estimates in this report.

Collectively, the feedstocks analyzed in this report total nearly 400 million tons of low-value biomass generated annually in the United States, representing enough availability to supply a large-scale manufacturing revolution in the building products market.

Reducing environmental hazards by upcycling biomass

Many of the feedstocks identified in this report as appropriate for upcycling into building products have associated environmental hazards if left unused.

For example, the wildfires that have been ravaging many parts of the United States are exacerbated by overstocking of forests with small-diameter trees. An estimated 80 million residential and commercial buildings, representing $8.8 trillion in real estate value and one-fifth of all American homes, are at risk.[40] Upcycling low-value small-diameter trees harvested as part of wildfire mitigation treatments can help reduce the cost of these treatments (which can exceed $2,000 per acre) and reduce the need for pile-burning this material.[41]

Municipal sewage sludge also poses hazards. It frequently contains per- and polyfluoroalkyl substances (PFAS), creating environmental and health risks when applied as fertilizer.[42] Converting this sludge into biochar through pyrolysis, with appropriate treatment methods in place, could conceivably destroy or immobilize PFAS compounds. Incorporating this biochar into concrete may further sequester these contaminants, potentially reducing their environmental impact.

In addition, expanding value-added markets for urban street tree residues, grain straw, and recycled fiber products can provide foresters, farmers, and recyclers with sustainable alternatives to disposal methods that contribute to methane emissions, air pollution, and water contamination, such as landfilling, incineration, and leaving plant matter to decompose in fields.

Call to Action

A unique opportunity exists to reduce embodied carbon and store 100–300 million tons of carbon by 2050 while kickstarting a nationwide manufacturing renaissance that provides healthy, affordable products for new homes.

Exhibit 17

By upcycling underused biomass into building products, by 2050:

100M metric tons of CO_2e could be stored profitably in new residential buildings over the next 25 years in a low-adoption scenario.

$79B of new domestic manufacturing opportunities could be created, generating 42,000 new jobs in domestic manufacturing industries.

400M tons of underused biomass from our farms, forests, and landfills could be converted into healthy, affordable products to supply growing housing demand.

RMI Graphic. Source: RMI Analysis

Over the past five years, a small number of innovative bio-based product manufacturers have sprung up around the country, indicating that the opportunities identified in this report are being recognized in the market. To get from this promising start to the full potential for this new American harvest, all the stakeholders who shape the home building sector will need to contribute to the effort. The following are suggested actions that can be taken today across the sector.

Exhibit 18 Suggested actions for stakeholders

Stakeholder	Action
Biomass producers (farmers, foresters, municipal wastewater treatment and recycling departments)	• Understand the potential uses for your residues and by-products as valuable building product feedstocks.[43] • Connect with existing and emerging manufacturers.[44] • Explore on-site manufacturing opportunities to add value to residues and by-products.
Home builders	• Use embodied carbon assessments to evaluate the benefits of bio-based products.[45] • Undertake demonstration projects for trial deployment of bio-based products.[46] • Consider advanced purchase agreements with bio-based material manufacturers.[47]
Developers	• Provide partnerships and incentives for builders to demonstrate bio-based products in new developments.[48]
Architects and home designers	• Build knowledge of bio-based products and specifications.[49] • Use embodied carbon assessments to demonstrate value of bio-based products.[50]
Product manufacturers	• Undertake early-stage life-cycle assessment of new products to establish carbon storage values. • Produce EPDs as soon as possible after production starts.[51] • Seek partnerships with biomass producers in new markets. • Seek partnerships with builders for demonstration projects using bio-based materials.
Policymakers	• Include carbon storage values in life-cycle assessment requirements.[52] • Provide incentives/valuation for carbon storage. • Streamline alternative compliance pathways for innovative bio-based building products. • Invest in R&D for bio-based products, especially where partnerships benefit both biomass producers and manufacturers in the jurisdiction.[53] • Support creation of EPDs for small bio-based material manufacturers.
Lenders	• Include embodied carbon and carbon storage assessments for green lending programs. • Provide incentives for projects demonstrating carbon storage.
Environmental NGOs	• Provide further research and guidance for the valuation of carbon stored in building products.[54] • Elevate inspiring case studies of producers, manufacturers and builders at the forefront of bio-based construction.[55] • Convene and connect stakeholders to facilitate awareness, education and adoption.[56]
Public	• Seek out homes and builders that provide low embodied carbon and carbon storage assessments for their buildings.

Case study: DR Horton & Plantd: A partnership to accelerate bio-based products

Much has been written about the dreaded “valley of death” experienced by startups, where great ideas and prototypes are unable to deliver on their promise due to the many hurdles in getting a product to market at scale.

Plantd, a company that makes structural panels from fast-growing grasses in North Carolina, is being helped over some hurdles by the country’s largest home builder, D.R. Horton. By offering Plantd a multi-year contract to supply 10 million panels, D.R. Horton has provided the kind of market endorsement and support that can be invaluable for a startup manufacturer.

Plantd panels can replace oriented strand board (OSB) and plywood in home construction. “At D.R. Horton, we’re always interested in innovative solutions that align with our commitment to building high-quality homes while reducing our environmental impact,” said Brad Conlon, D.R. Horton’s Senior Vice President of Business Development, in a press release. “Plantd’s panels offer the durability and moisture resistance we need, along with a clear sustainability advantage. We are excited about our expanded collaboration with the Plantd team.”

Plantd estimates that the 10 million panels destined for D.R. Horton homes will sequester 165,000 metric tons of CO_2 and avoid cutting down 1.2 million trees. Nathan Silvernail, co-CEO of Plantd believes, “For too long, we’ve relied on outdated materials that harm the environment and limit innovation. Plantd’s panels are introducing a new standard for sustainable, high-performance materials, and we believe this is just the beginning of a much larger shift toward building practices that solve climate change rather than contribute to it.”

This kind of partnership points to the kind of collaboration that could drastically increase the speed and impact of the new American harvest.

Installation of Plantd panels. Courtesy of Plantd, **https://www.newswire.com/news/plantd-signs-multi-year-contract-with-d-r-horton-for-10-million-carbon-22444348**

Appendices

Appendix A: Building model results

We analyzed the 2023 US Census data to determine the various typologies for new home construction based on four key criteria: number of stories, foundation type, framing type and garage size. Only house types that represented more than 0.1% of the total sample were included in the study, resulting in 40 unique models. Each of these models was created in the BEAM software in two versions, a baseline to represent typical construction practices and products and a version that uses all the products identified in BEAM as offering net carbon storage (production emissions are outweighed by physical carbon stored in the product). For each model, we calculated the gross emissions, gross carbon storage, and net emissions, and created weighted averages using the number of each model represented in the data set. Intensity values were calculated by dividing the results for each model (gross emissions, gross carbon storage, and net emissions) by the conditioned floor area. These intensity values were used to project the weighted results of the study across the total square footage of new construction in the United States.

A detailed review of the results can be found **here**.

Appendix B: Manufacturing economics calculation methodology

Supplier and induced job multipliers were obtained from the **Economic Policy Institute** in the "durable goods" category. Labor intensities of production for materials were estimated using facility data from TimberHP, Godfrey Forestry Products, LP Building Solutions, and Kingsford. Detailed analysis methodology can be found **here**. The value-added multiplier used to estimate the total economic benefit of bio-based material manufacturers was calculated using Bureau of Economic Analysis (BEA) data. The final demand of goods produced by bio-based manufacturers was calculated by summing the total requirements for Manufacturing (North American Industry Classification System Code 23G) across all sectors given by BEA total industry requirements data for 2023 (**BEA Table: "Industry-by-Industry Total Requirements, After Redefinitions - Sector"**). This result was multiplied by the ratio of Value Added to Gross Output for Manufacturing, calculated from **BEA Table: "Value Added by Industry"** and **BEA Table: "Gross Output by Industry"** respectively for 2024 Q3 data.

Equations: Value added multiplier calculation methodology and values.

$$\text{Value Added Multiplier} = \text{Total Output Multiplier} \times \left(\frac{\text{Value Added}}{\text{Total Output}} \right)$$

$$1.5 \approx 3.76 \cdot \left(\frac{2.9 \text{ trillion dollars}}{7.3 \text{ trillion dollars}} \right)$$

Appendix C: Biomass feedstocks results

In analyzing the biomass feedstocks, we found data for all of the feedstocks we considered in the study using reports from the US Department of Agriculture and the US Environmental Protection Agency, and harvest indices from various grower's associations, creating a typical average tonnage value for each feedstock.

Using the BEAM models for each house, we determined the mass of each bio-based product required to construct the house and multiplied these results by the total number of homes built in a year to determine if sufficient feedstocks exist to support a significant percentage of potential new home construction.

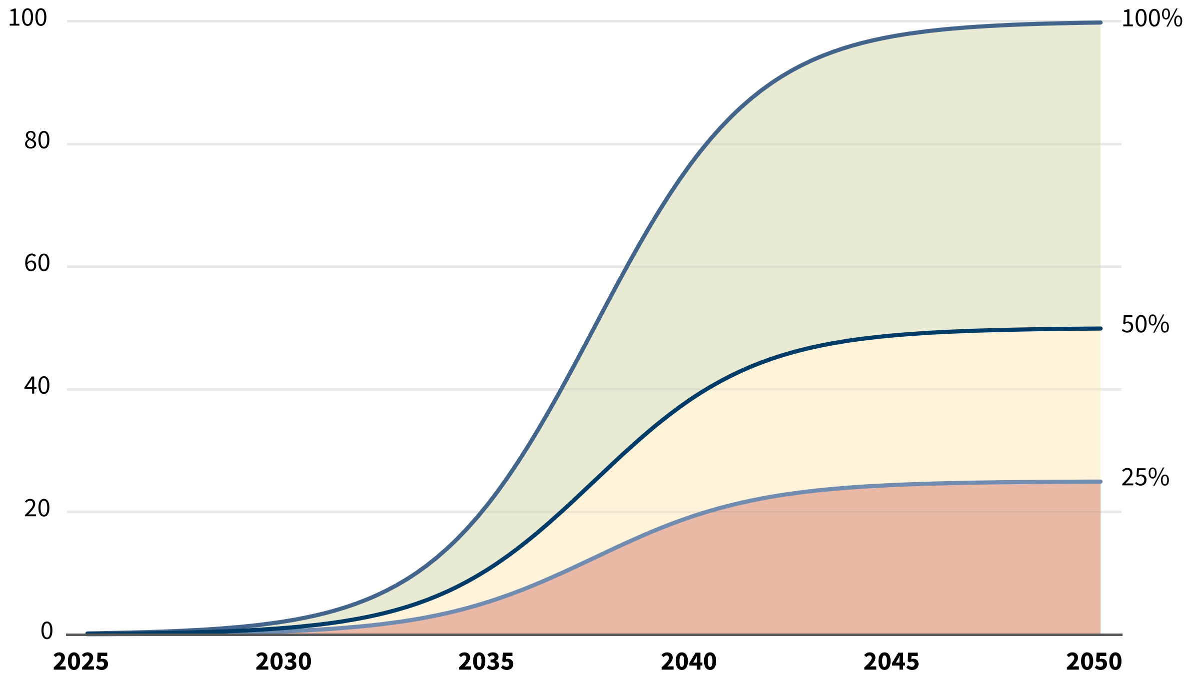
A detailed view of the results can be found **here**.

Appendix D: Adoption scenarios

Exhibit D1 illustrates the S-curve adoption rates for the 25%, 50%, and 100% adoption scenarios of bio-based construction.

Exhibit D1 Bio-based material adoption scenarios

Percentage adoption of bio-based materials in new home construction over time in 25%, 50%, and 100% adoption scenarios.



Note: Adoption curves modeled using logistic growth equation with a midpoint year of 2037.

RMI Graphic. Source: RMI Analysis

The equation below was used to model logistic growth for each scenario.

$$A(t) = \frac{A_{max}}{1 + e^{-r(t-t_m)}}$$

Where:

- *A(t)* is the adoption level at year *t*
- A_{max} is the adoption level at 2050 (25%, 50%, or 100%)
- t_m is the midpoint year (2037.5 in this analysis)
- *r* is a growth rate parameter (0.5 in this analysis)

Calculations for these adoption curves may be viewed **here**.

Endnotes

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RMI Innovation Center
22830 Two Rivers Road
Basalt, CO 81621

www.rmi.org