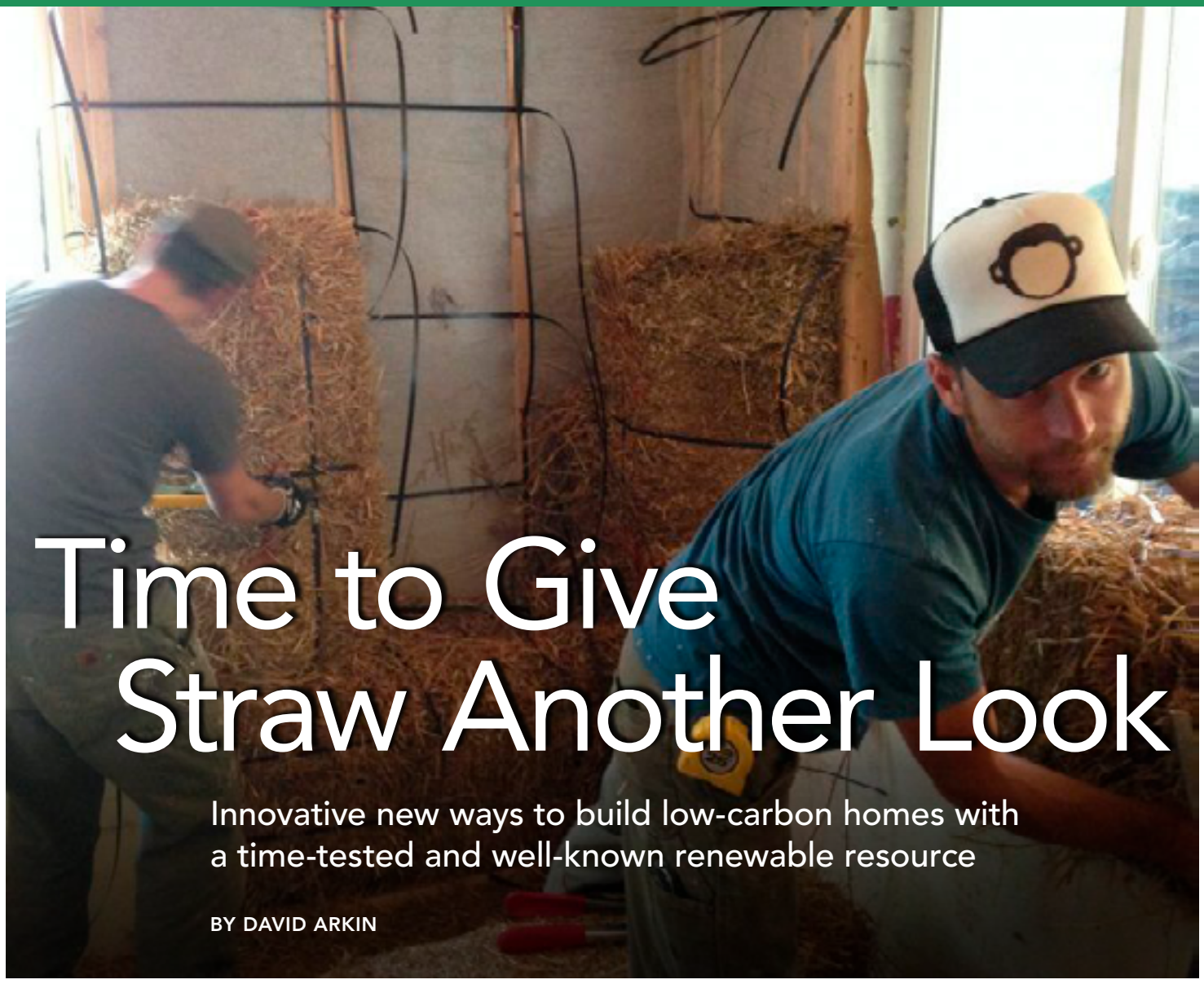

Time to Give Straw Another Look

Innovative new ways to build low-carbon homes with a time-tested and well-known renewable resource

BY DAVID ARKIN

Mention straw-bale construction, and, while many have heard of it, the majority of people still reply with skepticism: "Won't it rot?" "Doesn't it burn?" "What about insects, moisture, air-tightness…?" and the list goes on.

Despite much testing, a proven track record, relative ease to build with, and examples of durability from buildings over 100-years-old, straw bale construction hasn't achieved the widespread popularity it seems destined to reach. With inclusion in the International Residential Code (IRC) in 2015, a long list of benefits (read on), and a role to play in helping to solve global climate change, straw as a building material is in the news again.

Owing to its renewed success—and the point of this article—are the many new and varied ways to build with straw. But first, a quick recap for those who are reading about straw-bale construction for the first time.

History and benefits of straw-bale building

Straw-bale construction emerged in the late 1800s, in the Sandhills region of Nebraska, where trees were scarce and the soils not suitable for building the prairie-sod homes many pioneers of the Great Plains favored. A clever individual started stacking the big fuzzy bricks from newly invented baling equipment, and strawbale construction was born. Like both democracy and jazz, this uniquely

Photo courtesy of New Frameworks

Designed for California's wildfire country, this 872-sq.-ft. cabin is a hybrid straw-bale home. That means that while some of the walls are conventionally built with dimensional lumber and the roof is made of SIPS, the rest is built with straw-bale construction techniques.

American innovation has been exported around the world.

Straw bale's modern revival can be traced to a 1984 article in *Fine Homebuilding* magazine by Gary Strang about a straw-bale studio built by Jon Hammond, a young architect in Davis, California, who had built the small structure on his family's farm. Enthusiasts Matts Myhrman, the late Judy Knox, and others made a pilgrimage to Nebraska, and in turn traveled the country teaching workshops and promoting the many benefits of straw-bale construction.

"What I wanted to be doing was inspiring deep change. Little did I know, for the first year or two, what a transformational vehicle we had by the tail and that straw-bale construction would become a phenomenon touching the lives of individuals and groups throughout the world," said Judy Knox.

The benefits of straw bale construction are widely known but worth enumerating again, if briefly:

- High insulation values: Depending on thickness, straw-bale walls can easily achieve R-30.
- Thermal-mass properties: Straw-bale walls commonly have a 12-hour thermal transfer rate to the middle of the wall.
- Affordability: Straw bales are an affordable insulator and construction does not require a super high skill level. In fact it is is accessible to do-it-yourselfers.
- Nontoxic, safe, and healthy construction process: No PPE required!

Photo courtesy of Eric Millette

- Part of healthy indoor-air quality (IAQ): Generally natural finishes are used on straw-bale walls, including lime plaster, clay, and other nontoxic, no-VOC, or otherwise other off-gassing compounds.
- Humidity control: Straw has a remarkable capacity to hold and release moisture without the risk of mold growth. Clay plaster finishes, in particular, are also hygroscopic, meaning they absorb and release moisture naturally as well.
- Thick walls: Deep window and door openings are aesthetically pleasing and offer design opportunities for storage, seating, etc.
- Agricultural by-product: Straw is available locally nearly everywhere.
- Annually renewable: Unlike trees, which may need 40 years to mature, straw is grown and can be harvested in one season.
- Acoustic performance: Due to the inherent mass of the walls, straw-bale homes are known to be quiet.
- Structural integrity: Plastered straw-bale walls can be stronger than plywood shear walls.
- Tested and proven fire resistance: Designed right, straw-bale walls can have a two-hour fire rating when finished with lime plaster.
- Airtightness: Just like houses insulated with other air-permeable insulation, straw-bale homes can achieve Passive House levels of airtightness when built to do so.
- Stores carbon: Here's the data: 1.62 lb. of CO_2 per lb. of straw (2000-sq.-ft. home = 10.5 tons).

Taking straw bale mainstream

In the early days of straw-bale building, bales were stacked and pinned, first with rebar in the middle, and later with bamboo on the surface. Innovation quickly led designers and builders to post-and-beam structures supporting the upper floors and roof, with the bales infilled between the framing. In this type of construction, pinning could be eliminated.

A testing regimen led by **Bruce King, P.E.**, of the **Ecological Building Network** and members of the **California Straw Building Association** (CASBA) answered many concerns and ultimately led to the adoption of Appendix S in the IRC. Many books have now been written on the topic of building with bales, most recently CASBA's **"Straw Bale Building Details,"** an illustrated guide for building with straw in its baled form.

Straw bales gained popularity in the 1990s and early 2000s, and while it hasn't waned, it hasn't grown substantially either. As a co-director of CASBA and an enthusiastic proponent of the technology, I've been searching for an answer as to why. One is likely a lack of general awareness, and another a knee-jerk reaction (often blamed on the first little pig) that straw is not a suitable building material; or that it's difficult to get a permit (even though it's now in the building code); or that it's only for poor people; or only for rich people; or only for those targeting the pinnacle of green building.

Another reason straw-bale construction has not made it to the mainstream could be a perception that straw homes must have lumpy walls with rounded corners and other Hobbit-like details, even though a number of architects and designers have created handsome modern structures, utilizing bale walls for higher efficiency that allows for greater use of glass without paying an energy-performance penalty (see photo above).

As Matts likes to say, "you can do anything with straw bales, except have skinny walls," though that's changing too. Our firm has created many award-winning straw-bale buldings, including *Fine Homebuilding*'s Best New Home of 2012, **"Santa Cruz Straw Bale."**

But perhaps the biggest factor limiting growth of straw-bale construction is that it isn't readily available as a building product—one that can be specified from a manufacturer, let alone purchased at a local supply yard. Even though wood literally grows on trees, nearly all of it is purchased from a lumber yard, and in many cases in a highly processed and value-added form. And this is the case for nearly all building materials—one does not make their own gypsum board, for example, or concrete blocks, or nearly anything else, often things that could be made from locally available and often inexpensive (if not free) resources.

Builders and designers are risk-averse, understandably so, and use of manufactured products in accordance with the manufacturer's recommendations shifts some responsibility to the product's source should something go wrong. A farmer is not taking any liability if something goes wrong with the bale of straw you bought

The ModCell Bale House

from them. Keeping the straw dry—and therefore effective—falls entirely on the designers, builders, and owners, and this burden of responsibility has likely kept the many benefits of straw largely out of production home building or other uses of it at scale.

However, the past few years have seen an emergence of several new ways to build with straw, lessening the perceived risk or construction complexities, and in a few cases actual products are coming onto the market. Here are some of the most exciting innovations and developments.

Panelized wall systems

ModCell is a UK-based company that pioneered prefabricated wall systems with the Bale House at the University of Bath in 2009, and has brought its panelized bale walls to several larger-scale multifamily and commercial projects since then.

Chris Magwood of the **Endeavour Centre** in Peterborough, Ontario, built **an affordable housing project** utilizing a panelized wall system,


A prefab, straw-insulated panel from EcoCocon

and wrote about it in **"Essential Prefab Straw Bale Construction,"** Like ModCell, they promote the ability to assemble panels in a climate-controlled setting, and then deliver them to the job site prefinished, craning them into place.

Top photo courtesy of ModCell. Bottom right photo courtesy of EcoCocon.

Insulating a stick-framed, mixed-use building with straw bales

The finished building, designed by the author's firm

Ecococon, represented in the U.S. by **Build With Nature**, is a timber and straw wall-panel system that is computer- and factory-generated for quick and easy assembly on the job site, and then finished in place. They have completed their first home in North America, in upstate New York, and are looking to expand operations with a production facility somewhere in the states.

Straw bales as insulation only

The straw-bale construction appendix in the IRC mentions the use of straw bales placed "on-end," which was contemplating their use as insulation between standard 2x wood framing, a concept first conceived by architect Daniel Smith of Berkeley, California. Placement of approximately 23-in.-wide bales between 2×6 studs at 24 in. on center has been proven feasible in both residential and commercial projects.

We took this approach on a 34,000-sq.-ft. mixed-use building constructed in Eugene, Oregon, for $175 per square foot. Vapor-permeable plywood wall sheathing (not OSB) is utilized on the exterior, along with a highly permeable weather barrier and nearly any finish material.

Jacob Deva Racusin of New Frameworks Natural Building created a similar hybrid wall system by stacking straw bales to the interior of

With Racusin and New Frameworks' hybrid straw-bale approach, the bales can be installed before the dense-pack cellulose is blown into the walls, as seen here, or after, as seen in the photo at the top of the article.

Photos top left and right courtesy of author. Bottom right photo courtesy of New Frameworks.

Updating an existing home with straw-bale insulation

2×4 framed walls filled with cellulose insulation. The exterior can be finished conventionally with common sheathing and siding materials, but in combination with the straw insulation one can build an affordable high-performance wall in the most extreme climates—Jacob built in the Northeast.

Many older homes are woefully underinsulated, having been built at a time when energy was cheap and we simply didn't understand the negative impacts the operating energy of a home can have. Many are drafty and uncomfortably cold or hot, depending on the location and time of year. Retrofitting straw bales can drastically improve these homes.

When I was a boy in Wisconsin, we'd place a row of bales around the exposed foundation walls of our old farmhouse every fall to keep the pipes in the basement from freezing; this is not a new idea. Matts Myrhman wrapped a concrete-block house in Arizona with bales in the 1990s, and a tin barn café in Texas was given a similar retrofit.

More recently our firm wrapped part of a midcentury-modern home in Palo Alto, California, with straw bales, and architect Bob Theis worked with CASBA co-director Massey Burke and workshop volunteers wrapping a ranch-style home in El Sobrante; both yielded vastly increased comfort and performance—as well as an aesthetic upgrade—for the homeowners.

A **seven-story affordable housing project** in St. Die, France, was built with straw bales placed in particleboard modules and craned against the cross-laminated timber (CLT) walls. These panels were wrapped and finished with ceramic tiles. Overall the project stores an impressive amount of carbon—largely in the wood, but also in the straw—relative to the concrete and steel that would have been used.

Sheathing products made from straw

Over the past 30 years, we've seen a number of sheet products made from straw come and go. Among these was **Meadowboard**, from pressed rye grass and cyanurate glue, and Wheatboard, a similar product made from wheat, and others incorporating plant fibers.

Leading the return to plant-based board products is **Calplant1**, a medium-density fiberboard (MDF) of rice straw, soon starting production at its new factory near Winters, California. It promises to be **a direct substitute for wood-based MDF**, at a scale that's sure to impact the market, as MDF is ubiquitous in building products such as cabinets, trim, flooring substrates, and more.

While straw in its baled form is largely noted for its insulation value, there are many ways to utilize it in non-baled form, and an Austrian company has devised a means of shredding straw for use as a **blown-in insulation** product. We hope to see this available North America soon.

Compressing agricultural fibers to form compressed straw board (CSB) was discovered

Photo courtesy of the author

Straw MDF with a routed edge from Calplant1

in Sweden in 1933. Known as Stramit Board, it was exported to the UK in 1945 and to Australia in 1954. Also referred to over the years as Durra, Prestowall, Agriboard, Ortech, Ligni-cell, Kodu Kuubis and others, CSB is formed by the application of heat and pressure to cellulose materials. Heat causes naturally present moisture to be turned to steam. The lignin which forms 25% of cell walls of all plants is liquified and the long chain molecules act as a bonding agent. Pressure forces the materials together into a self-bonded whole, thus straw becomes a load-bearing board. Common in Australia, we look forward to CSB's return to this continent soon.

Plant-based, beyond straw

Many building methodologies, historically and to this day, employed straw as a component. Adobe construction has been accepted in the building code since the 1940s and is a traditional method of making sundried bricks of clay and straw. Light straw clay (LSC) utilizes these same materials but in a higher concentration of straw, using a clay slip (watery clay) to coat the straw for greater durability, similar to the wattle and daub of yore. Straw is an additive to clay plasters, a means of fiber reinforcement not unlike the way horse hair was added to plaster in the past.

Both Appendix R—Light Straw Clay—and Appendix S—Straw Bale Construction—can be found in the current IRC. Straw, however, is not the only plant-based building material, and I think we will continue to see this category grow in coming years.

Hempcrete has generated a fair amount of buzz (pardon the pun) lately, utilizing the starchy hurd, the center of the stalk, chopped and coated in a lime binder. Bamboo in the form of BamCore, a stud-free wall system that can be infilled with any insulation to a climate-appropriate wall thickness with minimal thermal bridging, is now available too. Both of these are carbon-storing, rapidly renewable, and plant-based.

Bottom line

Wood has long dominated the residential building world, and for good reason. It's natural, reasonably durable, easy to work with, and beautiful. In the rush to minimize the carbon footprint of buildings, wood in the form of heavy timber, cross-laminated timber, mass plywood panels, and other wood-based products has emerged as some of the best alternatives to concrete and steel. It may soon be a viable alternative to some of the less-than-climate-friendly insulation materials used today as well. But the impacts on our forests (and their soil health, where carbon is stored) cannot be ignored.

Rapidly-renewable resources including bamboo, hemp, mycelium, and, of course, straw are better choices for drawing down carbon. The building industry is budding with new, innovative low-carbon options for us to design and build with in a climate-responsible way. Traditional straw-bale building remains a viable option too. CASBA's new guide provides all the background information as well as pertinent details to undertake construction of a straw-bale home. If there were ever a time to give these material another look, that time is now.

To re-frame for builders what Michael Pollan landed on as the most simple rules for eating well: Build shelter, not too big, from mostly plants. Though in the case of these biogenic resources, using more instead of less could actually be a good thing.

David Arkin, AIA, LEED AP, is co-director of CASBA and, along with his wife Anni Tilt, AIA, a principal of Arkin Tilt Architects.

Photo courtesy of the manufacturer