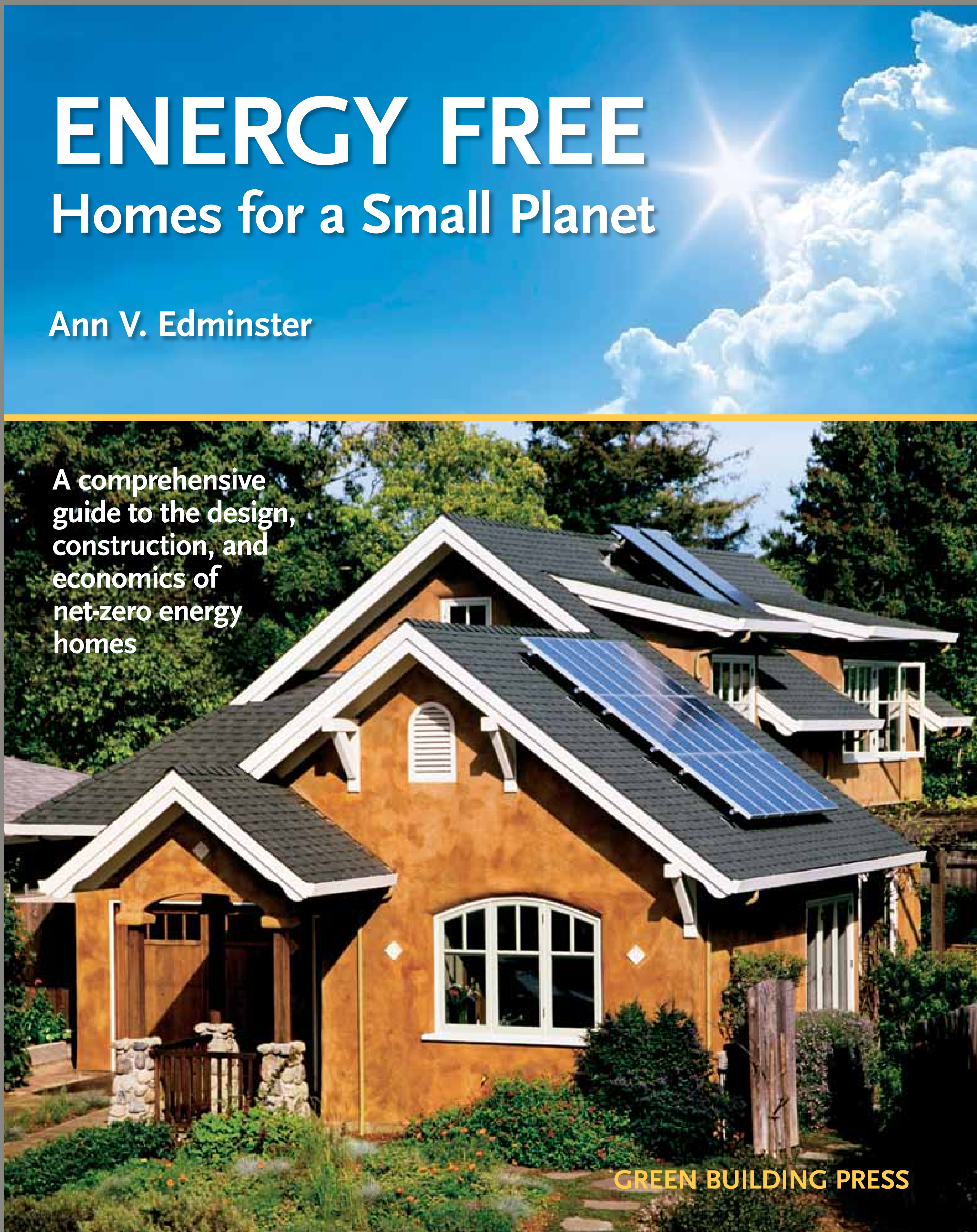

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or check the membership rosters of organizations such as the Energy and Environmental Building Association (**EEBA.org**). Also see the Chapter 4 sidebar "What Is Building Science and Why Does It Matter?" (Note that even the term "building scientist" is somewhat obscure and lacks a universal definition; the one given above is reasonably well-understood within the energy efficiency community.)

► Should word of mouth fail you, directories of green building professionals are available at:

www.buildingconcerns.com/nocal/ (Northern California only)

www.greenhomeguide.com/

www.directory.greenbuilder.com/search.gbpro

Now you know what skills are important to your NZE home project. If you have assembled a team already, you should survey the team members to find out what their experience and skills are relative to your needs, identify any voids, and fill the voids. You may be able to fill the voids from member firms that are already participating or via referrals from existing team members. Word of mouth is always the best way to find good design professionals. Resort to online referral sources or the yellow pages only as a last resort. If you find that you need to issue a request for qualifications (RFQ) or request for proposals (RFP), be sure to define your needs as precisely as possible, or you are likely to get proposals that are sufficiently dissimilar that comparing them may be difficult.

Phase 3. Launching the Process

Commit to an integrated design process

I have had the good fortune to work with a number of clients developing high-performance residential projects. Some have also made an early commitment to an integrated design process. Some have not. Some have engaged in a somewhat or partially integrated design process. Some have engaged in an integrated process, but relatively late in design. My empirical observation is that the higher the performance goals for the project, the more critical it is that the team engage in a comprehensive integrated design process, begun as early as possible. Achieving an energy-free home is a very high performance goal indeed; even the process of arriving at a satisfactory definition can be somewhat taxing. Therefore, it is wise to make a formal commitment to integrated design and to ensure that all team members are prepared to support it. Ideally, that agreement will be memorialized in everyone's contracts.

Hold a charrette

An integrated design process frequently begins with a charrette[7] or eco-charrette, an intensive design workshop, in which the entire project team comes together (often for the first time) to set goals and identify strategies for achieving the desired outcomes.

A charrette is an excellent way (arguably, the *only* way) to launch an integrated design process. As mentioned above, the owner, architect, structural engineer, mechanical engineer, interior designer, landscape architect, and general contractor should all participate – as should other team members, if any.

Here are some suggestions for getting the most out of the charrette:

1. Schedule it with consideration for as many participants' constraints as possible. (**Doodle.com** is a free, easy-to-use, web-based scheduling utility that simplifies this process.)
2. Draft an agenda that includes all critical design and planning issues. Assign time blocks to your topics, and be prepared to enforce the time limits and/or adjust the schedule as needed to accommodate the direction the discussion takes. Include regular breaks, and reserve at least a half hour for a

Agenda & Consultant Participation

Time		Topic/LEED category	Green consultant	Developer	City	Architect	Associate architect	Construction mgr	General contractor	MEP	Civil engineer	Landscape architect	Structural engineer
9:30		Introductions	●	●	●	●	●	●	●	●			
9:45	EA	Energy & Atmosphere	●	●	●	●	●	●	●	●			
10:45	EQ	Indoor Environmental Quality	●	●	●	●	●	●	●	●			
11:30	WE	Water Efficiency	●	●	●	●	●	●	●	●	●	●	
12:15	SS	Sustainable Sites	●	●	●	●	●	●	●		●	●	
12:45		Lunch + intros of new arrivals, overview of green goals	●	●	●	●	●	●	●	●	●	●	●
1:45	MR	Materials & Resources	●	●	●	●	●	●	●	●		●	●
2:30	ID	Innovation & Design Process	●	●	●	●	●	●	●	●			●
3:30	AE	Awareness & Education	●	●	●	●	●	●	●				
3:45		Next Steps & Responsibilities	●	●	●	●	●	●					
4:15		Incentive Programs/Other	●	●	●	●							
4:30	LL	Location & Linkages	●	●	●								
4:45		Adjourn											

● = *Please attend; attendance during other portions is optional.*

FIGURE 3-3. SAMPLE CHARRETTE AGENDA

Region	Sizing Factor (gallons heated per square foot of collector)	Collector Area (sq. ft.) for 80-gallon tank (gallon/sizing factor)	Number of Collector Panels
Desert Southwest, Florida	2.0	40	1–2
Southeast, Mountain States	1.5	53	2
Midwest and Atlantic States	1.0	80	2–3
New England, Northeast	0.75	107	3–4

FIGURE 6-3. SOLAR THERMAL COLLECTOR SIZING BY REGION

Choosing a collector

Collector panels are typically 4x8 or 4x10 feet. Two basic types of collectors are used in separate collector and storage systems: flat-plate and evacuated-tube. Each type is described briefly below.

A **flat-plate collector** consists of a glass-covered insulated box that contains copper pipes attached to a flat heat absorber plate, which transfers absorbed solar energy to the fluid (either water or antifreeze) in the pipes.

© Catherine Wanek

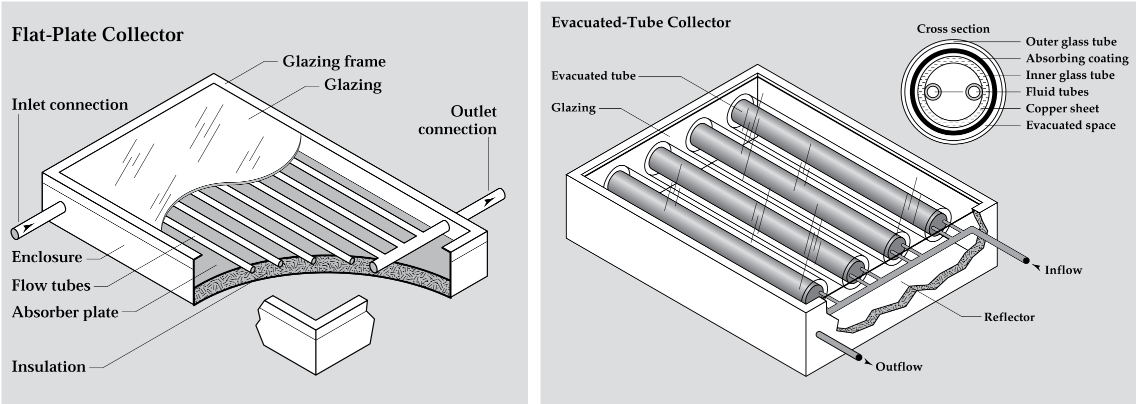
FIGURE 6-4. FLAT-PLATE COLLECTOR (BACKGROUND) AND PV ARRAY (FOREGROUND)

Courtesy of Sustainable Spaces

FIGURE 6-5. EVACUATED-TUBE COLLECTORS (ABOVE) AND PV ARRAY (BELOW)

An **evacuated-tube collector** (a.k.a. vacuum-tube collector) consists of a series of parallel glass or plastic double-walled tubes, inside each of which is a copper pipe containing a heat transfer medium, either antifreeze or air. Air is removed from the sealed space between the tube walls, creating a vacuum around the pipes. Since vacuums conduct heat poorly, this makes the tubes very efficient at retaining the captured solar energy.

In both flat-plate and evacuated-tube collectors, the fluid in the collector's pipes delivers heat to a solar water tank, which in turn feeds into a conventional water heater. Figure 6-6 illustrates flat-plate and evacuated-tube collectors and summarizes the advantages and disadvantages of each.



Courtesy of Building Technologies Program, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, buildings.energy.gov

Flat-plate collector:

- Best for applications that require water temperatures under 140°F (DHW, radiant floor, forced-air heating)
- Less expensive than evacuated-tube collectors

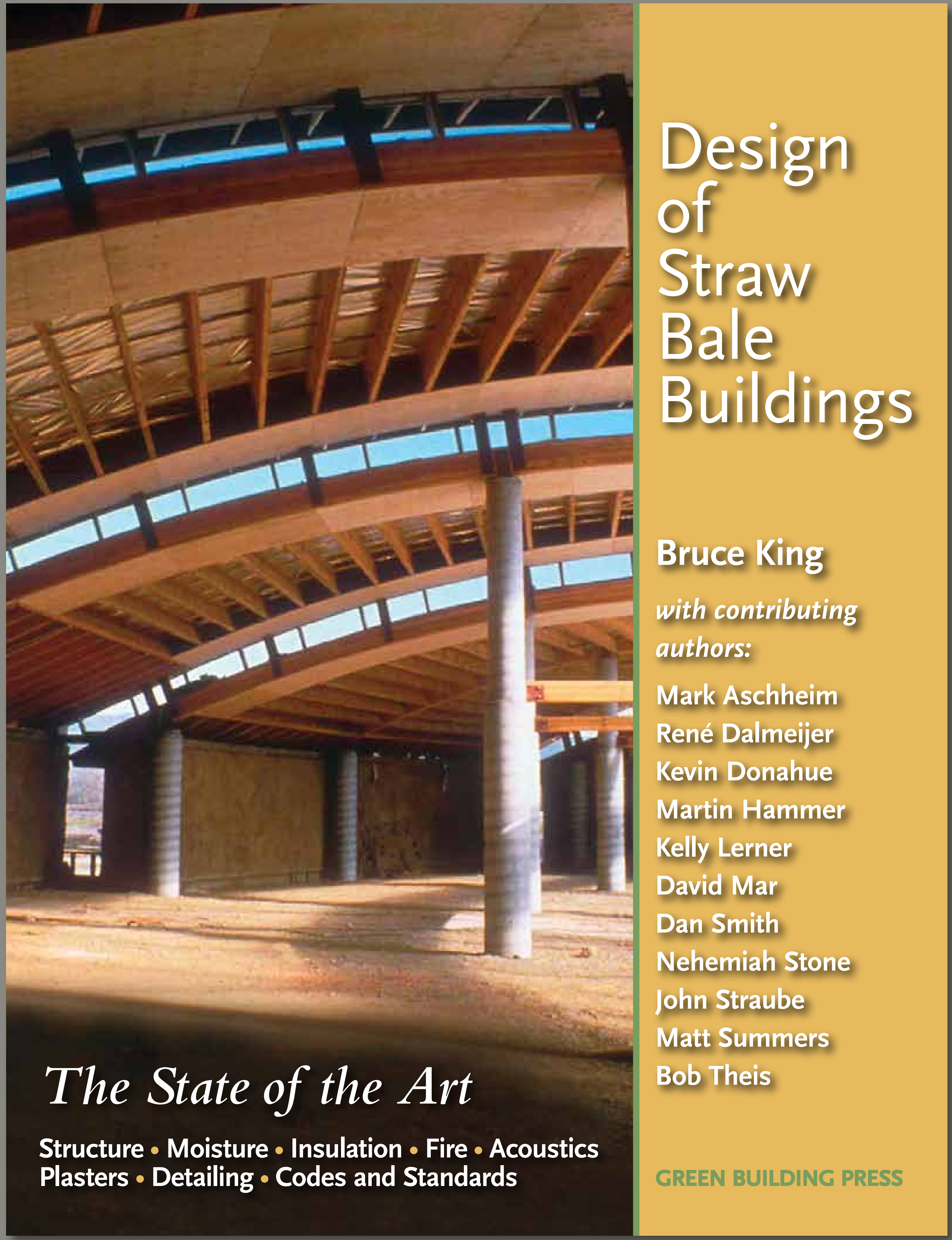
Evacuated-tube collector:

- Best for applications that require water temperatures above 140°F (DHW, baseboard hot water heating)
- Outperforms flat-plate collectors in cold, cloudy regions
- No condensation inside the collector (reduced maintenance risk)

FIGURE 6-6. FLAT-PLATE VS. EVACUATED -TUBE COLLECTORS

Passive or active? Open loop or closed?

Solar thermal systems can be set up so that the fluid heated in the collector is moved to the storage tank either passively, using a process known as thermosiphoning, or actively, using a pump. Thermosiphoning capitalizes on the natural convective movement of fluid upwards as it is heated. As the hot water rises, it



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areas where mold spores have begun proliferating. Such bales should always be discarded, even if very dry at the time of construction, as they are especially prone to experience problems if the wall is ever wetted.

4. Fiber length A concern to bale builders is the type of combine used to harvest the straw – conventional combines leave long straw fibers (which are good for building), while rotary combines chop the straw into short fibers (which makes for unstable, "crumbly" bales). Experienced builders look for average fiber lengths of at least 10 inches (25 cm).

5. *Straw*, not hay The original straw bale buildings in Nebraska used meadow hay, seeds and all, and many have lasted well. That said, it bears repeating that *hay* (i.e., bales containing a significant amount of seed or grain) is for horses, because the grain is carbohydrate that attracts insects and other animals, and is more inclined to rot. *Straw* (i.e., bales with minimal or no grain) is best for building.

1.2D

Bales transported by flatbed truck

photograph courtesy of Bryan Jenkins, University of California, Davis

2

Remember:
Amateurs built the Ark,
Professionals built the Titanic
– Anonymous

THE STRAW BALE FAMILY TREE

2.1A

A classic timber frame home from medieval Europe, framed with heavy timbers treated with pine tar or other natural protection. The walls were infilled with a packed straw-clay mix that was then plastered with lime. In addition to its high vapor permeability, this building type is very durable because it sheds water away from itself everywhere it can – at the roof, at windowsills, and even by building the floors to overhang the wall below with drip edges.

photo courtesy of John Straube

With the invention of the horse-powered baling machine about 140 years ago, the invention of straw bale construction was soon to follow. That development in the Sand Hills of Nebraska occurred within the far older context of European straw-clay construction – of which those early settlers were likely aware – and has of late spawned a number of new developments. This is a cursory look both back into history and forward to present and imminent developments in the marketplace.

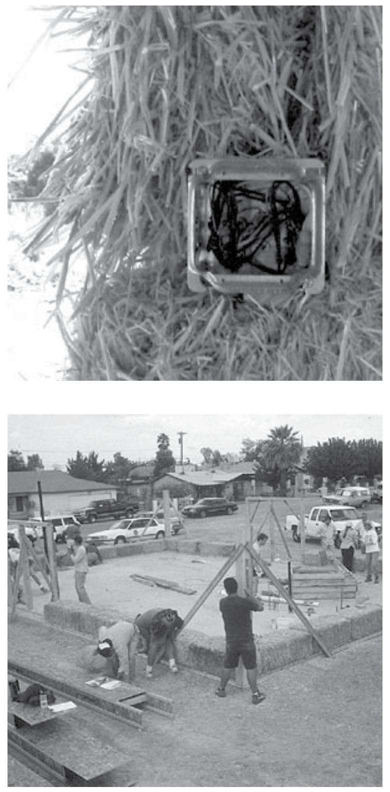
2.1 Historic Precursors to Straw Bale Construction

Straw-clay construction

Various traditions date back as much as thousands of years, in areas all over the world, of building walls by packing straw mixed with clay into or onto wood frames. Some, generally known as *wattle and daub*, involved packing the straw-clay mixture around a basketlike weaving of reeds, canes, bamboo, or wood. Another, more local to northern European and some Asian countries, involves densely packing straw soaked in light clay slip between the timbers of a stout wooden frame. Typically the straw-clay was then coated with lime plaster, producing the classic effect of white panels surrounded by exposed timber frames – mythologized in children's fairy tales, and horribly imitated in American housing tracts.

Cob construction

Cob could be thought of as heavy straw-clay – much more clay and sand than straw – that doesn't require a wood frame nor any formwork; lumps (cobs) of material are packed and sculpted by hand into walls and vaults. As with straw-clay, cob phase rain anxiety. (This is not for lack of trying – again, see chapter 2, *The Straw Bale Family Tree*.)



4.1.C

Top: an electrical junction box screwed to a wood stake driven into the face of straw, and Lower: setting corner plumb posts to guide bale erection

photos courtesy of Bruce King and David Eisenberg

4.1.3 Common Practice with All Straw Bale Building

Despite the many variations, there are several qualities common to all straw bale buildings:

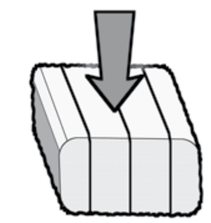
4.1.3a Voids All straw bale buildings have dozens of oddly-shaped spaces among the bales as well as between bales and surrounding framing, windows, doors, etc. The convention is to fill those spaces, prior to plastering, with a straw-clay mix that dries and then acts as a substrate for the plaster. Alternatively, some use a sprayed insulation like cellulose or polyurethane foam to fill cavities. The material chosen may vary, but this "chinking" of all the various voids is no minor matter; besides providing continuity for the plaster's support, the fill material is crucial to insuring thermal and acoustical insulation, and to blocking the potential passage of fire.

4.1.3b Pinning The bales must often be braced during stacking for stability and alignment in a manner akin to the temporary bracing of a wood studwall. Internal or external pinning of the walls with rebar or bamboo dowels was prescribed in early straw-bale codes, but is no longer considered to provide much structural value and is generally unnecessary. If used, however, external pins – typically, matched, parallel vertical rebar or bamboo on opposite sides of the wall, tied through the bales with twine – are far easier to build and have been shown[1] to contribute measurably to the wall stiffness.

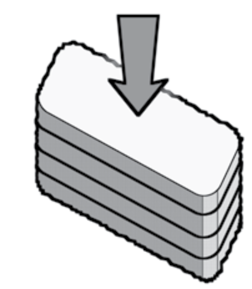
4.1.3c Fear of Water Yes, straw will rot, and moisture problems – even more than is generally the case in construction – are ever on the minds of designers and builders (or should be; see chapter 5, *Moisture*). The foundation must keep the bales well above grade, and the roof should provide a wide overhang – the proverbial "good hat and good pair of shoes." Roofs are conventional, or at least need not be anything special, connecting to the walls for shear and uplift via some manner of *roof-bearing assembly* (RBA) or bond beam (most commonly a wood assembly). The bottom of the bale wall must be well separated from the foundation by a waterproof barrier over the supporting surface, and by a layer of pea gravel (capillary break) between wood sill plates along the inside and outside faces, thereby ensuring that the bales will never be sitting in water.

4.1.3d Basic Details (See chapter 10, *Details and Design*.) Windows and doors are typically framed wood bucks that either sit on the foundation or "float" in the bale wall. Cabinetry and fixtures are screwed to wooden stakes pounded into the straw, and conduit can be let into grooves carved by chainsaws or weed whackers into the straw surface.

4.1D
Nomenclature of flat vs. on edge bale stacking



*Bales stacked and loaded **flat** are loaded perpendicular to their largest face – parallel to the plane of the tie hoops, and generally perpendicular to the straw fibers.*



*Bales stacked and loaded **on edge** are loaded parallel to their largest face – perpendicular to the plane of the tie hoops, and generally parallel to the straw fibers.*

4.1.3e Flat or On Edge? The designer/builder must decide whether to stack the bales *flat* or *on edge*. There is some debate as to which is better for load-carrying capacity, and testing evidence to support both sides, but flat bales are more stable during stacking and thus generally more common. Flat bales are also more easily bent for curving walls and allow the builder to let in posts – typically by carving a notch with a chainsaw or rotary saw – for a post-and-beam structure. By contrast, bales on edge have their ties exposed on the inside and outside face, making let-in posts difficult, and rendering them somewhat more vulnerable to fire damage (see chapter 6, *Fire*). In general, a post-and-beam structure performs more efficiently if the posts are set within the bale wall core, as the plaster can then brace the posts and rely on them as edge elements under lateral loading.

4.1.3f Precompression The rice straw bales commonly used in California are well-known for being very stiff, that is, not very compressible (the reasons why are uncertain, but probably have a lot to do with the "hairiness" of the rice straws, making them stick together somewhat like velcro; see figure 1.1A). This is the exception, however; most bales in locations around the world are relatively compressible. For example, an eight foot high [2.4 M] stack of ordinary wheat straw bales in Canada or Australia or Germany might settle two or three inches [50-70 mm] with time under its own weight, or, as is now commonly done, under mechanical precompression after stacking; a stack of the same height of rice bales might not settle at all. This settling phenomenon is attributable to the compression of the space between bales and to the initial "set" within the bale itself, and is only partially related to the measured Modulus of Elasticity of the bales. Many builders of walls, especially ones intended to be load-bearing, routinely precompress the walls before applying plaster so as to avoid the otherwise inevitable settling cracks.

Making Better Concrete

Guidelines to Using Fly Ash for Higher Quality, Eco-Friendly Structures

By Bruce King, P.E.

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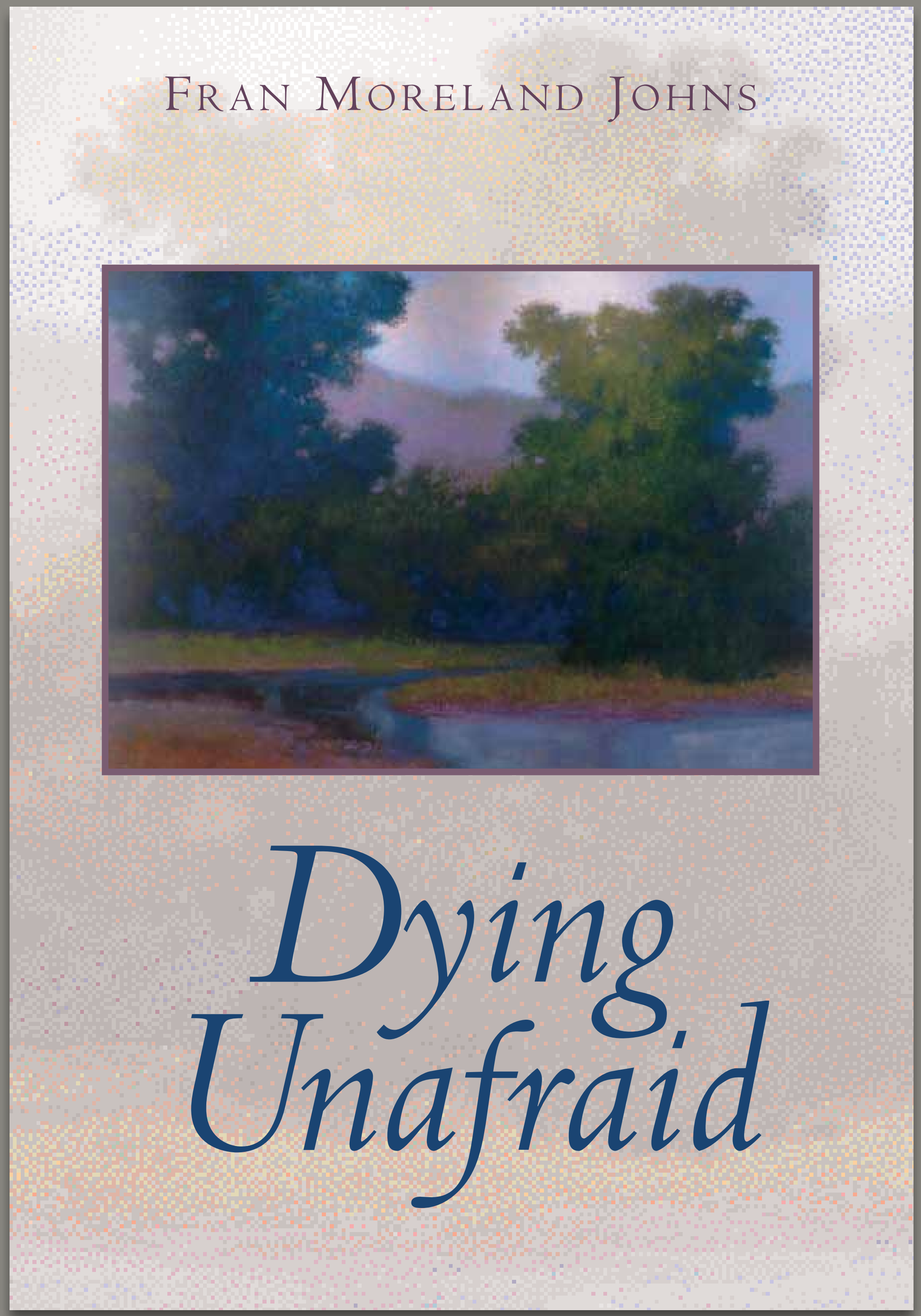

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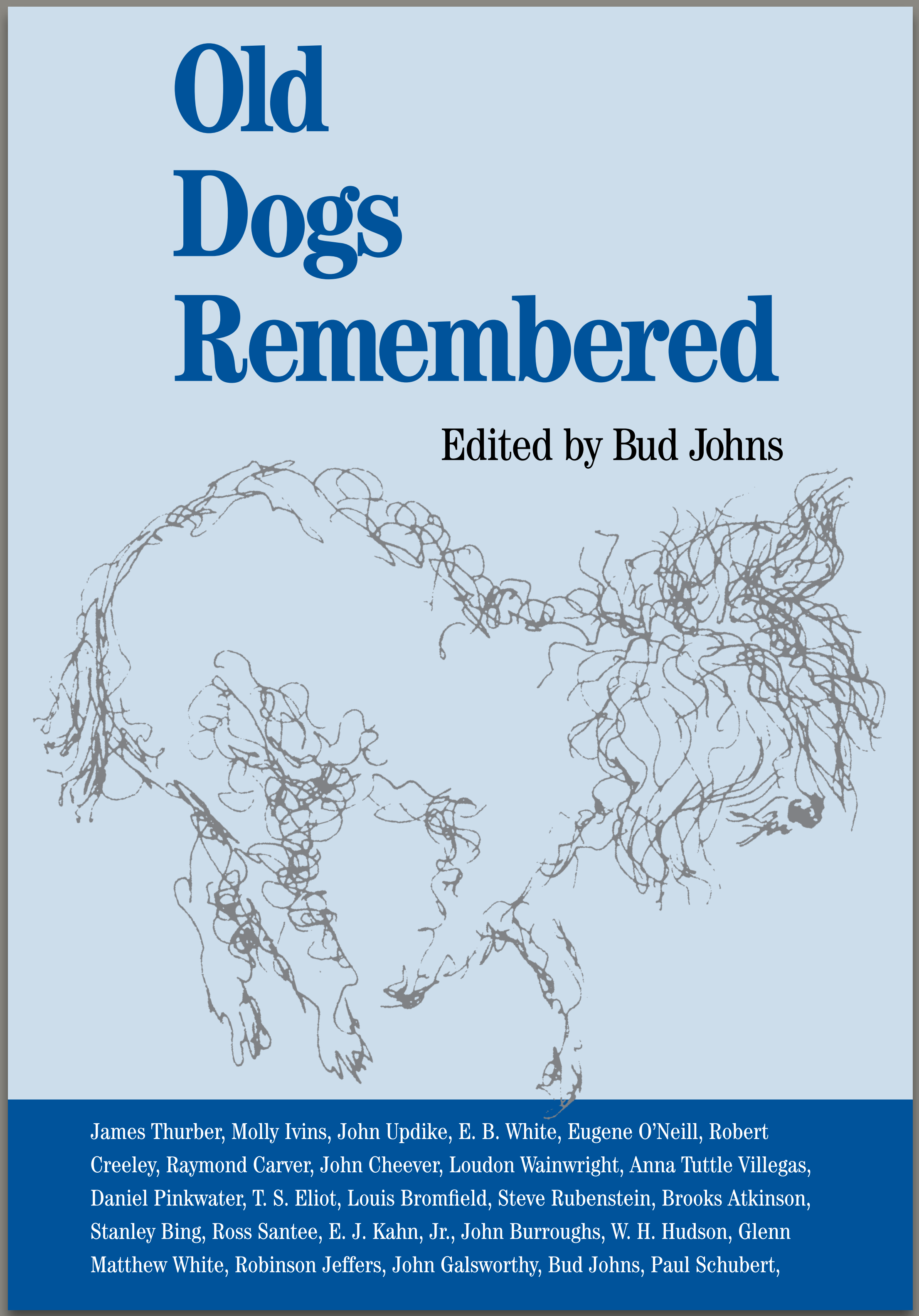

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