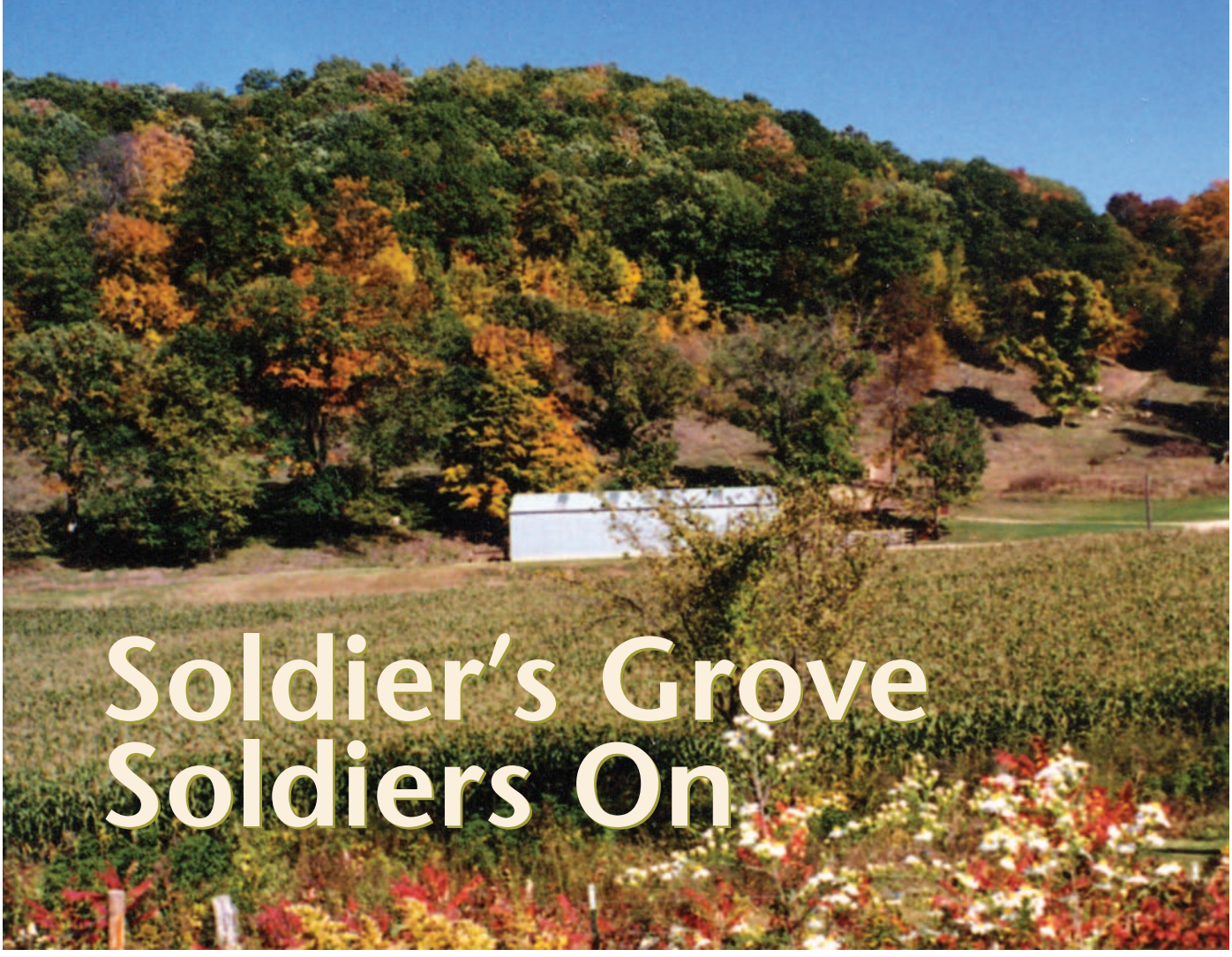

PETE KNAPIK

Soldier's Grove Soldiers On

Take a Back-to-the-Future look at this Wisconsin town 25 years after it re-created itself with a solar-heated commercial district

by Drew Gillett and Nick Pine

Twenty-five years ago, the residents of Soldier's Grove, Wisconsin, decided to move their town's commercial district to avoid damage from recurring floods, and they chose to heat their new commercial buildings with solar energy. Today, most of the solar buildings are still going strong, but some are not. There are valuable lessons to be learned from what worked and what didn't.

Creating a Solar Town

Near Soldier's Grove (pop. 622), the Kickapoo River winds its way through southwestern Wisconsin. After the river flooded in 1907, 1912, 1917, 1935 and 1951, the town rebuilt itself just as it had always been. But, after the 1978 flood and an offer by the Army Corps of Engineers to build a $3.5 million dike to protect the town's $1.1 million worth of commercial property, the townspeople decided that this time they would re-create rather than restore their town.

"Soldier's Grove is an excellent example of people's willingness to innovate in a tough time," says William Becker, the U.S. Department of Energy's (DOE) Denver regional renewable energy director.

DREW GILLETT

Above: Fall colors abound in the hills of rural Soldier's Grove near The Inn at Lonesome Hollow Bed and Breakfast. Inn owners Pete and Nora Knapik helped the authors to prepare this retrospective of Soldier's Grove. Aerial: Soldier's Grove, Wisconsin, (pop. 622) is located near the Kickapoo River and the Ocooch Mountains of southwest Wisconsin.

The creative and independent people of Soldier's Grove decided to move the town's commercial center to higher ground a half-mile south of the old town center. Besides the obvious desire to stay out of the flood plain, they wanted to increase tourist traffic. They chose to relocate adjacent to U.S. Highway 61—the main road from Lacrosse, Wisconsin, to Dubuque, Iowa. It was a sort of homecoming—in the 1950s, Soldier's Grove had been located along Route 61 before the highway was rerouted.

Solar Pioneers in 1978

In 1978, after two energy crises and with oil projected to be at $8 a gallon within 20 years, Soldier's Grove decided to "go solar" and keep energy dollars local, despite a study by DOE's Argonne National Lab in

Argonne, Illinois, that instead recommended installing a wood-fired central heating system in the new town.

Once the town committed itself to using solar energy, it passed some heroic laws. According to DOE, Soldier's Grove enacted the nation's first ordinance requiring new commercial structures to use solar energy to meet at least half of their heating energy needs. Another law prohibited any new building from shading any part of an existing building or parcel from 9 a.m. to 3 p.m. on the winter solstice. And new commercial buildings were obliged to use enough insulation to limit the maximum heat loss to half of the state's mandated limit at the time. As a result, Soldier's Grove has many earth-bermed buildings with walls insulated to R48 and ceilings insulated to R72. The town also passed laws that mandated earth-tone colors and tasteful signs on building exterior, and required handicapped access as early as 1978.

Solar Nonchalance in 2003

After 20 years of solar excitement, one might now describe the mood in Soldier's Grove as "solar nonchalance."

Oddly enough, none of the houses in town appear to have any form of solar heat, despite the fact that the townsfolk have been using solar energy in their commercial buildings for two decades. And while eight of the 10 solar buildings profiled by Michael Schofield in his 1991 master's thesis, "An Economic Evaluation of Solar Energy at Soldier's Grove," (see Project Details, page 36) are still solar heated today, the first three appear to get less than half of their heat from solar energy, and the first four appear to be underinsulated. In addition, some of the systems need minor maintenance. And, to compound the situation, in today's difficult job market Soldier's Grove often grants exemptions from compliance with the solar-heat law to new buildings that offer employment opportunities for the community.

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Building Performance Update

If Soldier's Grove were to receive a solar report card today, it might say "Needs Improvement." For example, of the buildings studied by Schofield in 1991, the Taylor Street Tap now has a nonsolar addition, and rental units have replaced its passive solar windows and cathedral ceilings as the practical needs and priorities of the owners have changed over time. A newer ambulance building now partially shades the older fire station's south wall, with automatic (now manual) thermal curtains. And the Wonder Bar's hydronic system, which was shut down for a minor plumbing problem a few years ago, was never repaired. The space that used to contain its pumps and controls is now used for storage. On a more positive note, John's TV still keeps warm with solar heat from its 354-cubic-foot rock bed.

Of the solar buildings not studied in 1991, most are still going strong. The Soldier's Grove Community/Library building is still solar-heated and daylit. Its "solar

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Above: Soldier's Grove town clerk Ardelle Knutson demonstrates the window quilts near her desk in the community building.

Top right: Building occupants, including the IGA supermarket, do not use the majority of the attic space north of the solar-attic walls (below the ridgelines). The townspeople could have created more useable space by building shallow, vertical "solar attics" under monoslope roofs.

Right: The 7000-square-foot IGA's combined electric and gas bills now average $16,478 a year, which is 32 percent less than the store's owner pays for gas and electricity for a 5000-square-foot nonsolar building nearby.

attic" has sloped fiberglass glazing in place of some of the brown shingles on its steep south roof, and sun shines into the empty attic with a black drywall floor and a black wall under the ridge. On sunny days, a blower moves warm attic air down into the building and stores heat in hollow concrete blocks under the slab floor. At night, motorized one-way dampers keep warm building air from escaping through the attic. And the folks in the 16 Golden Acres apartment units enjoy their daylighting and Trombe walls and use their thermal shutters on a daily basis.

PETE KNAPIK

While the People's Bank is daylit, occupants tend to leave lights on during the day and only close thermal curtains on bitter cold days.

On the other hand, the American Legion removed its tavern's sunspace because of wood rot, and the owner of the Mobil station rebuilt it as a nonsolar structure after problems with condensation. The Burkum Hardware and Swiggum Repair ground-level air heaters are still working well, despite broken glass (from snow and lawn mowers) that has not been replaced. And while the Soldier's Grove Post Office and People's Bank are daylit, and the buildings store heat in simple slab floors, the occupants tend to leave lights on during the day and only close the thermal curtains on bitter cold days.

Other solar buildings in town include a duplex apartment, an office building, a storage building and a karate studio. There's a new nonsolar car wash and two nonfunctioning solar water heaters on a home west of U.S. 61. Two other water heaters planned for commercial buildings were never installed, and the Wonder Bar's heat-pump water heater has been removed. It is also interesting to note that the very first building in the solar town (a dental office now owned by the Community Development Corp.) has yet to receive its solar glazing.

Lessons Learned

A review of Soldier's Grove's solar experiences yields some obvious lessons. First, avoid contractual problems. For example, Burkum Hardware might have solar hot water today if the plumber hadn't gone bankrupt and disappeared with the plans. The medical center had an alleged problem with its architect that kept its solar water heater from being installed. And poor design or workmanship caused problems at the American Legion and Olsen's Mobil.

The second lesson concerns the use of space. Most of the solar attics in Soldier's Grove are unused for anything but heat collection because they get too hot—reportedly 180° Fahrenheit (F)—and pop thermometers and melt Wisconsin-man-

Soldier's Grove Solar Buildings

PROJECT DETAILS

Michael Schofield's 1991 master's thesis, "An Economic Evaluation of Solar Energy at Soldier's Grove," studied 10 solar buildings: the pharmacy, medical center, fire station, Taylor Street Tap, Wonder Bar, Dryad Woodworks, Burkum Hardware, John's TV, Swiggum Repair and the IGA supermarket. And while eight of the 10 buildings are still solar heated, the first three seem to get less than half of their heat from solar energy, and the first four appear to be underinsulated. Below is a chart of performance data for each of these buildings:

SOLDIER'S GROVE SOLAR BUILDING PERFORMANCE 1991-PRESENT

Building name	Building area (sq. ft.)	Collector type (1)	Collector area (sq. ft.)	Heat storage (Btu/sq. ft of collector)	Building heat loss (Btu/sq. ft. per degree day)(2)	Solar heating fraction (percent) (3)	Collector yield (000s Btu/sq. ft. of collector per year)(4)	December load ratio (5)	Cost per sq. ft. of collector ($)	Simple payback (in years)	Solar heated
Pharmacy	2271	SA	640	33	5.6	38	59	0.9	16.	36	Yes
Med Ctr.	2500	SA	768	23	6.9	35	60	0.8	16.	23	Yes
Fire	5640	PW	1000	67	9.2	46	177	0.3	27.	20	Yes
Taylor	2620	PW	284	-	11.0	51	401	0.2	31.	10	No
Wonder	2400	SW	360	17	0.3	100	16	8.6	58.	181	No
Dryad(6)	1350	SA	528	13	1.7	66	22	4.0	19.	44	Yes
Burkum	4800	VA	333	-	1.8	100	200	0.6	24.	16	Yes
John's	2800	SA	454	16	2.7	73	92	1.0	32.	47	Yes
Swiggum	4920	VA	276	-	4.0	59	324	0.2	22.	9	Yes
IGA	7040	SA	1512	-	0	0	0	0	5.	inf.	Yes

Notes:
1. Collector types are VA = vertical air, PW = passive window, SA = sloped air or solar attic, and SW = sloped water.
2. Compare building heat loss to the insulation law's max 4 Btus per sq. ft. per degree day.
3. Compare solar heating fraction to the legal minimum of 50 percent.
4. Most of the town's solar collectors follow a familiar rule of thumb: they produce the heat equivalent of about one gallon per year of oil heat per square foot of solar glazing. Yet, the Swiggum and Taylor buildings appear to offset more heat than the total amount of sun that falls on them in the winter, according to National Renewable Energy Laboratory (NREL) weather data for nearby Madison, Wisconsin.
5. The December load ratio is the ratio of the gross solar-collector gain to the building heat loss on an average December day.
6. The Dryad building appears to collect and store four times more heat than it needs on an average December day, yet it is less than 100 percent solar heated.

dated heat detectors. In addition, building occupants do not use the majority of the attic space north of the solar-attic walls (below the ridgelines) except for the pharmacy, which has office space in its attic, and the Dryad building, which has an apartment upstairs. In hindsight, they could have created more useable space by building shallow, vertical "solar attics" under monoslope roofs.

In another example of 20-20 hindsight, the shading of the older firehouse by the newer, nonsolar ambulance building is unfortunate in a town with a limited number of good solar building sites. Much of the town is already partially shaded by 300-foot-high hills with 60-foot trees on top. This site-shading problem originally led building owners to look upward for solar solutions, which, again in hindsight, may not have been the best solution. Owners installed solar attics instead of systems with glazing closer to ground level that might have used less electrical power for blowers, delivered lower operating costs and a higher coefficient of performance and provided an opportunity for greater architectural diversity in the town.

Building heat storage could be better. The pharmacy's retrofit AC system cools its rock bed in summertime, which hurts efficiency. And the Schoville duplex has a Trombe wall below and eutectic salts above in its attic. This extra thermal mass tends to cripple solar performance by storing solar heat during the day and letting it leak back out through the glazing at night. It tends to create a constantly lukewarm attic instead of a low-mass attic that gets hot during the day and cold at night. In addition, the uninsulated Trombe walls at Golden Acres might work better as insulated air heaters below ceilings that include thermal mass, or with a retrofit low-e copper foil coating applied to the concrete to reduce heat loss.

Lesson three—create an environment where new laws work together instead of against each other. For example, the Swiss Farms cheese factory was exempted from the solar-heat law because of the internal heat gain from its dairy equipment. It appears that the IGA supermarket should have been exempted as well because of heat gain from its refrigeration equipment. Without the insulation law (which appears to save more energy than the solar-heat law), the IGA's huge solar attic might have worked harder with a shorter payback time. For the first few years, the IGA's backup gas furnace was never lit. The 7000-square-foot store's combined electric and gas bills now average $16,478 a year (mostly for electricity), which is 32 percent less per square foot than the $17,335 the store's owner pays for gas and electricity for a 5000-square-foot, nonsolar store nearby. On cold, sunny winter days, IGA employees in T-shirts deliberately overheat the canned goods with the solar attic's 1512 square feet of glazing to ensure the store is still warm the next morning.

Less obvious lessons include looking at the impact of separating a business community from a residential town center and creating a need for more gasoline, which may outweigh the solar heat savings (about 10,000 gallons of oil per year). The town might have saved more fuel by building raised buildings on the old site and placing parking and solar air heaters below. Looking ahead, the payback on most of the buildings might now be improved by installing more daylighting and light-sensitive dimmers and solar water-heating systems that are used year-round. Short-term payback gains might now be realized by repairing the solar water heaters in town that have stopped working—a 1965 Mustang in someone's garage wouldn't be considered worthless just because it has flat tires.

There is also a need in Soldier's Grove for more local understanding of solar technologies and for more regular maintenance of solar equipment. For example, although the medical center owner said his building didn't store heat well because of a design problem, it turned out that it had a separated air duct in the attic. With no instrumentation, it's hard to tell if a "50-percent solar-heating system" stops working.

DREW GILLETT

The Taylor Street Tap now has a large, white nonsolar addition, and rental units have replaced its passive solar windows and cathedral ceilings.

A Valuable Legacy

In some ways, the solar buildings of Soldier's Grove are like war veterans to be revered, respected and taken care of for the outstanding service they performed in the days of 15 percent inflation and oil price shocks. While some have fallen prey to old age, neglect and a government that promised a future but failed to deliver simple follow-up care, most of the buildings are still excellent examples of solar energy at work. The fact that they are still working is testimony to intestinal fortitude, good design and caring owners.

At this point, Soldier's Grove could use some support—perhaps $100,000 to repair existing systems, do blower door testing, remove the thermal mass of decaying attic drywall, change the bare attic surfaces to more efficient transpired-mesh collectors that heat air as it flows through a dark screen, and possibly add water-cooled photovoltaic panels on attic floors with solar reflectors above them. The town could also use some basic instrumentation and major cost-effective improvements like water heaters and daylighting dimmers, and it could promote its solar museum and serve as a model for more solar-heated towns. (While times have changed, some things remain the same—our nation is still in a war for oil.)

The DOE's Becker writes that "the yardstick for measuring whether a project is worthwhile is this: are the community and the world better off than they would have been if the project had not been accomplished?" By Becker's yardstick, the re-creation of Soldier's Grove was, and is, a worthwhile project. ✪

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