PROJECT FOCUS #2

Small Farm Energy Project

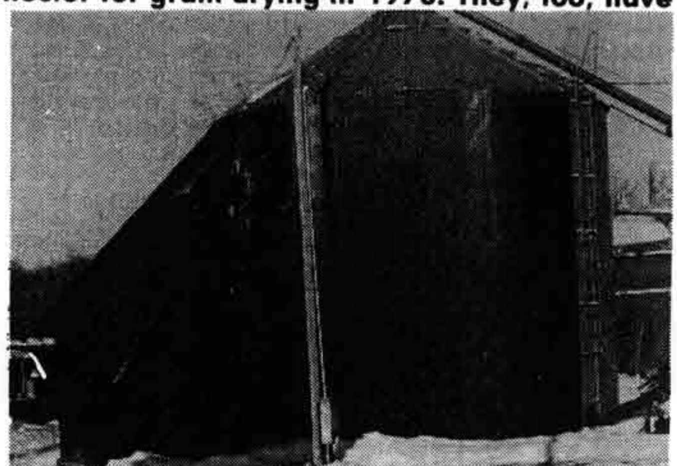
The Fish Solar Grain Dryer

July, 1980
[Revised Edition]

Since the original publication of "Project Focus #2" in January, 1979, Earl Fish used his solar grain drying system in the fall of 1979. Due to the wet fall of that year, Fish filled his 6000 bu. bin with nearly 27% moisture corn, although moisture levels should be limited to about 22%. Warm winter weather conditions did cause some damage to the corn. In previous years, Fish had no difficulties with drying corn under 22%. Farmers should not exceed such moisture limitations for solar drying; results indicate that solar grain drying can be used successfully when used properly.

Many farmers in Northeast Nebraska are considering the possibility of Solar grain drying, thanks to the efforts of Earl Fish of Belden, who likes to tell everyone how well his solar dryer performs. Fish, who was skeptical of solar grain drying at first, began harnessing the sun's rays for his 6000 bu. grain drying bin in the fall of 1977. He was the first cooperator of the Small Farm Energy Project to install a major solar innovation. In his grain drying operation, Fish had used propane in prior years, but not from 1977-1979. He figures that the solar system, costing less than $500 to build has saved him over $100 per year in drying costs.

Two other cooperators of the Energy Project, LaVern Truby and Edgar Wuebben of Cedar County, followed the example of Fish by building their own versions of a solar collector for grain drying in 1978. They, too, have reported success.



-The solar grain dryer at the Earl Fish farm is mounted on a 6000 bu. bin. Construction cost was under $500 and has saved over $100 per season in energy costs. Air is drawn under the black collector plate from the north side of the collector. The fan housing on the left directs solar heated air into the grain bin. Fish did have a slight problem with paint adhering to the metal at the top of the fan housing. Thorough cleaning and etching of the galvanized metal is important before the paint is applied. Primer is also now recommended, but was not used on the Fish collector.

The Fish Farm And Solar Dryer

Grain and Livestock Farm

Earl Fish is a jovial fellow who farms 380 acres in south central Cedar county. 250 acres are in grain crops. Beef and dairy cows are a part of the farm, and Fish feeds hogs and cattle. Corn is harvested using a combine.

Earl Fish and his wife, Dolores, have several sons who have moved off the farm. Bonnie and Brian are still at home and Brian is considering staying on the farm. **The solar grain dryer is just part of the energy saving program** of the Fish family. Dolores has talked Earl into building a **solar and wood heated greenhouse** attached to their home. The greenhouse was completed in the fall of 1978 and **provides supplemental heat to the home**, cutting down on propane use there, too.

The Grain Bin

The **6000 bu. bin** of the solar drying system is 24 ft. in diameter with 19 ft. sidewalls; it is equipped with a stirrator and conventional drying floor. The bin **uses a 7.5 h.p. drying fan** with capacity of an estimated 7500 to 9000 cu. ft. per min. air flow.

Collector Construction

The Fish "bare plate" **solar collector was completely home built** using materials available from local lumber yards. The collector is mounted over the south two-thirds of the bin wall. It was constructed by bolting **1"x2" lumber as horizontal firring strips** over the bin wall. A second 1"x2" board was nailed to the first layer with ring-shank nails. **Galvanized corrugated sheet metal was then nailed over the lumber and painted flat black as the collector plate.** A housing, 6 ft. wide and extending 10 ft. from the bin, was also built around the fan located on the south side of the bin. Air is then drawn from the north side of the bin, through the 2" space between the bin wall and collector plate, and to the fan housing. As the air passes behind the collector plate, it is heated before being directed to the grain. The air space was sized to provide an air velocity of 1000 feet per minute.

-Earl Fish, right, of Belden, Nebr. has talked to many neighbors and farm visitors about the 2-year success of his solar grain dryer in the background. Fish was the first cooperator of the Small Farm Energy Project to install a major solar innovation.

Four neighbors and friends helped Fish at various times during the construction of the solar system.

Energy Savings & Solar Research

Energy Use In Conventional Drying

"Energy required for drying corn often exceeds the total amount required for preparing the seedbed, planting, cultivating, and harvesting the crop," reports a Nov., 1976 USDA and ERDA publication on solar grain drying. It suggests that "low temperature drying" by natural air or solar heated air can save considerable energy, when compared to "high-speed drying", which normally makes use of propane or electric heat.

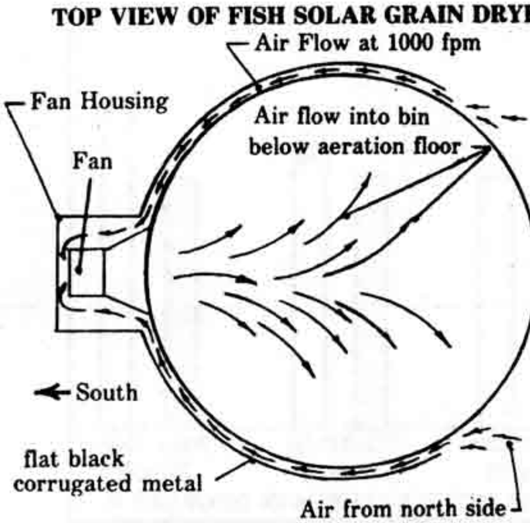
Low Temperature Drying

The objective of low-temperature drying, as in solar drying, **is to lower the relative humidity of air through the bin by raising the temperature from five to ten degrees [F.].** This takes advantage of the natural drying capacity of air. Only 1200 Btu's are needed to remove a pound of water by natural air compared to the 2000 to 3000 Btu's used in "high-speed, high-temperature drying," according to Wm. H. Peterson in his report, "Low-Temperature Drying".

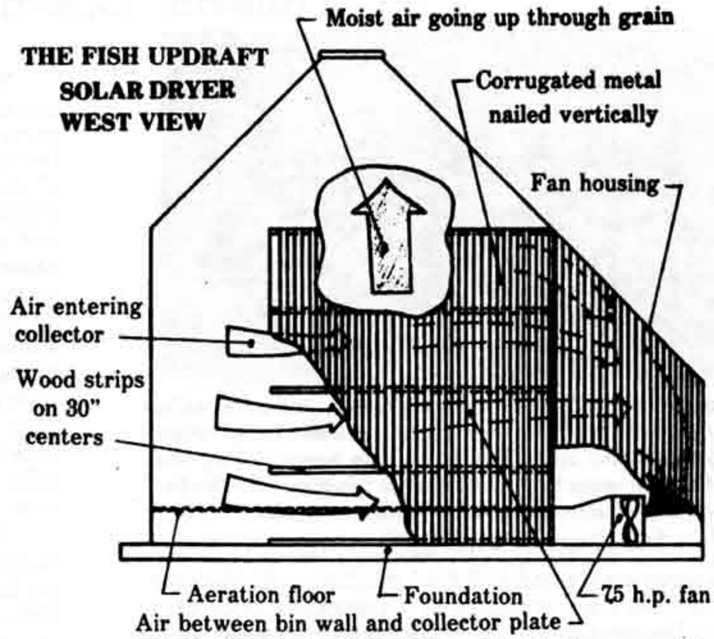
Energy Savings With the Fish Solar Dryer

Nearly 10,000 bu. of corn were dried by Earl Fish in his solar system in 1977, 11,000 bu. in 1978. The first 6000 bu. of corn dried went into the bin averaging about **21% moisture;** some was as high as 23% in 1977, drier in 1978. **The first 6000 bu. of corn in 1977 was dried to 15% moisture in 11 days.** Fish compared his results with a neighbor using propane to dry a similar batch of corn with the same moisture, but in 6 days. **Fish estimated that he saved nearly $100 in drying costs.** In his calculations, he included the cost of running the fan extra days over the time that would have been required for propane drying. The total season fan cost was estimated at $50 in 1977 and determined from extra power used in October when

TOP VIEW OF FISH SOLAR GRAIN DRYER



THE FISH UPDRAFT SOLAR DRYER WEST VIEW



compared to September and November when the fan was not in use. "I was surprised at the savings," Fish comments.

In 1979, Fish harvested corn at over 26% moisture and did have corn damage. Moisture levels should be limited to about 22% maximum.

The solar system used by Earl Fish was **built from plans available from So. Dakota State U.** and developed by extension engineer Bill Peterson. Peterson has conducted farm research on solar dryers in So. Dakota for a number of years. Like Fish, Peterson indicates an annual savings of around $100 for a solar system on a 6000 bu. bin, based on 2 cents per kwh of electric heat.

Solar Monitoring

Several factors complicate the testing of a solar grain dryer including the amount of grain in the bin, the moisture content of the grain, relative humidity and temperature of air, the rate of air flow, the "heat front" passing through the grain as drying begins, etc. As a result the Energy Project used a simple test for the grain dryer by **calculating the amount of heat added to the air going into the collector and noting the change in relative humidity by solar heating.** The number of days needed to dry the grain to the desired level was also recorded.

In 1978, Fish began combining corn at 20% moisture on October 2nd. He filled the 6000 bu. bin by October 10th. On October 14th he transferred 4000 bushels of corn at 15.9% moisture to another storage bin. Under the condition of a clear and sunny day, **the collector gave an average noon temperature rise of 11 degrees and a relative humidity drop of 27%.** The fan motor adds some temperature rise also.

The System Cost and Payback

Dryer Cost

Actual cost of materials for the system was under $500. Most of the materials were purchased new. However, the lumber for the fan housing was recycled from an old building that Fish razed several years ago. If all new materials would have been used, the cost would have been just over $600. "It would probably cost $1000 if built commercially," Fish estimates. One manufacturer reportedly is selling units for even higher prices. **Fish did most of the work himself, and in his spare time over a period of several weeks.**

Five Year Pay-back

Using Fish's estimate of $100 saved in drying the season's first 6000 bu. of corn, and a solar system cost of $500, excluding labor, an **excellent pay-back of five years is realized. Fish has, however, dried more than a batch of 6000 bu. per season, which improves the cost effectiveness.** Usually, though, the second filling of the bin requires less drying time due to dryer grain conditions with the later fall harvest.

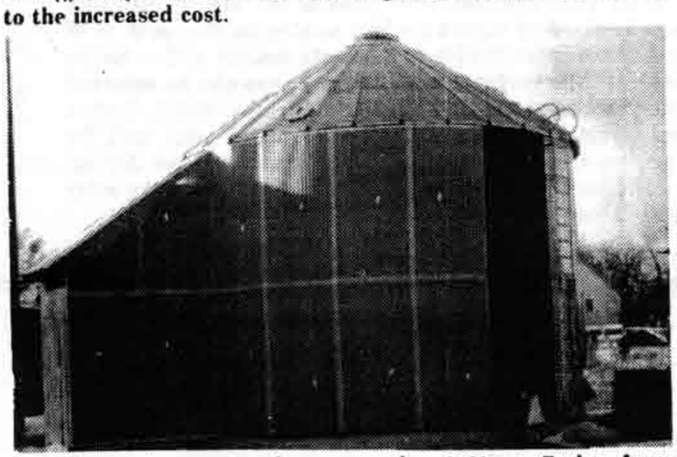
Through the Energy Project, Fish received over 50% cost share as an incentive to test and demonstrate the solar system. Therefore his pay-back is actually half of the above figure.

Energy cost increases will improve the cost effectiveness even further. New tax credits on solar equipment can perhaps also be applied to lowering the cost. Obviously, it can be shown that the home-built solar grain dryer will certainly pay for itself in 5 years or less.

Variations Of Solar Drying

Fiberglass Cover Used

LaVern Truby's solar grain dryer and bin are very similar to that of Earl Fish. **Truby**, however, **volunteered to test a new concept in the Energy Project's research efforts**, and to learn something himself. In the Truby drier, the **corrugated sheet metal collector is covered by Filon fiberglass glazing. Increased collector efficiency was shown in test results, but only in several degrees of temperature rise**, compared to the Fish dryer. **The cost of the system was nearly double** that of the Fish system, and labor was also considerably more for building the collector. Although the efficiency is higher and although testing of the system was limited to only several days in 1978, **the Energy Project is not recommending the fiberglass cover, due to the increased cost.**



-The solar grain dryer on the LaVern Truby farm incorporates a fiberglass cover over the corrugated black metal collector plate shown on the north and right side.

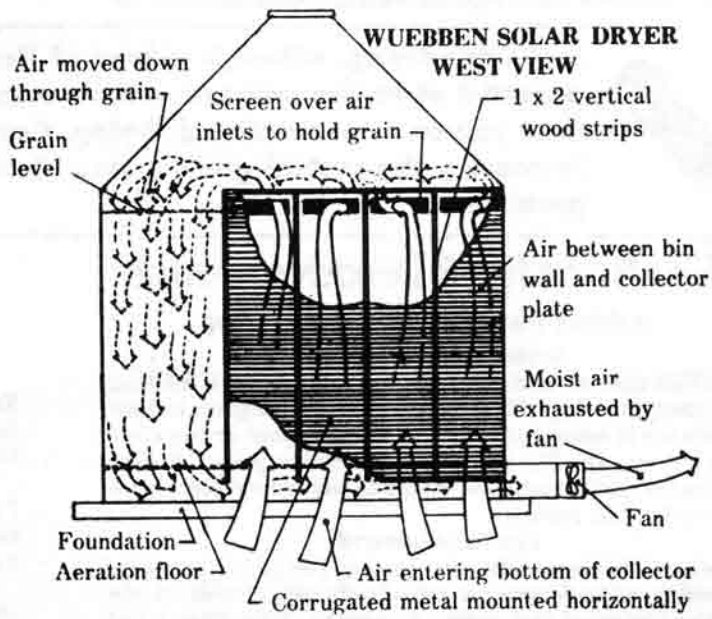
-LaVern Truby, above, installs wood strips over the solar collector plate on his 6000 bu. bin, while Dennis Demmel of the Energy Project assists. The 1 x 2 wood strips were used to support a fiberglass cover. Similar wood strips were used under the corrugated metal plate. The strips were soaked with water for improved flexibility before bolting to bin.

-Don Wuebben, right, is shown preparing the corrugated metal of the Wuebben grain dryer for painting. The photo shows 7" holes in the top of the bin wall before it was covered by the last sheet of metal. The front-end loader on the right speeds up construction. Air enters the collector at the base of the wall, and travels up the wall before entering the bin. The corrugated metal is mounted horizontally to the single, vertical 1 x 2 strips shown, using #10 x ¾" screws. The roof in this bin did not allow for condensation to leave at the eaves; that is another reason for keeping the reversed air flow.

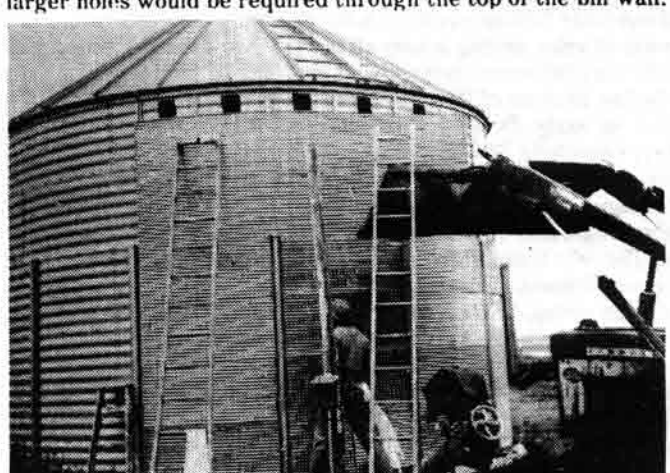
Downdraft or Reversed Air Flow

Edgar Wuebben and sons, Don and Terry, were confronted with several obstacles to installing a solar collector to their 3500 bu. aeration bin. **The fan** pulls air from the top of the bin, through the grain and then **exhausts the moist air to the outside. Exterior vertical reinforcing channels on the bin wall** did not allow for using the design used by Earl Fish. The Wuebbens contemplated the situation for several weeks. Don finally came up with the final design idea. He suggested **cutting holes in the top of the bin walls to draw air from the outer walls and into the top of the bin.** 7" square holes were used.

Air is then drawn from the base of the bin wall, up the wall under the collector plate, and into the top of the bin, before being drawn down through the grain. The Wuebben system has a small ½ h.p. fan, resulting in a low air velocity in the collector. As a result, the temperature rise is higher than that of the Fish system. The bin has an aeration floor. This is more effective than aeration tubes, commonly used for natural aeration, with a small fan and bin as the Wuebbens use. Edgar Wuebben has considered a larger fan, but he notes that the small fan has served his style of operation well for several years. Grain moisture is limited to 20% maximum moisture, and when it is that wet, the bin is not completely filled.



The Wuebben dryer was built for under $200 using old sheet metal. The chief advantage to the design is that it requires no fan housing, and is therefore less expensive. The design, however, may not work well with larger drying fans, because larger holes would be required through the top of the bin wall.



Options To Solar Drying

Natural Aeration

Some researchers indicate that **natural air drying may be sufficient to dry grain in areas like Nebraska without solar drying.** East of the Missouri River, humidity levels are higher, requiring more energy in drying; therefore solar drying can be more beneficial in those areas. Natural drying by aeration without any additional heat may require more fan time and electricity, however many farmers are using this method successfully. Local extension offices have fliers available on the topic.

Harvesting in the Ear

Of course, **another option** in grain drying **is to harvest corn in the ear,** which is an additional method of low-cost "natural" drying. Harvesting in the ear was prominent in the past, but the change was to harvesting in the shelled form due to the capability of lowering field losses when harvest is done at higher grain moisture levels. Convenience was another factor in shelling corn in the field rather than from corn cribs. However, the economics of field losses and energy for drying grain at higher moisture levels may have reversed. **Using "natural aeration" or solar drying** for shelled corn **still uses the electrical energy to run fans, which can be saved if corn is harvested in the ear.** However some regional weather conditions may not allow for ear corn harvest.

High Moisture Storage

High moisture storage, although more costly in capital investment, is yet another option to drying. It **has very low energy costs,** but usually limits use of the grain to the farm feeding operation rather than marketing it.

Considerations For New Grain Bins

The Energy Project has been advising farmers, bin contractors and USDA officials of certain considerations that should be made for new bins, with the **option of adding solar drying equipment in the future.** Here are several. 1) The bin should be located such that **no other buildings or trees to the south obstruct the low sun** of fall harvest season. 2) The **fan is** usually best located **directly south** of the bin, for consistent draw of air from east and west sides of the bin. 3) **Entrance doors** and unloading augers are best located **on the north ⅓** of the circumference of the bin to eliminate conflict with a future collector. 4) **Solar systems for drying grain can also be mounted on other buildings,** including machine sheds or shops. Such a system would allow for "multiple use" of the solar unit for heating shop areas or swine houses, in addition to grain drying. Cost effectiveness is therefore enhanced by utilizing the solar unit over a longer period of the year.

Solar drying, although a form of "low-temperature" drying, has the potential of saving propane and electrical energy, commonly used as a heat source in conventional drying. Costs of both fuels are escalating, increasing the cost of grain drying. Solar drying is one answer to the problem.

Other Benefits & Disadvantages

Added Benefits Of Solar Drying

Grain Quality Improved

Earl Fish cites several advantages of solar drying in addition to the energy savings. **"The quality of the dried grain is what interests me in solar drying",** he says. High speed drying often damages corn. Quality grain brings a better price. "A local cattle feeder said he would be willing to pay several cents more per bushel," Fish reports.

Fan Noise Lowered

Another advantage of the solar system, Fish points out, is **the fan housing,** which **lowers fan noise levels considerably.** "I like it for the control of that noise," he reports. "One drier a half mile west of me makes more noise than mine," Fish adds.

Disadvantages of Solar Drying

There are several disadvantages or conditions that a farmer should consider before adapting solar drying.

The use of **solar drying is only effective when the sun shines.** A cloudy wet fall could mean switching back to propane. The solar drying success of Earl Fish was timed with excellent fall sunshine in early October that later turned to wet, cloudy weather, especially in 1977.

Many farms are accustomed to drying several batches of grain a season with high speed drying, whereas **only one batch on the average may be acceptable for solar drying during one season.** The low temperature process of solar drying is essentially a supplement to natural aeration.

Earl Fish notes, **"Fellows who are in a hurry** might want to use their propane heat at night, but for me it worked just fine." He is also quick to point out that **the longer drying time involved is not something a big operator is probably going to stand still for.**

Bin structural variations, as in the Wuebben case, can also cause complications in building a solar collector.

More Solar Dryer Information

References

"Plans for Solar Grain Driers", Agricultural Extension Engineer, So. Dakota State U., Brookings, S.D. 57006, $1. Plans for constructing a solar collector onto an existing round grain bin. These plans are blueprints.

"Solar Grain Drying, Rules of Thumb", Small Farm Energy Project, P.O. Box 736, Hartington, NE 68739. Includes suggestions for air gaps, paint and other construction points. $.50

"Low-Temperature Drying", by William H. Peterson, EMC 660, Ag. Engineering, S.D. State University, Brookings, S.D. 57006. Includes information of fan sizes, "fill depths" for various moisture conditions of grain, and other valuable information on the topic.

"Catalog Sheet of Solar Heated Building Plans", Dept. of Ag. Engineering, U. of Illinois, Urbana, Ill. 61801. The free, 2-page listing describes some 10 plans that are available from the U. of Ill. Costs of the large blue prints are also included. Half of the plans apply to grain drying, using portable collectors, machine sheds, and other buildings as "multi-use" collectors.

"Project Focus #10 - The Young Portable Solar Collector", available from the Energy Project for 50 cents, reports on the 10 X 24 ft. portable air heater used for grain drying and home heating. Construction plans are also available for $2.

"The Return to Ear Corn Harvest", SFEP Newsletter, Sept., 1979, page 5. Floyd L. Herum, Ohio ag. engineer, indicates the reasons why he believes harvesting corn in the ear is in the future. Available for 25 cents from the Energy Project.

Low Temperature & Solar Grain Drying Handbook, MWPS-22, Ag. Engineering Extension, 101 Ag. Engr. Bldg., U. of Nebr., Lincoln, NE 68583, 1980, $3. This 86-page book includes basic solar information and information on low temperature and solar drying, portable collectors, wrap around collectors, collectors mounted to buildings and charts on static pressures.