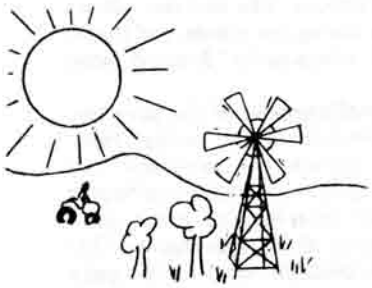


PROJECT FOCUS #1

Small Farm Energy Project

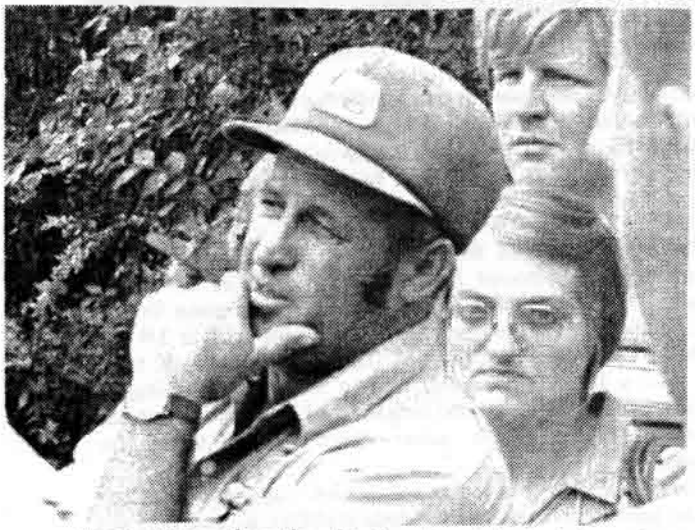
The Kaiser Wind Electric System

JUNE, 1980
[Revised Edition]

"Project Focus" is part of a primer on energy alternatives that would help lower the high costs of energy inputs on small farms. The examples are drawn from innovations built by northeast Nebraska farmers who are participants in the Small Farm Energy Project, a special 3-year research effort sponsored by the Center for Rural Affairs of Walthill, Nebraska and based in Hartington, Nebraska. The aim of Project Focus is to help small farmers discover and develop viable alternatives for their own farms.

The use of wind generators was wide spread prior to rural electrification. The state of the art of wind generation of electricity hasn't changed much since that time because cheap electricity has stalled the development of wind systems.

Although the Energy Project has tended to emphasize home-built energy innovations, the sophistication of wind generating equipment usually requires commercially built systems. The strong interest in exploring the potential of wind energy led to the installation of a commercial wind system by Benny and Shirley Kaiser on their farm in 1978. The wind system has been one of the most expensive energy innovations used by Energy Project cooperators, and it has given a low return on investment. Despite various difficulties with the system, the experience has provided useful information. Wind energy promises to be an increasingly important energy source as wind systems become more refined and as the cost of electricity continues to rise.



—Benny Kaiser describes his farm's wind electric system to a tour group visiting his farm. The wind system has been of interest to many persons in the area, but has been troubled with a series of technical malfunctions. Kaiser and his family have assisted the Energy Project by maintaining records of the performance of the wind system.

Policy Issues

Electric Utilities

The installation of a wind electric system by the Kaiser family represented an opportunity for the Energy Project to demonstrate and study some important concepts in the debate of decentralized versus centralized power in rural areas. It was felt that wind energy is of considerable potential in rural areas, and monitoring equipment was installed to help determine the feasibility of the energy source.

In order to realize the full potential of wind energy, however, it was clear that **various institutional barriers had to be removed or changed.** The newest wind technologies involve connection to existing power lines; most Rural Electric Cooperatives (REC's) and utilities are oriented to centralized power, so their willingness to allow these systems to be connected to their lines is often less than enthusiastic.

Insurance Companies

In addition, the Kaisers encountered **difficulties in dealing with their insurance company.** The wind turbine was damaged at one time by high winds. The Farmers Mutual Insurance Company paid the claim but cancelled coverage of the wind system. The local agent looked over the repaired system, but failed to provide a new policy. The dealer for the wind system identified other insurance companies who would insure the system as part of a whole farm policy, and the Kaisers have considered changing policies.

—Installation of the wind electric generator is shown on the left. A crane was used to place the generator, manufactured in So. Dakota, onto the top of the 54 ft. single pole tower. A later model of the generator was installed using a "gin pole". The steel tower was a contribution of Valmont Industries. The local REC has cooperated in allowing connection of the wind system to REC lines. The wind system was one of the most expensive innovations installed by Energy Project cooperators, and has provided a low return on investment. However, wind systems may play an important role in the future of supplying electricity to farms, especially as electric prices continue to rise.

Wind Equipment & Costs

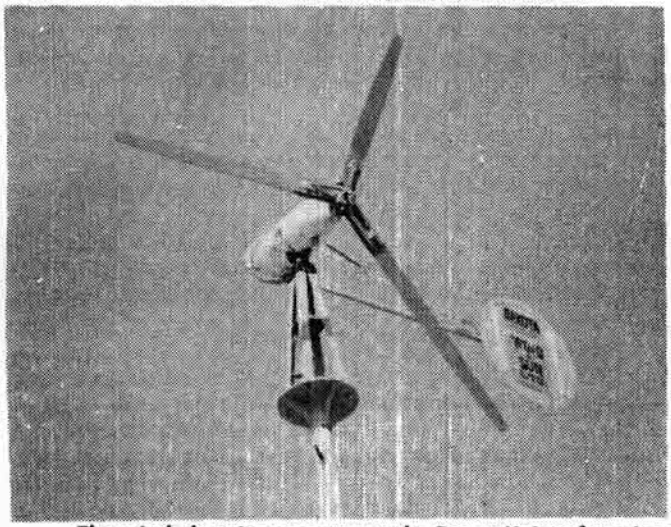
The Kaiser wind system consists of a direct drive, DC generator; a Gemini synchronous invertor, which allows utilization of local REC power lines for "storage"; and a tower made of a single steel pole without guy wires.

The Generator

The wind generator is a version of the old Jacobs Wind Electric System, now being manufactured by Dakota Wind and Sun Ltd. in Aberdeen, S.D. **The generator has** been modified to increase its output capacity to 4 kilowatts (kw), which is reached in winds at or above 25 mph. The original Kaiser generator was not designed for use with the 4 kw Gemini Invertor, and, in addition, **the brush holders failed shortly after the wind system was installed.** As a result, the generator was subsequently replaced with an appropriate generator.

Three blades made from Sitka Spruce provide a rotor diameter of 14 feet . The rotor utili zes a blade actuated centrifugal governor so that when the wind increases, the centrifugal force causes each propeller blade to turn such that the force of the wind upon the blade is reduced. This feathering mechanism is designed to prevent damage during high winds. The tail vane of the wind system is connected by a cable to the base of the tower. Normally the tail is held in the off position by this cable, and must be cranked into the wind in order to activate the system. This is an important safety feature; if the cable breaks, the wind generator will return to its normal off position instead of remaining in its power position, unable to be stopped.

Soon after the system was installed, **a tornado-like wind** clocked at over 100 mph apparently succeeded in moving the tail from its normally "off" position and slamming it into the blades, **bending the tail and breaking one blade.** The manufacturers described it as a freak incident, and the system was eventually repaired. The Kaisers have also experienced difficulties with the cable controlling the tail mechanism.



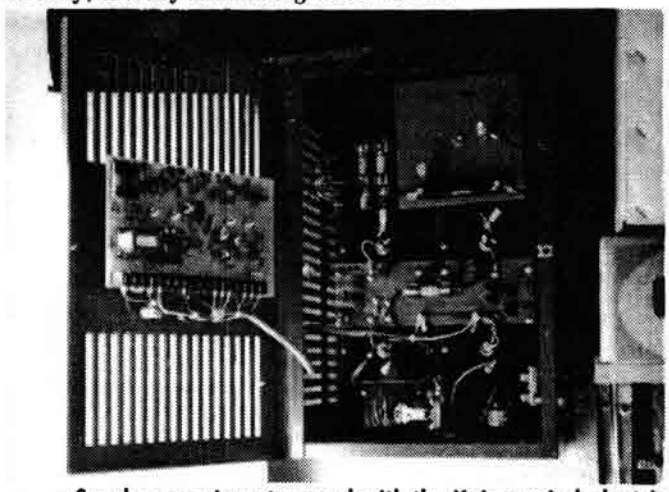
—The wind electric generator at the Benny Kaiser farm is a 4 kw generator using a three-bladed turbine. It was manufactured in So. Dakota. This photo shows the tail folded in the "off" position for severe weather protection. The generator pivots on the stub tower, which is bolted to the single pole, steel tower.

The Synchronous Invertor

In the past, batteries had to be utilized for storage with wind systems to assure a constant and regular flow of electricity, since wind power is irregular due to fluctuations in wind speeds. **The synchronous invertor takes the variable voltage DC current produced by the wind generator and converts it to AC current** matched to the voltages and frequencies of the AC power in REC lines. This eliminates the cost, maintenance, and electrical compatibility problems associated with battery storage systems. **The invertor allows power to be drawn from REC lines during low winds, and it also allows for excess power from high winds to be "dumped" onto the lines.**

There have been **numerous malfunctions of the invertor,** often interrupting electrical production for some time. According to the dealer for the system, the generator and invertor are not fully compatible equipment. There has been a **history of difficulties with similar invertors** on other wind systems elsewhere, and the **efficiency of the conversion** of DC power to AC current is highly **questionable** and could be quite low.

The Kaisers are seriously considering the purchase of an Enertech **induction generator,** which would produce AC power directly, thereby eliminating the invertor.



—Synchronous invertor used with the Kaiser wind electric system. The invertor converts DC current from the generator to AC power for use on the farm. It also allows the farm to use power from the REC, in addition to wind power, during low wind periods.

The Wind Tower

The steel pole and its base bolts, used by the Kaiser system, were contributed by Valmont Industries in Valley, Nebraska. The base of the pole has a mounting plate that is used to bolt the 12" diameter base of the pole to four 1¾"x7' steel bolts embedded in concrete. The pole consists of a 38' tower with a 12' extension and topped with a 4', four-legged generator mount giving a **total height of 54 feet.** The tower has removable step pegs to allow climbing the tower for maintenance.

The manufacturer of the generator has suggested that guy wires be used with the tower to help stabilize it, and perhaps avoid future repeated damage to the tail assembly and rotor.

Initial System Cost

Tower Base, concrete	$90.82
Tower & Base Bolts, contributed by Valmont Industries—no charge (estimated value, $750)	
Top Stub Tower, by dealer, Natural Power Systems—no charge (estimated value, $80)	
Tower Cap, Dakota Wind & Sun, Ltd.	95.00
Wind Turbine and Generator, Dakota Wind & Sun, Ltd.	2,690.00
Gemini Invertor, Windworks	734.00
Sales Tax on above	127.02
Miscellaneous Wire & Hardware	55.66
Labor for Trenching, Installation of Tower & Wiring	105.00
Total Equipment Expenditure	**$3,897.50**

(Note that the above prices are those at time of purchase, Fall, 1977, and subject to extensive price increases.)

Installation & Hook-up

Installation Steps

Site selection was the first important step for best wind reception. Prevailing winds in the area are northwest and southeast, so obstructions of trees or buildings were avoided in these directions from the wind tower location. At the selected site a concrete base for the pole was poured. The REC's boom truck was used to set the pole on the bolts of the concrete base. The wind generator was then placed on the pole by using a "gin pole". The wire from the generator to the synchronous invertor was run down the interior of the hollow pole and then underground to the invertor, which is located inside the house.

A lightning arrester has been installed to protect the system from lightning.

REC Hook-up Procedure

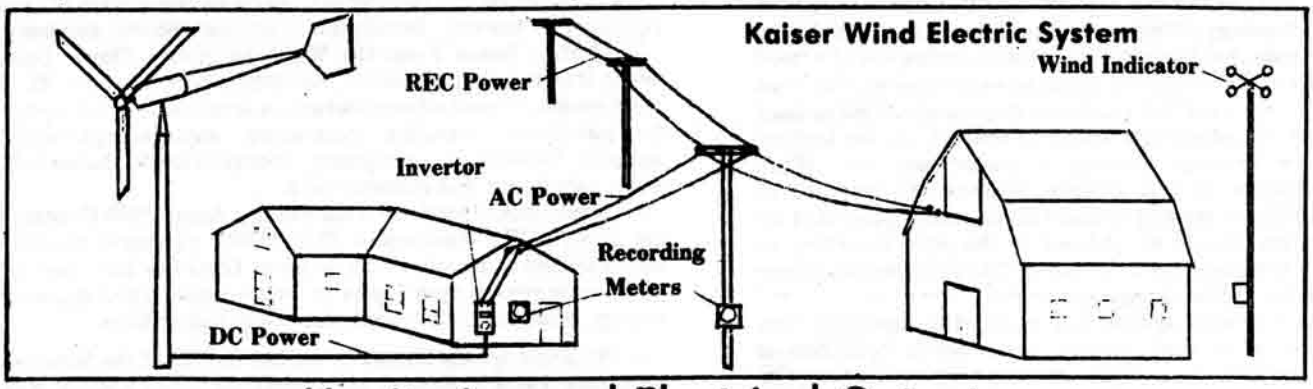
The local REC, Cedar-Knox Public Power District, has cooperated in allowing the wind system to be connected to the local power lines. The process of obtaining this arrangement started during the Spring of 1977 when a Project cooperator approached the manager of the REC to ask about the possibilities of connecting such a system to REC lines. The initial response was that the REC had a contract with the Nebraska Public Power District, which stipulated all REC power would be purchased from NPPD. However, NPPD officials later stated that they had no objections to wind systems as long as their customer, the local REC, agreed to the arrangement.

The REC was then supplied with technical information on the Gemini Synchronous Invertor and several newspaper articles on similar efforts in other areas of the country. One article discussed the court battle in which a New York group won permission to connect a wind electric system to Consolidated Edison's power lines. Verbal approval for allowing the hook-up was shortly received from the district manager, who requested copies of other agreements so that a formal written agreement could be established. The Energy Project provided the manager with various copies of agreements used in other parts of the country.

After more communications with an REC representative on such points as a ratchet meter, a demand charge, and reluctance to credit the farmer for power placed onto the REC lines, the matter was presented to the Board of Directors of the Center for Rural Affairs, sponsoring agency of the Energy Project. They suggested that these issues should be discussed before the REC Board of Directors.

The Energy Project Advisory Committee then made a presentation to the REC Board with the cooperating farmer and Energy Project staff present to answer questions. The manager, who dominated the REC response, explained that **the district's main peak demand occurred during summer months when wind output is low,** and that high winds during the winter would not benefit the district either. The REC, however, agreed to use a Wisconsin **contract** as a model and **required that a demand charge be imposed if the farmer's REC electrical use dropped below a minimum amount.** The REC emphasized that metering equipment, used to determine what value such a wind system is to the REC, would be installed at the expense of the Small Farm Energy Project. The REC cooperated in the installation of the metering equipment.

There have been no technical problems with the interface of the wind system with the REC, according to a utility representative. It appears that electricity has been returned to the REC, though quite minimal. Although **the REC has not credited the Kaisers with electricity returned to the grid,** recent federal legislation obligates utilities to pay customers for power generated by small systems. However, such credits are likely to be priced at near wholesale rates, because of the cost of transmission lines and other equipment maintained at the cost of the utilities.



Monitoring and Electrical Output

Monitoring of the Wind System

On the Kaiser farm, **monitoring equipment was installed to measure the demand and flows of electricity when influenced by the wind generator.** Four factors were investigated: 1) wind velocity 2) AC electricity produced by wind energy 3) REC electricity supplied to the Kaiser farm 4) electricity produced by wind power and placed onto REC power lines. The recording chart meters used to graph electricity to and from REC lines were loaned from USDA through the assistance of Dr. Leo Soderholm of Iowa State U. The magnetic tape recording meter used to measure the production of AC electricity from the wind was rented from NPPD at the request of the local REC.

Electrical Output & Economics of Wind System

The output of the particular wind electric system installed on the Kaiser farm has been less than originally projected by the manufacturer and dealer. As an example, output ranged from 230 kwh in October to 145 kwh in November during 1978, with **an average of 181 kwh/month.** The dealer initially projected monthly output ranging from 300 kwh to 700 kwh with an average of 500 kwh per month. Late in 1978, the manufacturer notified the Energy Project that **300 kwh/month was the most energy to be expected** from the system during months with average wind speeds of 12 mph.

The electrical output by the wind system indicated that the system **will supply approximately 10% of the Kaiser farm's present electrical needs.** Cedar Co. farmers currently pay an average of approximately 4 cents/kwh for REC power. **It is evident that the wind system will require many years to pay for itself.**

Tax credits for the investment in solar and wind systems provide some financial assistance to the farmer wishing to establish such a system. The current credit allowed is 40% on the first 10,000 dollars invested, or a maximum credit of $4000.

Investment credit is also a potential incentive for the wind energy enthusiast where energy is used for a farm or business.

Other Considerations

Difficulties With Wind Power

It may be important for farmers hoping to meet their electrical needs with wind power to understand that many of the wind systems available today were designed to meet farm electric demands equivalent to those prior to rural electrification. Inexpensive REC electricity put a damper on people trying to develop better wind generators. Electric motors, heat lamps and automated pipeline dairies have eased a farmer's tasks, but dramatically increased the demand for electricity. **There has been a lag in the development of wind technology suited to the power demands of today's farms due to the low cost of electricity in the past.**

In contrast to other innovations utilized by Energy Project cooperators, the **wind system is a complex technology.** The Kaisers have not been able to overcome the technical problems by repairing and maintaining the system themselves. **"Getting someone to repair the machine is more of a problem than the wind system itself"**, says Benny Kaiser. Based on the Kaiser experience, other **farmers who are considering wind electric systems might be wise to plan on performing repairs themselves,** at least at the present time when the technology and service are not yet refined.

Future Prospects

The U.S. Department of Energy (DOE) is sponsoring **wind energy development programs** which may result in wind electric systems capable of meeting a larger portion of farm electric needs. At Rocky Flats nuclear processing facilities outside of Denver, Colo., two major wind projects are going on. Commercially available farm-scale wind generators are being tested. Also, wind machine specialists are continuing in the design of improved wind generators rated from 1 to 40 kw.

Although Congress has passed legislation which requires that utilities pay for power dumped onto their lines by other sources, the fact that the rate paid for such energy is left to their discretion perpetuates **interest in alternative methods of storing wind energy.** Windworks, an organization in Mukwanago , Wisconsin, has been looking at the possible use of a **"load dumping circuit."** When there would be excess power, the "load dumping circuit" would be activated, and instead of going back into the grid, the electricity would be utilized, i.e. for heating water, space heating, running a compressor, etc. Windworks' conclusion on this process involves the question of economics. Fifty to seventy percent of the power generated by a wind system should be utilized at the site, according to Windworks, and therefore only about 25% of the surplus power is utilized with a "load dumping circuit."

This type of wind system has no standby capability. One characteristic of a wind system that uses a synchronous invertor is that if for some reason there is no power on the REC lines, AC current is not generated. DC current could be generated for space or water heating. For lighting, however, the wind system no longer has the buffering effect of the power coming from the REC lines. This means there could be a fluctuation in the current received due to the variable nature of the wind. For only limited standby capability, such as for DC lighting, a storage battery could be used to furnish the buffering necessary when there is no power on the lines.

Despite the many potential difficulties that can be encountered with wind electric systems, **it is apparent that wind can be a good source of energy.** This is particularly evident when considering the fact that **wind availability tends to be closely matched with farm demand,** as indicated by farm energy use records of the Energy Project. If, as is assumed, more practical and problem-free wind electric systems can be developed to meet the higher demands of modern farms, wind promises to be an important power source for rural areas. **Reduced demands by farms will also be beneficial to enhancing the potential of wind energy use. Conserving electricity, it should be noted, will still be cheaper than producing the electricity by wind or other methods.**

Other Uses of Wind Power

Many farmers are returning to the use of wind energy for **pumping water** on their farms. This usually requires rebuilding wind water pumps on the farm that have been idle for several decades when electricity was low-cost.

Some individuals have used simple **home-built wind machines like the Savonius rotor,** which is built from old 30 to 50 gallon drums cut in half. The half barrels are used as wind scoops on a vertical axis machine in several tiers. However, experience at the Energy Project indicates that such machines are perhaps over rated.

Wind electric generating equipment that produces a significant amount of electricity is quite sophisticated and, as a result, home-built systems are rare. Considerable knowledge of wind and its properties are required before an individual can build a system. In addition, maintenance of such systems is quite demanding and requires the best of mechanical and electrical talents. However, such systems have been built and utilized from time to time, but are usually not in operation due to technical malfunctions.

Wind Energy References

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Energy From the Wind, by B. Burke and R. Meroney, Colorado State U., Fort Collins, CO 80521,3800 references,$15. Annotated bibliography of journal articles, books, and reports.

The Homebuilt, Wind-generated Electricity Handbook, by Michael Hackleman, Earthmind, 5246 Boyer Rd., Mariposa, CA 95338, $8,194 pages, 1975. This book was designed for small scale applications and includes discussion on restoration of used equipment, towers, installation, control boxes, and more.

Electric Power From the Wind, by Henry Clews, Solar Wind, P.O. Box 7, East Holden, ME 04429, 1973, 40 pages, $2. A brief review of most all considerations involved in wind energy for electricity, including generators, storage, conversion devices, installation, equipment manufacturers, home-built units, calculation and resource lists.

Windletter, American Wind Energy Assn., 1609 Connecticut Ave., N.W., Washington, D.C. 20009, published monthly and provided to members of the Assn. Dues are $25 per yr. Windletter covers such topics as policy issues affecting wind energy, equipment standards, financing, and utilities.

"Utilities Special Report", a special section of the Summer, 1979 **New Land Review** of the Center for Rural Affairs, P.O. Box 405, Walthill, NE 68067. Includes several articles on regulation of electrical rates, effects of utility policies upon rural customers, public power in Nebraska, and also an article on the Kaiser wind system and generation of electricity for utility lines. Write for a copy of this New Land Review. Contributions are welcome.

"Wind Energy Bibliography", Small Farm Energy Project, P.O. Box 736, Hartington, NE 68739, 3 pages, 25 cents. This is an annotated bibliography of various publications on generating electricity with wind, pumping water, home-built systems, policy issues, and more.

For More Information

"Project Focus" is published by the Small Farm Energy Project, a research and demonstration project sponsored by the Center for Rural Affairs and funded by the Community Services Administration. For more information, contact the Energy Project, P.O. Box 736, Hartington, Nebraska 68739, phone 402-254-6893.