Power from the Wind

In our search for new energy sources we might pause to consider an old one

BENGELSDORF: The world is finding out these days what scientists and engineers have known for a long time, that it's not only love that makes the world go round, it also takes matter and energy. All of our energy comes from the stars. Consider the sun—the star that is closest to our planet. The oil, natural gas, or coal we burn today are but the remnants of ancient sunbeams. The sunbeams of today supply us with the food we eat, the fresh water we drink, and the oxygen we breathe. The sun also causes ocean water to evaporate in clouds to fall as rain or snow to fill our lakes and rivers, and as the water of the river flows back to the ocean, it can be made to turn a turbine to provide electricity. We call this hydroelectricity. But the sun also provides the energy to move the air which creates the wind. Can we harness the flowing air as we have harnessed the flowing water that generates electricity? Homer J. Stewart, professor of aeronautics at Caltech, thinks we can.

Dr. Stewart, I understand that there was a project in the United States, and a technically successful project, that did harness the winds to produce electricity. Could you tell us about it?

STEWART: Well, of course windmills have been used to make power historically for over a thousand years, to turn grindstones, pump water, and similar things. Most of these were relatively small windmills—maybe one horsepower or two or three horsepower output. In the late 1930's I participated in a general project to design and build a one-megawatt windmill. This was installed in the mountains of Vermont on Grandpa's Knob, and it was operated for about four years during World War II.

BENGELSDORF: I understand this was at an elevation of about 2,000 feet where some of the wind speeds got up to about 115 mph.

STEWART: Yes. Of course, almost any site that is generally favorable from the wind standpoint is going to be one that periodically has a major storm of one kind or another. So part of the design of any such equipment has to be a protection against excessive winds. In that case we also had icing problems to worry about—which was one reason the windmill was placed at 2,000 feet rather than going higher. There were also some other problems that made the lower altitude look more favorable than the very high mountain regions.

BENGELSDORF: Could you tell us a little bit about this Grandpa's Knob machine? How many blades did it have?

STEWART: It had two blades. They were quite large; the overall disk that the windmill's blades swept out was 175 feet in diameter, and the tower on which it was mounted was 150 feet high. Each of the two blades had a cord of about 10 feet. So they looked more like middle-sized airplane wings than they did like propeller blades, as we normally think of propellers.

BENGELSDORF: So one would think of them as sort of two airplane wings turning around.

STEWART: That's about what it was like.

Homer J. Stewart

"Power from the Wind" is a transcript of a radio interview with Homer J. Stewart, professor of aeronautics at Caltech. This is one of a series of interviews with Caltech faculty members, broadcast regularly (Mondays, 7:15 p.m.) over KPCS (89.3 FM), Pasadena. The program, "Frontiers of Science," is conducted by Irving Bengelsdorf, Caltech director of science communication.

BENGELSDORF: You mentioned that it had a capability of about 1,000 kilowatts (1 megawatt). That would be about 1,000th that of Hoover Dam, at Lake Mead, which is about 1,250 megawatts.

STEWART: Yes, a megawatt is a power unit that is compatible with a small village of maybe 500 or 1,000 people, but it's not compatible with a city. It would probably take hundreds or thousands of windmills of this size to supply the power needs of any large area.

BENGELSDORF: The interesting thing about this Grandpa's Knob project was that it actually did put electricity into the grid of the Vermont electric company.

STEWART: Yes, for four years during the war it actually operated right in with their public power system. Its peak power was a megawatt. Obviously, if the winds aren't blowing you don't get any power, so the average power was about a quarter of its peaks. It averaged out about 240 kilowatts throughout the year.

BENGELSDORF: This project met with a mishap in 1945. Could you explain that?

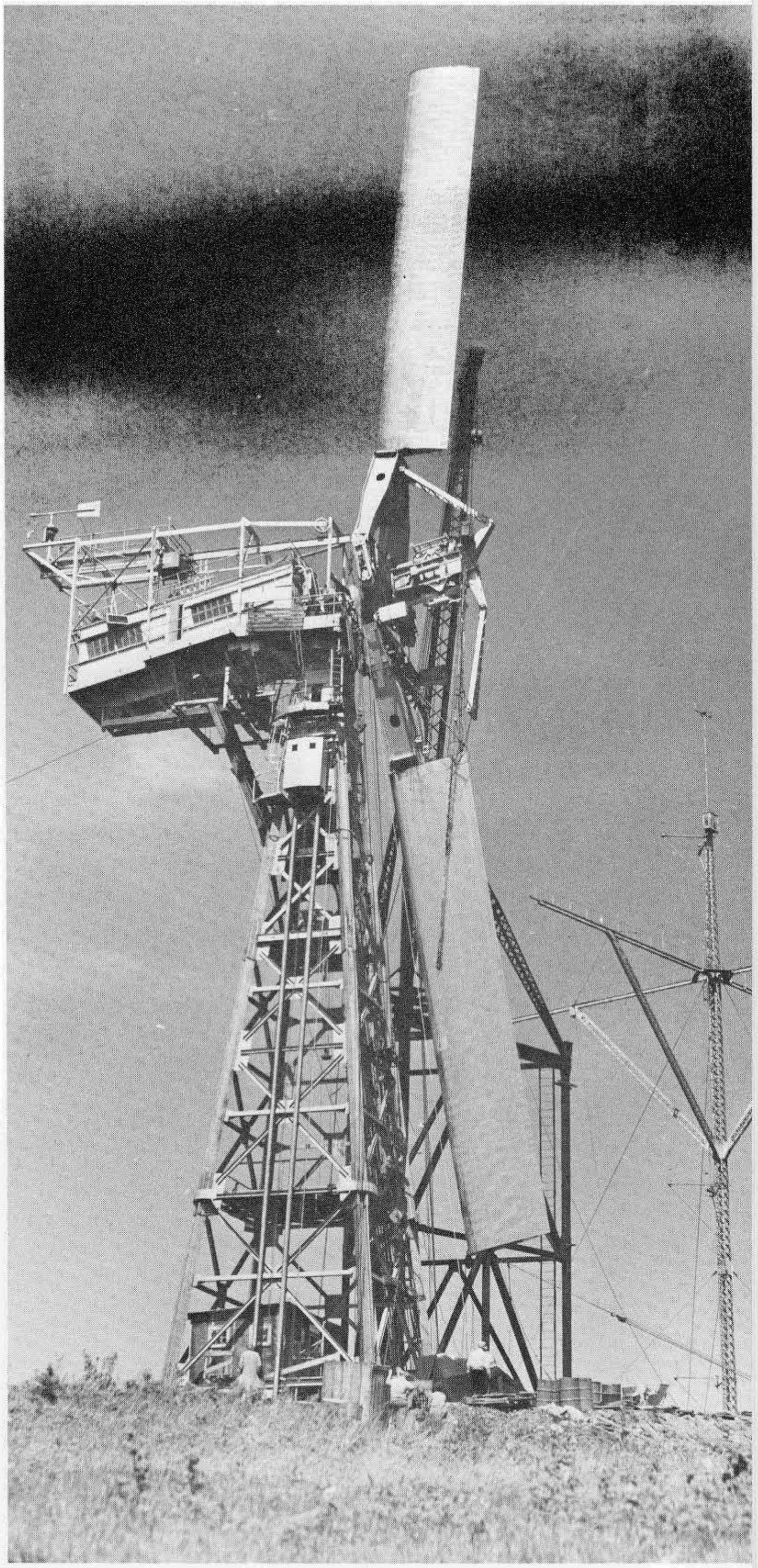
STEWART: Yes. Toward the end of the war the machine was shut down for a period because one of the bearings needed servicing and it wasn't readily available during the wartime procurement problems. Then after the war was over, the decision was made to repair it and put it back into operation. During the interval some of the blade skin had become damaged and had to be repaired. Unfortunately, in the process of repairing that, they managed to do some poor-grade welding and damaged some of the basic structure. The damage wasn't detected before it was started up again and at that time the basic structure failed and the blade broke and it was really a very major failure.

BENGELSDORF: Right. One of the two blades tore off the machine. So although the project was abandoned in November of 1945, it did demonstrate technical feasibility. What about the economics?

STEWART: That, of course, is the question. The purpose behind the project was to develop some real equipment by which the economic value could be determined more accurately than we could determine in advance by paperwork. In 1946 they concluded that by one standard the windmill missed being competitive with coal-steam by about 15 percent.

BENGELSDORF: Of course, we've come a long way since 1946 and economics have changed, so you seem to be a little more optimistic about this.

STEWART: Yes, in many ways. In the first place the coal-steam or oil-steam kind of systems are at a significant economic disadvantage now compared to what they were then. For example, the great increases in the price of oil



From 1941 to 1945, when the wind blew on Grandpa's Knob in Castleton, Vermont, the 32-ton stainless steel blades of this enormous windmill generated up to 1,000 kilowatts of electricity.

are apt to be at least partially reflected forevermore. And coal is also very much more costly than it was then. Then in addition, the environmental protection problems that we're most sensitive to these days require the installation of quite expensive technical equipment to process the sulfur in the coal either before it is burned or out of the stack gases after it's burned; and similarly with oil. Natural low-sulfur oil is quite rare and very expensive.

In addition to the factors that have served to make conventional systems more expensive, modern technological developments of the last 30 years offer promise of improving the windmill in its competitive position. For example, aerodynamic design, air foils, the things we learned during World War II and thereafter—and in particular the work on modern gliders—show how we can get maybe 50 percent reduction in blade area.

BENGELSDORF: And you can also have lighter blades.

STEWART: Much lighter blades as a result. This would result in better efficiency, better control mechanisms, electronics, and so forth. The control mechanisms in those days were very exotic pieces of machinery and of course now we've had 30 years more of experience in similar types of things, and such equipment is not only much better but it's much cheaper.

BENGELSDORF: What about where you would put them? Do you have to have a special place for these windmills? Do you have to go to the top of a mountain?

STEWART: There are places where, of course, you *wouldn't* put them. For example, the Los Angeles Basin is so well protected by the mountains surrounding it that the average winds down here are very light.

BENGELSDORF: That's part of our pollution problem.

STEWART: It certainly is. On the other hand, almost the entire Mojave Desert, in particular the Cajon Pass area of the desert as it approaches the pass, has quite favorable wind distributions. In fact, some data taken from the Goldstone Tracking Station out in the Mojave show that the wind statistics there are much the same as at the site we had in Vermont—which is quite favorable.

BENGELSDORF: You are saying that one of the windmills placed out in the Mojave Desert just outside of the Los Angeles area would behave like one placed on one of the mountains in Vermont.

STEWART: That's right. The actual statistics, when I integrate them, turn out to give exactly the same performance on an annual average basis.

BENGELSDORF: This indicates that you could tap a great deal of the available wind potential.

STEWART: Yes, and there is a lot of wind power. Wind is different from water power. We already exploit almost all of the favorable water power sites in the United States and they supply only about 4 percent of our electrical power requirement. Back in the 30's—when we were organizing this project—Hurd Willett, in the meteorology department of MIT, made an estimate that corresponds to a potential availability at good sites in the United States of about a million megawatts. That is more than the total electric power we're now using.

BENGELSDORF: So it really could supplement in large fraction the power usage of the United States.

STEWART: I think it could. Even in the long run, I think it might serve as a 10 to 20 percent supplement to the long-term nuclear systems that we may rely on for our main power.

BENGELSDORF: That's certainly a very large number. How do you envision the size of these machines? How many machines, for instance, per acre?

STEWART: Well, the Grandpa's Knob machine is about the size we have to expect. If you try to make machines much smaller, the generator costs get too large and the control costs get too large. If we try to make them much larger, the blade and windmill structure get too costly. So I think that general size is about what we can think of. This is one of the reasons I'd like to see a design like that done again, so we could reexamine these questions in modern technological terms.

BENGELSDORF: How much money would you need for funding to carry out a prototype windmill?

STEWART: I think that to get a device to parallel the Grandpa's Knob experiment, to get it running and get some data from it, would take something like $10 million and several years of time.

BENGELSDORF: So in a few years with $10 million, which is sort of a pittance in modern day research, you could demonstrate, perhaps with a prototype at the Goldstone area in the Mojave Desert, whether these windmills were practical or not.

STEWART: That's a proposal that I would like to have approved. □