WIND MACHINES

P. B. S. Lissaman

AeroVironment, Inc.
Pasadena, California

Starting in 1969 the American Institute of Aeronautics and Astronautics (AIAA) has sponsored an annual technical symposium on the aero-hydrodynamics of sailboats. As AIAA Distinguished Lecturer (1972-1973) the speaker was asked to prepare a semi-technical lecture describing the history and contents of these four symposia under the title The Ancient Interface, Blackboard to Bluewater. A version of this talk was given, with the emphasis on wind-driven vehicles.

The basic elements of the air/water momentum exchange were described: the environment, the potential, the air and water subsystems, the total system, and the rule. Many of these topics have direct analogues in aerogenerator design. Aspects of optimal sail design and of waveless hulls were briefly outlined. A wind-driven vehicle, designed by Andrew Bauer and capable of moving directly downwind faster than the wind, was described.

The lecture was illustrated with slides and movie clips showing surfing catamarans (Arnold), land and water versions of the Bauer vehicle, hang gliding (Kilbourne), land sailing (Ripinsky), and wind surfing (Schweitzer).

REPORT OF THE COMMITTEE* ON

WIND CHARACTERISTICS AND SITING

Reliable data for wind power installations are not always readily obtainable from existing records. Wind stations have often been located at airports in order to meet the requirements of aviation.

Wind power needs are best served by choosing sites where the winds are higher than those representative of a broad area. Unfortunately, there are few wind records for such high wind speed sites. Having in mind the desirability of several established proof-of-concept units in the near future, it is recommended that three areas be chosen in which such units will be located.

On the basis of existing meteorological data, three recommended high wind areas are the Pacific Coast, the Great Plains, and the Atlantic Coast. A variety of nonmeteorological as well as meteorological criteria should be employed in pinpointing exact sites.

Relevant meteorological data are wind speed, wind direction, wind turbulence, and the variation of these within the lowest hundred meters. A priority listing of research and development requirements for an area is given below.

1. Basic wind information, existing data: A search should be made for all existing wind data for the area. These data should be assembled, their relevance assessed, and then analyzed if the data appear to be relevant and reliable. A summary of existing relevant wind information can then be prepared.

2. Basic wind information, new data: These are hourly averages of wind speed and direction at two heights, 10 meters and 30 meters, along with peak gust speeds at both heights with the frequency of occurrence of gusts in the high range specified.

A minimum of 12 months of data at each site is required, overlapping the long term record at a nearby station to determine if the winds for the 12-month period are reasonably representative of climatic normals.

Devices for recording directly the standard deviation of wind speed are commercially available and are recommended for the 30 meter height.

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*E. Hewson, chairman; W. Barnes; D. Beattie; K. Bergey; R. Cohen; V. Nelson; R. Rotty; A. Stodhart; T. Wentink; and J. Wharton.

Standardization of units and of methods of making and analyzing measurements should be adopted.

3. Basic wind information, turbulence structure: A detailed study of turbulence structure in the lower levels should be undertaken, using existing wind data from one of the Great Plains' instrumented TV towers. Such a structure may be taken as reasonably representative, except over very rough terrain.

The extensive literature on the dynamic wind loading of structures should be examined as being highly relevant. Discussions should be held with the leading authorities in this area for the purpose of determining the extent to which recent research may be applicable to the design of equipment for generating power from the wind.

4. Weather modification: The possibility of significant weather modifications being caused by single or clustered wind turbines should be examined.

5. Public policy: The content of environmental impact statements should be set forth for the guidance of those who are to prepare and those who are to evaluate such statements. Possible legal restraints should be analyzed in detail. Sites should be selected so as to minimize both audible and visual pollution.

6. Dissemination of information: A comprehensive, annotated bibliography should be prepared, kept up to date, and widely distributed. Translations of significant results of research in other languages should be made and distributed. Some appropriate agency should be encouraged to collect and reproduce the documents that are fundamental to wind power studies. Many of these are generally unobtainable at the present time.

Explorations should be commenced with the Solar Energy Society and its Journal concerning the possibility of changing names to the Solar and Wind Energy Society and Journal. Sponsoring agencies should support such publication by authorizing substantial page charges.

7. Size of proof-of-concept units: Since ten 100-kilowatt wind turbine units appear to have substantial advantages over one 1000-kilowatt unit at this time, sites chosen for proof-of-concept units should be suitable for accommodating ten such units even if all are not installed at one time.

DISCUSSION

Q: Why do you recommend that the heights 10 and 30 meters be established as standard for measurements of hourly average wind speeds and directions, along with peak gust speeds?

A: Thirty meters was chosen as being approximately the height of the hub of a large wind turbine. For a smaller wind turbine the hub would be below 30 meters. Thus the winds at 30 meters could be taken as giving roughly those which specify anticipated wind power production and associated with gust loading on the system of rotating blades. A second set of wind measurements at 10 meters offers two primary advantages. First, since 10 meters has been adopted internationally as the height at which surface wind observations should be taken if at all possible, winds at this height at proposed wind power sites permit ready comparison with long term winds measured elsewhere. Second, wind measurements at two such heights permit meaningful vertical extrapolations of wind speed, direction, and peak gusts beyond 30 meters to provide valuable preliminary wind power design data.

Q: Why not take measurements up to 500 or 1000 feet to obtain wind information at heights which were of interest to Percy Thomas of the Federal Power Commission?

A: The group's recommendations are based on the premise that the first larger wind turbines to be built in the United States, such as the proof-of-concept units mentioned above, will have a rated capacity of 100 or perhaps 200 kilowatts. Wind measurements at 10 and 30 meters, along with the upward extrapolations that such measurements permit, are entirely adequate for the preliminary wind surveys designed to locate possible sites for wind power installations. If much larger units are contemplated, wind measurements up to 500 or 1000 feet require expensive high towers.

Q: Use a balloon.

A: A balloon will not give the required long term data. Do you mean a pilot balloon?

Q: A tethered balloon.

A1: Tethered balloons are both expensive and difficult to use, and especially so for measurements for a full year. When high winds - those of great interest for wind power - occur it would be necessary to reel in the balloon to prevent it from being blown away or driven to the ground. Attempts have been made to measure higher level winds by the use of tethered balloons but very limited success has been achieved.

A2: If we are concerned with winds at high levels above ground, measurements are not needed because synoptic data for gradient winds 2000 feet above the ground can be obtained from the pressure pattern charts.

Q: If I understand you correctly, you mentioned 10 units of 1 megawatt each. What were the size of these?

A: No. I spoke of 10 units of 100 kilowatts each for a total of 1 megawatt.

Q: Why did you choose those numbers and sizes?

A: This choice represents our group's distillation of the discussion of the previous two days. This was, in our opinion, the consensus of the workshop. We also mentioned five units of 200 kilowatts each for a total of 1 megawatt. The total capacity of a group of proof-of-concept units should be no greater than 1 megawatt in the present stage of development.

Q: What is the present status of the wind measuring network in the United States? How adequate is it?

A: For the flat areas of the Great Plains and the land to the east, the network is adequate for first rough estimates of wind power potential. Over both coastal waters and the mountainous regions the existing information is completely inadequate. For wind power estimates for such areas, we need information not on representative winds but on ones that are not representative because they are stronger than characteristic regional winds. For example, over coastal waters the wind currents and water currents are a coupled system with feedback from each component to the other, and the whole must be considered as a unit. Thus the location of maximum coastal winds may be expected to shift somewhat with the season in a manner which may become predictable as the dynamics of this coupled system is better understood through research. Similarly, research into the kinematics and dynamics of high-speed air flows in mountainous terrain will assist in locating favorable wind power sites. For certain selected areas over both coastal waters and mountainous terrain there is already sufficient wind information available to permit us to proceed with proof-of-concept experiments of the type discussed in this workshop.

REPORT OF THE COMMITTEE* ON

ROTOR CHARACTERISTICS

I would like to preface my report on the Rotor Committee's work by two pieces of information that have come to my attention since we left our meeting last night. I think these points help us understand better the challenge facing wind power. One of them is an observation, by one of the more active participants in this symposium, that every time he sees the pictures of Professor Hutter's hundred kilowatt machine which is truly an engineering achievement of some significance, he is reminded of the fact that it provides approximately half the horsepower that is under the hoods of each of the United States' 50 million automobiles. The other piece of information that I think is worth remembering comes under the general heading of "the black goo that comes out of the ground is tough to beat." Perhaps some of you saw on the TV news this morning that the AEC has announced that 150 000 gallong of radioactive waste leaked into the soil in Richland, Washington, recently. But they assure us there is no need for concern for the population, and in 150 years the soil will be usable again.

To summarize the conclusions of the Rotor Committee, the quest for improvement in performance of rotors should not look for improved aerodynamic performance of the rotor blades. The current state of the art is getting all but about 7 percent of the theoretical limit of the energy that is in a square foot of wind. The magic 0.593 number is there, and we are not going to beat it by improving blades. The concentration of effort in aerodynamic performance, per se, should direct itself either to capturing a greater fraction of the wind stream tube by use of novel concepts, or to reducing the cost of energy available by conventional means. It is in that context that the rest of the Committee's information is to be interpreted.

1. The most significant technical problems that limit improvement of rotors are in the dynamics of the blades. Blade dynamics becomes an increasingly important factor in escalating costs as one attempts to go to larger machines in order to realize the economies of scale.

2. Today's commercial state of the art deliberately sacrifices a little aerodynamic performance in the interest of producing a blade of a particular size and load capacity more cheaply. This makes perfectly good sense, because in losing a couple of points in efficiency you can change the cost by a very large factor, and therefore get more power per dollar. Rather than look for improved aerodynamic performance, we need

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*R. Oman, chairman; H. Chang; U. Hutter; T. Lawand; P. Lissaman; H. Meyer; W. Nixon; J. Noel; R. Ormiston; R. Puthoff; W. Vance; W. Wiesner; C. Wilcox; and R. Wilson.

better aerodynamic performance for a given investment.

3. One of the problems that is significant in terms of the reliability and long life of rotors is the general problem of fatigue - and I deliberately avoided calling this metal fatigue because there is good indication that fiber-reinforced composites will be used extensively in wind turbine blades. Fasteners are a particularly bad cause of local fatigue problems in the vibratory environment of a turbine. The aerospace industry has made recent progress in improving fatigue life of fastened joints by the use of interference fasteners, but their costs are still quite high.

4. The definition of the failure modes of windmills is an area that needs specific study. What are the ways in which windmills can go bad? What are the pathological conditions of the loading of a windmill rotor?

5. Although materials and manufacturing improvements can be taken from other technologies, there is still a great need for improvement in both of these areas, especially with the direct result of reducing cost. Costs of advanced composites are dropping rapidly with increased usage, and some of the unique stiffness properties of advanced fibers make them very attractive candidates for blending into a fiberglass layup to increase stiffness. High stiffness and low weight are very important in raising the vibration-limited speed of large blades.

6. One point was made after we adjourned, but was discussed in an impromptu appendix to our session because it is considered to be rather important. The use of strictly disciplined dynamic modeling - careful observance of similitude laws in small-scale experiments - is a very powerful technique that should be given considerable emphasis before commitment to any large-scale expensive installation. The emphasis here cannot be made too strongly on the need for strict similitude discipline in that work.

7. A lot of people have worried about the wakes from towers and the passing of the tower disturbance in the wind field as the blade goes by. The consensus of those who have experience in this area is that the turbulence, gust loads, tower vibrations, and so forth, present far more significant dynamic disturbances to the rotor than do the wakes of the tower.

8. There is a very strong need - and perhaps this should not be so far down on the list - for better, and totally reliable, control techniques to match rotor speed and pitch characteristics to changing wind factors. This is particularly important in terms of ensuring that any failure of the wind turbine will occur in a safe manner.

9. Under the requested general heading of environmental problems, it seems to be unequivocal at this point that wind turbines are not noisy. Professor Hutter cited an example of a large installation on top of a hotel in the Schwarzwald where the wind turbine could not be heard

anywhere around the hotel, but the diesel generator that it replaced was audible to everybody in the hotel at all times that it was running.

There is the general aesthetic problem of the visible impact - visible pollution, if you wish - of large numbers of large wind towers, but that must be left to somebody other than rotor designers to solve. The increase in surface friction factor of the wind and its potential effect on climatology has been a concern that many people have voiced. The consensus of this Committee is that it is more likely to be a favorable than an unfavorable effect in most of the places in which wind turbines would be installed, most notably the Midwest plains, where what the farmers want most is something to "soak up" the wind. If you have ever sailed around Nantucket Shoals, you would agree with that conclusion.

There were concerns for such things as vandalism and public safety, the need to fence and to protect wind turbine sites, air traffic interference and direct impact by airplanes, the wakes of wind turbines as a disturbance factor to airplanes, and the legal questions of wind rights. No one felt these problems were basic limitations, and we felt they were outside of our charter to deal with rotors.

To summarize the development tasks to be done and their relative priorities, Professor Hutter nominated the following list, and it was enthusiastically received by the balance of the Committee.

The first priority is selecting and trading off configuration candidates; that is, deciding the best way to get the most power per dollar out of the wind. I would personally add that we probably should start with the European systems that have been developed most recently and use them as baselines against which to compare candidate designs and concepts.

The second priority is the question of dynamics, particularly dynamic problems associated with removing those limitations to the increase in rotor diameter that are the main factor responsible for escalating the costs of large designs.

In a normal engineering development program, the place we start is in the definition of the requirements; the determination of what the thing we are going to make is supposed to do. In this list of priorities, we place the definition of the requirements for wind turbines third because wind turbine requirements are so heavily dependent on particular site and demand characteristics. However, requirements definition must receive some emphasis, in particular, the identification of failure mechanisms and acceptable failure modes.

Fourth on the list would be a better understanding of the control problem, both from the standpoint of the computational end of it - the autopilot, to use an aerospace analogy - and of how one actually brings the intelligence of the control logic into the control surfaces - the hydraulics, the muscles, mechanisms, whatever. Both of these areas need further emphasis.

Materials, fatigue resistance, and aerodynamic improvements of blades were not called out for special mention, because wind turbine technology can be copied directly from applicable portions of current practice in aircraft technology. The rest of the questions of wind turbine design we feel were best left to the provinces of other committees.

DISCUSSION

Q: What should the size of the first prototypes be and how much power should they deliver? Should you go for large or intermediate size windmills?

A: Well, the comment on the need for dynamic modeling is relevant to that question. If we are going to be choosing configurations, it would be my personal opinion that we would want a small one if we are talking about something which is not pretty close to the types that have already been pioneered. Scaling laws that have been carefully formulated can be used to generate larger prototypes from the performance of the smaller machines. If, on the other hand, we decide on a machine that looks very much like Professor Hutter's or the one that Mr. Noel is selling, where considerable amount of development work is done, then I think we can go pretty big right away with good design.

Q: What do you mean by pretty big?

A: I think everybody has his own idea what big is, but a 100-kilowatt machine is state of the art. Beyond that there have been problems with blade failure. The blade failure is largely attributed to vibration problems and metal fatigue. So, if we feel we have a good handle on the vibration and fatigue problems, we can go bigger than that. That's one answer.

Q: Any suggestions or recommendations as to what type of rotor has been recommended as the most economically feasible? Maybe Professor Hutter may have a comment on that.

A: If you want me to comment on this, I should say the plant in 1942 had a diameter of about 53 meters. That was the state of the art in 1942. Presently, there are some installations between 30 and 34 meters diameter. Eventual problems occurred in lesser rotor diameters so we came from this point to increase the diameters as necessary.

The next aim should be a plant of 130-meter-diameter swept area. This should be a step not to get into too serious risks. But the aim could be to make even bigger ones and find the solutions to do this.

As we mentioned yesterday, there are additional problems - especially dynamics - of erecting such a plant. A very special problem that could occur would be that the formation of the blades, due to the gravity field, could cause a permanent unbalance of the rotor system.

We should aim towards 10 000 square meters. This should be feasible in the next few years.

We should be able to develop this and put such plants into operation and put them in many climate conditions from Alaska to Florida.

I have just a short remark. The question has been how much power should be installed in such a plant. This is a question which has been a topic of some of the organizational studies.

I plan to install not too much kilowatts. If you install less kilowatts per square meter, less than 300 watts per square meter, it should be an average of 200 watts per square meter. Plants of this installation size have been operated with many years successful running.

If you install more - if you have a 5000 kilowatt plant, it looks good, but it doesn't give any more kilowatt hours.

I might add, as an aside, that when I attended this session last evening, one of the men commented that a wind turbine system is really a fatigue machine. I thought that was a nice description.

REPORT OF THE COMMITTEE* ON

ENERGY STORAGE AND ENERGY CONVERSION SYSTEMS

This summary has been prepared from the notes of Dr. George Szego of InterTechnology Corporation who served as Chairman for this session. The group agreed to limit our deliberations to that area of the wind energy system between the rotating shaft and the end load. We also decided to consider all approaches in terms of a 30-year service life requirement.

Let me first discuss energy storage systems, starting with the electrolysis of water which stores energy in the form of hydrogen. It was generally concluded that for a 30-year system, costs on the order of $200 per installed kilowatt capacity were approximately the present state-of-the-art. This is reported to be a reasonably mature technology, although problems such as hydrogen embrittlement are going to require future study. The availability of suitable water is also something of a problem, with purification being required before electrolysis. The end product is hydrogen, and there was some discussion of the feasibility of storing hydrogen in the gaseous state. We feel this is primarily an economic rather than a technology problem.

If the hydrogen is transported by pipeline, there may be problems related to leakage rates and, therefore, safety, and there is also a question of the economic feasibility of doing this because of the higher pumping power losses involved in compressing hydrogen gas compared with natural gas. Liquefaction is practical and is used today. However, it is an extremely low temperature process which would require special pipelines. A question was raised as to the loss rates from large storage tanks, and whether these are economically acceptable? A general feeling toward hydrogen is that it must be regarded as a potential hazard, and the safety aspects will have to be explored carefully. There is also a psychology problem -- that is, a "Hindenburg Syndrome" -- involved in getting the public to accept large scale use of hydrogen.

For secondary batteries, the performance characteristics can be reasonably well identified. Presently, energy densities tend to fall in the range of 10 to 100 watt-hours per pound and power densities at 30 to 100 watts per pound for lifetimes of a maximum of 5 years. The cost associated with 5-year lead-acid batteries is about $80 per kilowatt-hour. Lead-acid batteries like water electrolysis is a reasonably mature technology, and it is felt that there is only a modest opportunity for

*G. Szego, chairman; H. Allison; N. Beard; W. Carl; R. Dodge; W. Hughes; E. Lutzy; D. Rabenhorst; R. Ramakumar; D. Reitan; G. Rinard; L. Robertson; T. Rowe; H. Schwartz; G. Sheperd; R. Thomas; and J. Tompkin.

performance and cost improvements. The most promising research and development opportunities are in other advanced battery systems. Regarding policies, there appear to be possible critical materials shortages, particularly if lead and zinc are going to be required on a very large scale. There is also a question of whether bulk energy systems based on batteries will have heat dissipation problems and therefore result in thermal pollution. Batteries, in general, were considered to be nonhazardous, with the possible exception of large, high-temperature, alkali-metal batteries.

Compressed air storage was discussed at some length. The general cost figure arrived at was $80 per kilowatt with a land area requirement of about 6 acres per megawatt.

Efficiencies of cold air storage systems were reported as 67 percent -- that is, three kilowatts put into this system would yield two kilowatts delivered later on.

(Note: Regarding the question of efficiency, Dr. Szego asked that it be entered in the record that by adding 4500 Btu's per kilowatt-hour to the stored gas before it enters the turbine, the overall system efficiency is raised to 130 percent. Based on the information available, the committee was unable to assess the validity of this claim. Research and development is required, particularly in the area of turbine technology since the 600 psi systems will require a 40-to-1 pressure ratio turbine, which is not state-of-the-art. This approach does not appear to be applicable for very small installations. It appears that the approach would be environmentally satisfactory.)

The flywheel is reported to be capable of storing 30-watt-hours per pound, and delivering extremely high powers for short periods of time; the figure of 1000 kilowatts per pound for 2/10ths of a second being one example given. Costs are expected to be in the order of $50 to $75 per kilowatt-hour for a 30-year lifetime. Research and development are needed in the areas of economic analysis, construction of prototypes, and on technical problems related to bearings and dynamic resonances. In the policy area, the major questions seemed to be, first, safety and, second, the public's lack of familiarity with this concept.

Pumped water storage systems are fairly straightforward. Efficiencies are about 67 percent. Costs are reasonably well-defined. A figure of $180 per kilowatt-hour electric was quoted. They suffer mainly from the limited number of acceptable sites available which are determined by the climate, geology, and geomorphology of the area. Frequently, the acceptable areas are far from load centers, and they are environmentally undesirable because they occupy large areas of land. No R & D seems to be required in this area since this is an established procedure.

In the energy conversion area, it was noted that there are some approaches to wind energy utilization that require no energy storage. On-line generation of wind power, for example, was felt by a number of members of the panel to be feasible without storage by simply feeding the power into the grid as it's produced. This would require frequencycontrolled alternators, as one approach. Research and development is needed for such alternators to accomplish reductions in weight, size, and costs. Direct, nonsynchronous machines were also advocated. Here ac is converted to dc and back to ac again, using batteries as the intermediate dc step. This has the advantage of decoupling the variable frequency source, the windmill, from the fixed-frequency load. This procedure has been used for large scale plants. Some development would be needed for small scale applications.

Because of the limitations of time and the broad scope of this topic, the Committee was concerned that these recommendations could gain unwarranted authenticity and credibility by virtue of their appearance in the proceedings of the conference. The Committee wishes to note that these are the opinions of a heterogeneous group, and that they should be reviewed by competent authorities to assure that the recommendations are, in fact, credible.

DISCUSSION

Q: I'm an electrical engineer and couldn't be expected to know anything about thermodynamics and I really don't. But I am having trouble comparing compressed air and pumped water storage, for example. Obviously, if our experience tells us we can get two for three with a noncompressible fluid, how do we get two for three with a compressible one? What happens to dv/t? I'm not criticizing, I'm just asking somebody to explain it.

A: I don't feel I know enough about Dr. Szego's concept to comment on it. I have not read an analysis of the pumped storage versus gaseous storage approach. Is there anyone else who does feel comfortable in discussing this point?

COMMENT: It seems to me you have an upper limit in a noncompressible one, but I could be wrong.

Q: Did you mention our discussion of energy storage with cryogenic conductors and our decision that it is of little promise?

A: Thank you for reminding me. I accidentally skipped it, as a matter of fact. Cryogenic conductors were discussed. They are too expensive, too large, and too hazardous. And they did not represent any appreciable R & D opportunity. The adjectives used to describe the approach ranged from "impractical" to "absurd."

COMMENT: There are two things I'd like to comment on. I didn't quite catch the point about the synchronous principle. There doesn't seem to be any problem about which type of machine one uses on a network. This seems to be a common principle.

The point I would really like to make has nothing to do with that. It's a pity in some ways that this energy storage problem has been discussed with and associated with wind power at this meeting. Because if anybody ties these figures for energy storage costs to wind power costs, then you have completely jammed the thing before you start. I think energy storage is a problem and it probably associates with all sorts of things. But not particularly with wind power.

A: I agree.

Q: There is another aspect of energy storage that we may not have discussed in the session last night. Thinking in terms of a large power generating unit that would supply utilities, how we would cope with the peak demands or base loads when the winds are below the optimum range? Perhaps to alleviate the economic factor of storage, I think the storage facility should be located near the wind-generating plant. I learned that little lesson 4 or 5 years ago where we had to set up our wind facilities to generate power and even produce hydrogen gas in, let's say, West Palm Springs to supply some of the needs, let's say, somewhere in Oklahoma, because they may have tornadoes. We cannot have units there. I'm speaking of a very large system, a grid system. So this storage problem and the economic costs could be minimized if we could study meteorological data to determine where we can install wind power plants and have storage facilities nearby. Hopefully, there is a transmission system in that proximity which the meteorological data could justify as an appropriate location.

COMMENT: I would like to add one comment to what Mr. Stoddard said. I think perhaps energy storage was discussed in the wrong context at this meeting. I think the question of energy storage has to be raised, and should be raised, but until you can define fairly clearly what the energy storage requirements are and whether they exist at all, it's very difficult to discuss methods for providing storage intelligently.

REPORT OF THE COMMITTEE* ON APPLICATIONS

A three pronged attack should be made to convince the people of the United States, applicable windpower manufacturing industry, and eventually the electric utility industry that wind power should be applied within the United States:

1. A rather short-term program that would provide financial support toward the demonstration of existing or improved windpower hardware for either heating or the provision of electricity at a number of demonstration residences within the next 2 years.

2. A relatively short-term program of about 3 years duration which would result in operating wind power plants of 25 to 100 kilowatts capacity by 1976.

3. A more deliberate 5- to 6-year technology improvement program which would culminate in the selection, construction, and operation of a number of wind power systems, totally self-contained with storage subsystems, of the 500- to 25 000-kilowatt size.

The suggested locations for the operating systems are

1. At institutions of higher learning which show a genuine interest in using the product and in using the installations as instructional, research, and public service facilities.

2. At one or more National Laboratories who want windpower systems and are willing to operate them as research and public demonstration facilities and who want to use their product.

3. At one or more remote U.S. Air Force Bases and at a number of other U.S. military bases where the wind resource is good and where fuel logistics are burdensome. Cooperation with the DOD should be investigated here.

4. At a very large number of new construction private homes.

5. At one or more New Town or institutional sites in conjunction with the MIUS program administered by HUD.

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*W. Heronemus, chairman; E. Barnhart; H. Clews; W. Hausz; W. Hughes; M. Jacobs; B. Jessop; R. Madey; J. Mockovciak; R. Powe; F. Rom; M. Sherman; and J. VanSant.

The geographical location for any one of the above should be such that the windpower resource is at least modest, and preferably large. Operating plant in regions of good winds near large population centers would be of greater value than remote plant. The New York City - Long Island, the Boston, and the Cape Cod regions are suggested as starters. Buffalo and Rochester, N.Y., and Cleveland, Ohio, are other suggestions.

We wondered if somehow a significant wind-power demonstration plant could be added to any 1976 BiCentennial parks or cities that might yet be considered.

A coordinated effort should be made to obtain the cooperation of the rural electric cooperatives and other state or regional associations of publicly owned utilities in the advancement of wind-power systems.

We agreed that in the next year and perhaps during the next 2 years, the major introduction of windpower systems to the U.S. public as reliable, operating alternatives would be done by individuals or very small companies like Henry Clew's "Solarwind" and Hans Meyer's efforts. Those efforts warrant support.

The impact of large numbers of single-dwelling units, perhaps a 25-kilowatt generator on a 40-foot pole with a 0.20 plant factor and a 300-kilowatt hour lead-acid storage battery, in any one market, operating successfully and economically for their owners, might be the best impetus toward adoption of wind power by a utility.

The federal government should be asked to consider direct grants to utilities to encourage their early adoption of significant windpower plant, following the pattern used by the government to encourage construction of nuclear plants.

It was asked that NSF/NASA sponsor the publication of a monthly newsletter to be mailed to anyone interested in windpower, this to be above and beyond any quarterly R&D project reporting system. Many younger people are seriously interested in this energy alternative, and they would like to be kept informed. "Communitas" of Washington, D.C., has offered to start such a newsletter based on the attendee list of this workshop. It was suggested that the newsletter be called "The Zephyr".

It was suggested that other deliberate continuing action be taken to encourage the interest of younger people in this program. Perhaps here we have something started which is "technology patterned for humane living". The country must convince many young people that technology can not only create problems, it can also be used to get us back on the track of a more ecologically sound way of life. How many excellent brains would again be turned toward hard science and engineering if the chance of making a contribution toward windpower systems and other pollution-free energy systems were the goal of that kind of education? Perhaps here we have a good opportunity to put at least some of the old and the new back into genuine harmony with each other.

As many people as possible should be shown that windpower can contribute. As many enterprises as possible must be excited into producing windpower hardware. Then, through large-scale defection from the individual residence utility customer and through an indoctrinated or propagandized portion of utility management the program must bore in. And if that by itself doesn't bring us ever-increasing amounts of wind-generated electricity, then direct grants should be attempted. In those areas where the federal government is already in the role of electricity producer and/or marketing agent, the job of conviction and conversion may be easier. In the East, particularly, where those roles are predominantly private-enterprise roles, the job will be tougher.

The debate about visual pollution associated with large wind plants should be started at once. It should be a moderated debate, kept both lively and honest An educated public, if given full particulars, will and should settle this. We must learn to face issues like this democratically.

DISCUSSION

Q: How about the identification of agencies which would come under regulation and control of wind generated power?

A: We did not talk about that last night. This is certainly something that has to be looked at as part of any significant deliberate program. The political institutional problems associated with ever getting something off the ground are just as important and perhaps more important than the technology. Yes?

COMMENT: I went to the Utility Commission in Oregon to find out their views or opinions on wind generating plants. First of all, they have no objection, provided it does not have any adverse effect on the community in which these wind generating plants would be located.

I asked if they would object to my getting into the business of producing electric power. "That's your prerogative", they said. That's the Utility Commissioner's answer in the state of Oregon. This will probably be the comment in many of the other 49 states.

COMMENT: I have an idea we would find 50 different approaches to this, and it's very important that we find out what they are.

PANEL DISCUSSION

Moderator:

Dr. Frederick H. Morse
National Science Foundation

Members:

Mr. Everett Lutzy
Manager, Town of Hull Municipal Light Plant

Dr. Robert L. Loftness
Manager, Washington Office
Electric Power Research Institute

Mr. Lawrence M. Robertson
The Western Electric Industry

Mr. James Wharton
Tillamook P. U. D.

Mr. Charles W. Lines
Assistant to the Chief
Division of Power Surveys and Analyses
Bureau of Power
Federal Power Commission

Mr. Brian R. Jessop
Rural Electrification Administration
U. S. Department of Agriculture

Mr. Lee L. Douglas
Boeing Vertol Company

Mr. John Mockovciak, Jr.
Manager, Energy Systems
Grumman Aerospace Corporation

Moderator, Dr. Morse:

One of the elements of any program which is introducing a new energy source, or perhaps not a new, but in the picture today is relatively new, it is quite important to get the point of view of other government agencies, of utilities, of the user, and of the industry or industries that might be involved in manufacturing the system.

So we have asked several people from other government agencies, from some utilities, and from industry if they would briefly say what the present or future role of their agency, company, or utility might be in a wind energy program and what the key problem or problems from their point of view might be. Then, as a group we will ask them what they feel the Federal government role should be in a national wind energy program.

Later we have scheduled a discussion of the NSF wind energy program and the NASA involvement in that program. Although this might be a minor handicap for our present discussion, let us remember that the objective is to develop wind energy systems which are reliable and economic and to prove the concept of large-scale wind energy extraction.

Mr. Lutzy:

In our nation, it is important how a company stays competitive in serving the public. Basically, our plan is to provide electric rates that are at least equal to, if not lower than, the rates of our competition. Secondly, the reliability of our service must be as great as, if not greater than, our competitors. And the service we offer must be equal to or more advanced than our competitors.

Now, since we are a municipal light plant, we are part of a town government. Therefore, we feel that the life of the utility depends on the life and the success of the economic conditions of the community we serve. Since the public owns us, we answer to it.

We meet our annual costs from revenue. We have a substantial investment in any generation and transmission of a distribution facility. Since we generally have to get bonds issued, this requires that we go before the public and get the vote of the people to approve any project we have. We must, therefore, show that our suggested project is good for the community, particularly since in Hull we have one of the highest tax rates in the nation. So naturally we don't propose anything that is not economically sound.

We are always watching technological developments for ways to improve the efficiency of operation of our electric utility. An example is automatic load control where you can see in the system what's exceptionally out of line on an on-line, real time basis. This automatic load control can improve the efficiency of operation, and it is variable, based on the way the customer uses it. We are considering telling the customer that if we use load control it will benefit him as well as us. Since a load control of his different appliances reduces our power costs, that part of the saving goes to him.

The highest peak demand in our electric system is at a time when the wind blows the hardest and that's generally when the temperature is the lowest. Therefore, the chill factor is such that tremendous heat loss occurs at the time the wind is blowing the strongest. So, the question is - is there any way to economically convert this wind power to a meaningful use? For us in Hull, its major use would be for heating in the winter.

If the total use was 20 000 kilowatt-hours a year, practically 60 to 70 percent or more would be used for winter heating, and this would result in saving fossil fuel energy. Also, when the wind blows, you use that energy and you don't do any polluting.

Dr. Loftness:

The Electric Power Research Institute (EPRI) has inherited the ongoing R and D activities of both the Electric Research Council and the Edison Electric Institute. Dr. Starr and members of the technical committees have reviewed those research and development programs still under negotiation at the time of the transfer and most of them have been approved.

We are now in the process of looking at new activities, including new energy sources. The role of EPRI will be to provide the utilities with options for the future and to fund research and development that is not being funded elsewhere to the extent our revenues from the utilities permit.

As far as I know, in reading the documents of EPRI and its predecessor organizations, I have not seen much reference to wind energy. This does not mean that the Institute will not be interested in wind energy. In fact, a symposium or workshop such as this is extremely valuable in pointing out the technical as well as economic status of wind energy. As with other alternate energy sources, the problem wind energy will have in the future will be the question of competing energy systems.

As you all are aware, the problem the country faces is a growing shortage of petroleum. In terms of national policy, it is possible that the Federal government, if it so desires, could require that wind energy machines be installed, even if the cost is higher, in order to reduce the importation of oil. The government could also direct that we gasify or liquify coal to meet our oil and gas needs or that we adopt other options, for example, the construction of large solar stations.

Decisions on these options by the government will require a factual base of information. On its part, EPRI would also like to have as much data as possible on the technical merits, the history, and the economics of alternate energy sources as well as information on new programs and proposed ideas. I am not saying that EPRI will fund every new idea, but we will certainly include them in the broad assessment we will have to make in judging which technical activities the Institute will fund.

Mr. Robertson:

I am here in a dual role: One as retired Vice President of Engineering of the Public Service Company of Colorado which is a utility which serves much of the State of Colorado and have a load of about two million kilowatts; the other role as the representative of the Western Energy Supply and Transmission Associates (WEST Associates) which is an association of about 23 organizations and utilities (public, private, and municipal) in the western one-third of the U.S.A. and Canada with a load of about 25 000 kilowatts. These utilities are all interconnected into a large network covering this area. Since this is a large area, there is quite a diversity in atmospheric conditions and wind velocities in different locations so that there would probably never be total calm nor severe storm conditions over the entire area at any one time. Therefore, I would assume that the total generation of power by wind, could be somewhat of an average if the units were located at suitable places over the area.

It appears that the wind units would not be large in relation to the capacity of the system and with the wide diversity possible, that the units could generate and feed power into the system in an amount and at such times as wind would be available. This should not upset the system and should not require any special system load control, dispatching, or scheduling.

With this sort of operation, it would not be necessary to provide energy storage equipment which some presentations at this workshop indicate would be quite costly and might even be hazardous and high maintenance. Thus, the kwh fed into the system could be metered and the value might be the incremental fuel cost at the location. This would dispense with involved and expensive metering and controls and this could be the best procedure at first. There seems to be some foregone conclusions that storage was needed but it would appear that this would not be necessary nor economical.

The fact that the units are relatively small compared to the load of the system means that they could be connected into the low voltage distribution systems at small cost and avoid requirement of expensive transmission and substation installations. The distribution lines cover most of the rural, suburban, and urban areas and little or no investment in such facilities would be required.

The utilities are interested in the wind energy conversion and would cooperate in obtaining data and in studying the proposals that might be made for installations and to assist in the plans and developments.

The utilities are interested in conserving energy and resources and in the public welfare and providing energy at the lowest cost and maximum reliability.

The units should be dispersed to get diversity of wind conditions, appearance, environmental satisfaction, security of service and equipment from storms and vandalism. Towers over 100 feet tall might produce severe objections.

Cost figures over the units which were presented at the workshop may be in line, and it would be necessary to determine the wind data, environmental data, costs of installation, fixed charges, operation and maintenance costs, and data, and revenue to be expected to establish the feasibility. It appears, off hand, that the idea might be feasible and economic in certain locations and under certain conditions.

The utilities are regulated by the Federal Power Commission and by State Utilities Commissions and whatever is done would have to be worked out with these bodies.

Mr. Wharton:

Since our utility in Tillamook, Oregon, is publicly owned, I was elected by our consumers; thus, it follows that I have to use economics as a guideline. In Tillamook, we are interested in windpower, because of our windy coast features and the Columbia Gorge wind exchange.

I would like to suggest some ideas that I feel would be of use to the utilities in the near future concerning windpower. In the Northwest only, where our power is hydrogenerated and it costs 3 to 3½ wholesale mil rate to our consumers, I think the 1 000 kilowatt size, or clustered even to produce 1 megawatt, could be feasibly run into the grid. I believe 5 or 6 mil wholesale rates should be the financial guideline. Now, if the Northwest is going to use wind machinery, you're going to have to realize that at present-day you're going to have a 5 or 6 mil economic guideline, unfortunately. And, at a later date, possibly when they run the nuclear plants that are now in construction into the grid at Bonneville, you then will be probably be talking about 8 mils. Now, please understand that these are just my opinions.

I would like to see a workable unit constructed and in use so that the utilities could look at the costs and esthetic ecology. I would ask you to consider a low profile. I realize this is not popular either, but you are not going to get the ecology movement to hold still for a gang of windmills hanging from a balloon or up on a wire. Anything that sticks up and attracts attention, is going to be attacked by the ecology people. I think 30 meters should be your extreme height. Now, this is going to put you in a pigeon hole again. It may be that I am wrong; this could easily be. But I think esthetics and public relations with ecologists will demand this, not only in the Northwest, but probably nationwide. Since the Northwest is not wind machine oriented, we must do a public relations job. The wind machine will definitely be in a fish bowl, so it should be engineered with an ecology and an economic basis in mind. The energy squeeze is on us, and utilities will want to make commitment decisions very soon. Therefore, I would urge you to use some haste on a prototype.

I would like to suggest the diversity of location concept, so that a wind machine would be run at varying times. I believe the Northwest would not need any storage facilities, because of the inter-tieline to Southern California, which we can use as an energy reservoir.

It will be extremely hard to sell the Northwest utilities on an experimental involvement basis. They are not used to this. They are used to an industry coming to them with a working model with the cost available and an environmental impact study already made.

Mr. Lines:

I believe the matter of policy, with regard to not only Federal agencies but the utility industry as a whole, has been mentioned. The Federal Power Commission, as a regulatory agency, establishes its policy, in general, by means of hearings, rule-making procedures, and the like. Therefore, nothing I can say, as a staff member, can predetermine any policy that the Commission, through its actions, might establish.

It may be of interest to review some of the responsibilities of the Federal Power Commission. In the area of licensing generating facilities and attendant bulk-power transmission systems, it is the licensing authority for non-Federal hydroelectric projects on navigable streams or on streams that affect interstate commerce. It has no licensing authority over thermal plants or any other kind of plants. It has no siting responsibilities or authority, other than those directly associated with the hydroelectric plants previously mentioned. For me to guess how a type of generation that has already been used in the industry would be considered in the future as to Commission policy would not be warranted. I do re-emphasize that a wind-electric generator has already operated in synchronism with the interconnected network of the utility industry.

The Federal Power Commission's responsibilities, with regard to the bulk-power systems of the United States, embraces, in the area of rates, the approval of wholesale rates. These are the rates between contracting utilities engaged in interstate commerce and not rates applicable to utility retail consumers. The quantity of energy subject to Federal Power Commission rate jurisdiction is relatively small when compared with the energy subject to retail rate approvals. The states generally, through state commissions or other agencies, exercise retail rate-making authority as it affects the ultimate consumer.

In other activities, as detailed in the Federal Power Act, the Commission collects data from all segments of the industry and disseminates these data in many forms for public use. Many of these data serve to keep the Commission staff current on trends and costs that affect the consumer. The cost of delivered electric energy as affected by any means, including the actions of the Federal Power Commission, is of interest to the Commission and its staff. The electric utility industry in the United States is the most capital intensive industry. Its capital requirements are tremendous and constitute quite a problem. In advocating the extensive use of wind powered generation, this capital intensiveness must be kept in mind. Wind power offers a costless source of fuel, but from what I have heard here, its use requires a very costly capital investment, firm capacity-wise, for an already highly capital intensive structure. It is a combination of these fuel and capacity costs that will have to be sold to the industry. I would not take exception to the range of costs that the preceding gentleman has mentioned, but wind powered generation does not appear to be currently competitive. One must also consider logistically the magnitude of the industry and the size of generating units employed in relation to the size and cost of the wind powered units discussed here for integration into the industry.

Mr. Jessop:

I am with the Power Plants Branch of the Rural Electrification Administration. We are probably responsible for putting more windmills out of action than any other agency. Economics is the name of the game from where I sit, I am not a policymaker; I deal with power plants and make recommendations on their cost of installation and their cost of operation. Sometimes I overestimate, and sometimes I underestimate. Nine times out of ten we've got enough funds to build the things, but that one time out of ten we run short of money. So costs are pretty important to us. I want to make clear that REA-financed powerplants are still only about 1½ percent of the total installed U.S. capacity. Even to our borrowers, we are in a minority. I should explain that our borrowers are mostly rural electrification cooperatives who have taken on utility responsibility in sparsely settled parts of the country. These cooperatives have brought up the number of connected households from 10 percent of the total in rural areas, in its inception in 1935, to about 98 percent recently.

So there is very little left that hasn't been covered. We have spread the tentacles of central station power service throughout the highways and byways of America until we have pretty well completed the job. But we are still working in a very, very remote areas. We are presently connecting plants in Alaskan villages and small settlements in the United States which are still without central power service.

As a consequence, the spread in the cost of power to these facilities is quite great. We have many borrowers who are able to generate power at around something like 1 cent, not 1 mil. And then we go up, in the remote Alaskan villages, to power costs which are more like 8 cents, 5 to 8 cents. But, if you are looking toward large applications, then I have here the Thirty-Second Annual Report of Energy Purchased by REA Borrowers. The costs have drifted down from about an average of 1.1 cent, when these figures were first compiled in 1940, to about 0.65 of a cent in 1965. After a flattening out process, they have again turned up; they are now going up quite rapidly.

But, so the past is prologue, and it isn't necessarily a good indication of what the future will be. Costwise our plants are going to cost more because of the environmental features. Large central station power generators, which we have built at a cost of about $120 to $170 per kilowatt, depending on the type of fuel we burn, are the cheapest because there are fewer environmental considerations and less fuel processing.

Coal-fired plants are more expensive; they range up to about $200 a kilowatt if we're in lignite fields. Possibly because of the things which must be added due to environmental considerations, we might have to go up to $400 per kilowatt for these central power stations. Costs for plants in remote areas, for example, Alaskan villages, have ranged from about $225 to $300 per kilowatt. These plants are small diesel powered ones.

All of these plants have one common characteristic: they can come on-line when the demand is there. They do have surplus capacity. In the case of the Alaskan plants, if one unit fails, or is taken out for maintenance, there is another unit standing by.

So these are reliable peak-supplying systems. I might make a comment on storage. Time is of the essence, and if you are dealing with a system with no storage, then you've got to compete against incremental fuel costs as far as the marketplace is concerned; this can be very, very low, even as low as 2 mils. But, again, fuel costs are going up, so here again you're aiming at a moving target. So you've got the choice, possibly, between storage competing with 2 to 4 mil power, without storage competing with 2 to 4 mil fuel costs, or with storage competing with 2 to 4 cent power costs. This is on peak power.

It seems to me, from what I've heard as an individual, that heat has the best application, because thermal transience is the longest. Not maybe as long as the transience you get with wind velocity, but they may be catching up on the deal, and thermal storage is usable feasible. Rocks are cheap, water is cheap. Put together a pool in the basement with rocks and water in it, and you've got a real good thermal tank.

<u>Mr. Douglas</u>:

The Boeing diversification program includes consideration of various forms of energy. One source of energy that we have worked at in some depth is that available from municipal, commercial, and industrial waste. As a systems problem, its economics depends on a balance of refuse collection, processing, and marketing of the products. Similarly, wind energy is a systems problem involving technologies, siting, and customers.

We have heard that rotor technology, suitable for wind energy plants, is available today. The real question is whether we can produce electricity at a price of 3½ to 7½ mils per kilowatt with the technology that is available and for the conditions prescribed by the power companies. If not electricity, can we pump water, run mills, or convert wind energy into useful work competitively in any market for energy?

I believe that our demonstration programs should be aimed at the systems problem rather than proof of concept of a component in isolation from its matching elements.

<u>Mr. Mockovciak</u>:

Our activities in the Grumman Aerospace Corporation's Energy Systems Group are twofold: one, energy conservation, and two, solar energy applications (which include the use of wind energy).

As regards our potential role in this area, we see ourselves as possible manufacturers of wind machines. From our standpoint, therefore, the existence of a market for wind energy machines is a major concern. We think that it exists or could be created, but advocates of wind energy must go out and "beat-the-bushes" to find people who really want to use it. A user motivation, I think, is a key to future wind energy usage.

For example, one of the suggestions that was made in a committee meeting last night is that perhaps there are many universities that would like to use wind energy, both as an actual energy plant supplying electrical power to its facilities and as a relevant engineering project involving both students and faculty in its design, construction, and operation. This example is illustrative of who could be real users of wind power. To reiterate, I believe that advocates of wind energy must identify the people who <u>want</u> to use it.

There are two ends to the wind generator spectrum: the small local wind generator application and the larger, utility-type wind generating machine. I personally feel that the utilities (since they are generally conservative) are going to take a "wait and see" attitude. Therefore, I believe that the place to begin is in the smaller, localized wind generator applications. When the utilities begin to see that wind machines do, in fact, provide electrical power, that people are satisfied with their performance, and that a base of operating experience is being developed across a reasonable spectrum of wind generator sizes, then I think the utilities will sit up and take notice.

Most important, in my view, are (1) acquiring operating experience and (2) establishing realistic costs. These two factors, if anything, are going to convince the utilities that wind energy can be a useful electrical power source.

One of the interesting aspects of the wind energy business is that there <u>is</u> an existing and adequate technology base. By that I mean that there is an adequate base to begin to engineer wind machines for power production. It disturbs me, however, that many advocates of wind generating machines call for more research and development. I would almost call this an "R & D syndrome." I frankly think there's an overemphasis on the amount of research and development that has to be done, and too little emphasis on finding ways to make it happen. I personally feel that we have an adequate technical base and that we should start thinking about building these machines and looking for people who want to use this energy.

Obviously, the people who may be interested in using wind energy are also going to be concerned with its cost. In this regard, I think that the government could play a key role. In the near term the government could offer direct subsidies in order to get the machines out where people could see them operating and performing useful functions. In other words, what I am suggesting is that the public (through the Federal government) could make wind energy "happen." If the public wants to use wind energy, the government can make it happen; the same way that we've made a tremendous highway system happen in this country, and the same way that we've provided direct subsidies for public housing where we want housing to happen! The government mechanisms are there, if the public motivation is also.

Moderator, Dr. Morse:

We will open the floor to questions. We are interested, from the point of view of industry, other government agencies, and utilities, in what role the Federal government might play in this wind energy program. What would it like to see done so that it could make the kind of decisions that it will have to make.

Are there any questions to the panelists?

Mr. Cohen:

It occurs to me that perhaps it might be worth looking into the possibility of coupling the high quality mechanical energy generated by windmills to heat pumps and storing that heat rather than degrading the energy and the heat to begin with.

Dr. Morse:

It's a thought.

Mr. Lutzy:

It's the basic role I am attempting to do. In other words, don't go through intermediate investment steps for high cost investments and gadgetry. Get that mechanical heat directly to the heat pump to improve its efficiency.

Dr. Morse:

By the way, NOAA is an agency that certainly has a role to play in that new wind energy program, and I didn't mean to exclude you.

A Voice:

I would like to ask what the proper mechanism of our existing governmental structure is for the government to decide to make it happen. They decided to make nuclear power happen, and it happened. We all have our own opinions on the way it happened, what it cost us to have it happen, but where do we start? What can we as private citizens do to make it happen?

Mr. Lines:

If I may, I will respond in general with more of a personal observation than a recount of any staff position of a Federal agency. I call to your attention two related items that might be of interest. One is in the June 1973 issue of Spectrum, the I.E.E.E. publication. It lists two pages of Federal agencies involved in energy policy and problems to some extent. The other item includes the President's energy messages of about 18 months ago and just recently. Over the past weekend, the President announced a proposed reorganization which included the establishment of a Cabinet-level agency in which energy and resources considerations would be centered and which would affect to some extent, among others, the Department of the Interior organization. There were other proposed changes. This proposal will be sent to Congress for its approval or action. The atomic energy program was established in a similar manner by the Act which established the AEC. The Joint Atomic Energy Committee is the congressional body that is actively interested in that program.

To answer your question directly, we have an outlet, through our congressional representation, to establish and make known our personal viewpoints and what we as individuals think of both the energy policy of this country and its many, many ramifications.

Dr. Savino:

As I listen, I get the feeling that among certain government agencies, such as the Rural Electrification, the FPC, and the power utilities, the attitude appears to be one of business as usual. We talk about things having to be cost effective as though we can continue supplying the public with all the power it can consume, as though we had plenty of it. Everyone here is aware of the fact that we are on more or less a collision course over the next 20 or 30 years. And there seems to be a reluctance to take the action that is necessary before we get into a real bind. I believe it was Dr. Hutter last evening who mentioned that we as individuals accept many dislocations in our lives. We have automobile accidents that cause a dislocation, or we lose our job. There are a number of such things that happen, yet when we push the light switch or decide to drive somewhere we want power available to us at that instant. We don't want any dislocations in our energy supply. Isn't it time the public utilities, as well as the agencies, tell it to the public like it is? We are going to have to start paying higher prices. We must stop chasing the demand curve. Shouldn't your companies and agencies also start getting involved in supporting alternative systems? Many of us believe we can no longer look to nuclear or fossil or any one or two systems to provide all the energy. There is going to have to be a mix, and we cannot have this mix unless we have the involvement of the utilities, the agencies, as well as the people who are proponents of this system. We, the proponents of wind power, can never create the environment necessary to move forward until you people who have the influence get involved instead of sitting back and waiting for someone to come forward and say here's a package that works -- would you like to use it?

Mr. Loftness:

As a matter of fact, that is precisely the reason EPRI was established by the utilities. They recognized that business as usual - the way it had been going on for many, many years - was no longer the case.

Obviously, EPRI will have activities that relate to conventional technologies - improvements in transmission and distribution, in nuclear power generation and related safety questions, and in fossil fuel generation - all to improve the ability to generate power with the equipment we now have. At the same time, EPRI will have a group on advanced technologies that will be concerned with evaluations, by the in-house staff, of the status of solar, geothermal, wind, ocean thermal gradient, and other alternate energy sources. Hopefully, there will be major inputs of information from individuals who are experts and who have been working in each field for a long time. These inputs will be judged, in terms of future research and development support, by the contribution each alternative might make to the total energy mix.

There is nobody I know in the utilities who feels it is possible to go on forever using oil or coal as they have in the past. There is a lot of current interest in fission power and fusion power, but there is also interest in looking for alternate sources of oil - from the liquefaction of coal, for instance - and in alternate sources of gas through coal gasification. These coal conversion processes are now more expensive than natural oil and gas, but, nevertheless, they are processes the utilities feel must be developed if they are going to continue to generate power to meet the needs of the country.

I think the utilities have given evidence of their interest in pursuing alternate energy technologies. I don't think people interested in, say, wind energy are any longer voices in the wilderness.

As I mentioned, the Institute is very much interested in having all the factual information it can possibly obtain. We can't possibly develop it all ourselves. We should proceed from the basis of information that already exists, and I would encourage all of you to submit the information you have to the Institute.

EPRI will not be alone in developing new technologies. For example, both NASA and the National Science Foundation have activities in solar energy and we will be working with them in this area. In any particular technology, we will be judging what needs to be done based on an assessment of the relative contribution of that technology. Where wind energy would come out in such an assessment, I don't know.

The assessment process would involve all the individuals who are interested in making a contribution to the argument on what should be done or what should not be done. Out of this dialogue, I believe there will be a decision among interested organizations, including the Federal government, that certain technologies should be funded as a national effort - as is the case now for solar energy. As you know, such an assessment has resulted in a tripling of the solar energy budget of the National Science Foundation in the past year.

In summary, I don't think there is a lack of recognition for the importance of new energy sources either in the government or in industry.

Mr. Lutzy:

It appears that we have come from a nation of abundance to a nation of scarcity, and that involved in this is basically the national security and the question of the balance of payments problems in regard to the value of the dollar on the world market, in regards to our being able to compete in the world that exists and to maintain our standard of living. I would think that, based on our feelings in the past, we did not want to be substantially committed to surviving based on foreign energy supply, as an example; this would demand a commitment in the very near future by the national government to solve these problems and to do so by the capabilities that exist in this country. The other thought is that, in regards to capital investment, we all are schooled that we must be economically competitive and must maximize the use of an investment, good or not. In our personal lives the percent use of any investment that we put our money in doesn't have to be justified. As an example, don't buy a generator to generate a little power, but buy a boat for $1400 or a snowmobile and put them in the corner. What's the percent use of a snowmobile, plus the consumption of energy in this? There is no comparison between this, so there is a question that maybe there ought to be a play opera between personal investment and business investment whereby some of this personal investment is put to a more meaningful use.

Mr. Mockovciak:

I'd like to address myself to EPRI's future role, but I must qualify this as a personal observation. Coming from an industrial organization and being heavily involved in past research and development activities, I have observed that the basic function of (what are called) new businesses, advanced programs, or research and development organizations is to promulgate the current business line. In other words, the "new business" aspect is a misnomer. It's called new business, but it really means keep the old business going.

In this regard, I can't help but observe, when exposed to the kinds of things that EPRI is proposing to do, that they are planning to do just that - keep the old business going. EPRI appears to be largely interested in improving the operations and performance of existing electrical power systems or those that already have extensive research and development bases. Thus, I can't help but feel that there really is no motivation there to make anything new happen.

I would, therefore, suggest that EPRI strongly consider sponsoring the engineering design and development of actual wind generating machines for a number of regional locations. Since there is no new technology needed, the machines can readily be engineered. There is nothing to prove by research and development studies, but much to prove by operating the machines: namely, prove that wind generators can supply electricity reliably, can be operated for long durations, and that they are or are not economically practical.

I am very much concerned, as I mentioned earlier, about this "R & D syndrome." We always seem to approach a problem saying that we need to institute a research and development program. I don't think that's the case with regard to wind energy. I think there is an adequate technology base that can be used to build wind power machines. Once we get some operating experience under our belt across a spectrum of sizes, that experience should point the way for new research and development directions. Furthermore, if the initial wind generating plants indicate that they can be made economically competitive, the research and development would likely become more economic as opposed to technically oriented.

In the nuclear field the utilities have worked out the economics of the atomic business. Right now it's costing about $550 per installed kilowatt. This does not include the decommissioning, and it has recently come out in hearings that the decommissioning of one of these plants, so the land could be reused, would cost much more than it did to build it. In addition to that, you have each of these thousand megawatt plants producing over a million pounds of radioactive waste that has to be taken care of. I think all of these costs have to be added in when we start to compare windpower with the other forms of power.

Mr. Schwartz:

A very important point was made; that is, it is difficult to see how all this can be made to work without the government interacting with the utilities. Dr. Starr testified recently before Congress that he didn't feel the Federal government had a role in deciding what kind of energy research should be done. That's best left to the utilities and suppliers. I wonder if there is; does Mr. Loftness have a comment on that?

Mr. Loftness:

I don't recall that particular statement. Was he stating that the government should not decide what the utilities should do, or what EPRI should do, or what the nation should do?

Mr. Schwartz:

His comment was he didn't feel the Federal government should be involved in energy research related to utilities and their suppliers; they can decide better what they could carry for policy.

Dr. Morse:

I think that in fact the increased funding in solar energy would counter that statement. I think there are Federal funds going into the development of new energy sources. In MHD there are significant funds, and in geothermal the same. I think there is that indication. I think that Joe Savino's comment as to how to get the utilities to take an active role, or to get the user to take a more active role, is a relevant point.

Mr. Schwartz:

The words "significant funds" have been used several times in connection with the forthcoming budgets in certain areas. I hope we will know about that this afternoon. But I wish to ask Mr. Loftness, or anybody else who has data on the subject, if there is anyone who can characterize the funding that is going into all forms of energy sources in terms of the annual capital outlay of the utilities?

Mr. Loftness:

The figure that Dr. Stever used in testimony before Congress was a Federal budget for next year of $772 million for energy research and development: about 65 percent was for nuclear research and development and the rest was spread across all other technologies. He used a figure of $1.2 billion being spent on energy research and development in the private sector - by industry, by the utilities, and by other organizations in non-Federal, funded activities.

Mr. Schwartz:

Is that engineering of new power plants using existing concepts?

Mr. Loftness:

He didn't break this down, so I don't know how he arrived at the figure of $1.2 billion for the non-government activities. EPRI itself will have a budget next year, supported by both the private and the public utilities, of a bit over $100 million for research and development. This compares to the $772 million for government-supported research and development work. I really can't imagine that Doctor Starr said that the government should not decide what research and development is important. I am sure, however, he would say that EPRI is not looking to the government for all of its direction on what should be done, and I don't think it will. I would expect, however, that many of the programs that EPRI will have will be cooperative programs with the U.S. Government. We already have a cooperative program in coal gasification, for example, and I would guess that programs in geothermal development, if we have them, will be in cooperation with government programs. There will be a lot of joint planning of activities, even if there aren't joint programs in the sense of being jointly funded. We are talking to the AEC about several joint programs; we feel the programs are important and they feel the programs are important. No one organization has either all the wisdom to decide what needs doing - or all the money to support every program.

Dr. Morse:

I think we could go on talking for quite a while on this topic, but we do have a session coming up in which the NSF and NASA programs will be discussed. Therefore, I think we will adjourn at this point.