High Voltage Transmission and Environmental Effects

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The expanding role of electric energy in the United States' economic, health, environmental and social development necessitates the construction of more high voltage (HV) transmission lines. Today, HV transmission lines have been the only vehicle to not only bring electric energy from far away power plants, but it has been done at great savings when used in economic dispatch and power pools' capacity exchanges. In the future, as the cost of energy increases, there will be an even greater demand to upgrade the transmission system to higher voltages in order to reduce the energy loss in these lines, improve reliability, and insure cost reduction by taking advantage of regional, time, and weather related differences.

Recently, however, it is becoming more difficult to acquire the necessary right of way for the development and construction of the necessary transmission system. Environmental issues and concerns about possible impact of electric field on living things and farm machinery are often used to object to giving the needed right of way for construction of new lines or upgrading existing ones. Some of these concerns are legitimate and must be addressed properly by research.

To address the concerns of transmission line effects in rural areas, Iowa State University in cooperation with ten local utilities including Central Iowa Power Cooperative, Cedar Rapids; Corn Belt Power Cooperative, Humboldt; Eastern Iowa Light and Power Cooperative, Wilton; Interstate Power Company, Dubuque; Iowa Electric Light and Power Company, Cedar Rapids; Iowa-Illinois Gas and Electric Company, Davenport; Iowa Power and Light Company, Des Moines; Iowa Public Service Company, Sioux City; Iowa Southern Utilities Company, Centerville; and Northwest Iowa Power Cooperative, LeMars, have established the Iowa Test and Evaluation Facility (ITEF), High Voltage Research and Demonstration. The major objectives of the research facility are:

a. Accumulation of pertinent data on EHV-UHV transmission systems to allow long-range evaluation of the suitability of higher voltage lines in the State of Iowa.
b. Accurate measurement of electrostatic and electromagnetic effects on the environment within or near the right of way.
c. Prediction of long-range effects on plants and animals from model development and analysis of data from well designed experiments.
d. Education of public by demonstrations of high voltage field effects and other sources of radio and television interference.
e. Serving as a high voltage laboratory for training utility engineers and ISU students.

Thus, one purpose of this facility is to study and report scientifically what the fields within the right of way of extra high voltage and ultra high voltage transmission lines do. Although the ten utility companies involved have partially financed portions of this program, they have no power to control the research or the information published as a result of studies undertaken at this facility.

The Iowa Test and Evaluation Facility is located in Webster County just east of the City of Fort Dodge, Iowa. A modular building providing office space and a large demonstration area was placed beneath a 345 kV transmission line running south to the Des Moines area, and a 161 kV transmission line running east from the substation toward Webster City. A 69 kV transmission line is also available at this same substation. The availability of these three transmission voltage levels was one of the factors determining the site location since they

represent the three major voltage levels used in the State of Iowa.

Besides the structure used for lectures and demonstrations, the facility includes a 150-ft wide area running south for three-quarter mile beneath the 345 kV line and access to the other right of way areas for experimental use. The owners and operators of the farms have been very cooperative in providing farm equipment for some demonstrations and monitoring crop performance. They have also been helpful by suggesting areas of concern to other farmers in the region.

The ITEF building itself is the center of most of the activity and is used to store the necessary equipment for taking measurements of electric and magnetic fields as well as electromagnetic radio wave levels from 10 kHz to 1.0 GHz. This radio frequency interference equipment is used to monitor suspected radio noise generation on HV lines and to determine any effect of new transmission lines on local radio and television reception in the vicinity of such lines. This also makes it possible to train graduate students both in the effective use of such instruments in the field and in analyzing all kinds of new data.

The HV demonstration usually lasts about five or six hours and includes a slide presentation and a number of simple high voltage and physical phenomena experiments both indoors and outdoors. These experiments are designed to teach guests what electric and magnetic fields are and what the numbers used to describe their magnitude really mean. These magnitudes are related to their common experiences with household appliances, machinery and other electrical equipment that they may have in their homes or on their farms. For instance, a Tesla coil is used to demonstrate corona discharges and the generation of ozone. A static generator provides an opportunity to feel what a 50 kV/m electric field is like. The sources of radio frequency interference (RFI) and television interference (TVI) within the household and their propagation from house to house via power lines are discussed, and how to differentiate between these external sources and those that may exist on the power line itself. Safety in the handling and use of electrical appliances and the tolerance limits are stressed throughout these presentations.

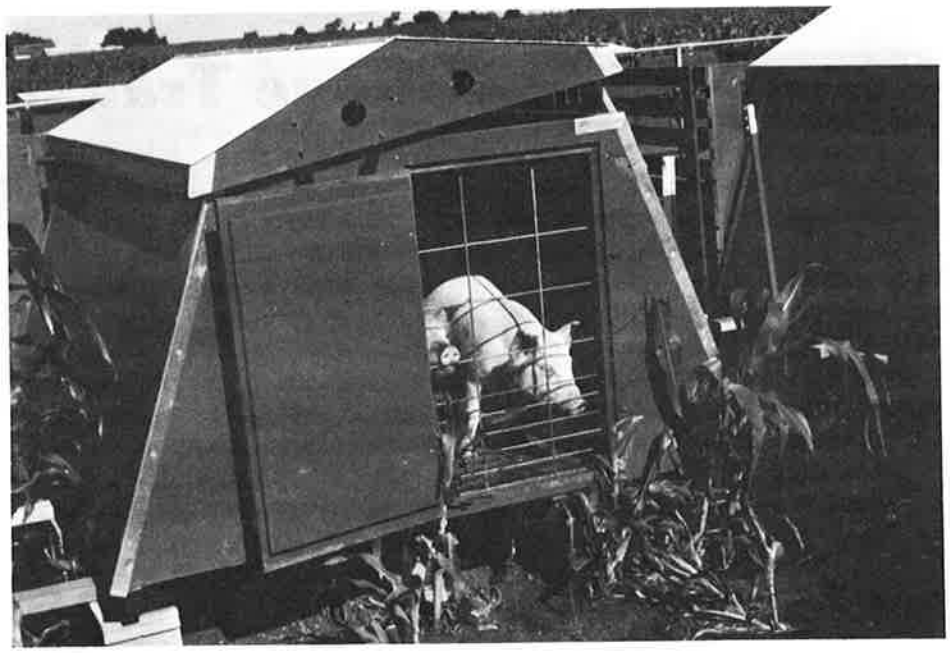

Figure 1. All "volunteers" reached a weight of over 200 pounds.

In the field demonstrations, actual field strengths are measured and short circuit current and open circuit voltages are measured on typical farm machinery mounted on insulating plates of polystyrene as well as a simulated insulated fence section. The short circuit currents are then compared to standard "safe" tolerance limits.

In 1981, Magne Waskaas published a summary of literature study on "Biological Effects of Electric and Magnetic Fields" in which he concluded that very little truly scientific data is available in spite of the numerous publications on the subject and that such data as is offered is often controversial and contradictory. Unwarranted extrapolations of data from one specie to another only served to confuse the issue.

It was in such a climate of uncertainty that the ITEF experiment on swine was begun, with full cooperation from the Animal Science and Veterinary Medicine faculties at Iowa State University and personnel from the Land O'Lakes Research Farm. Swine were chosen over beef cattle for this experiment for several reasons. First, perhaps, was the importance of pork production to the average Iowa farmer who is ultimately supporting our studies. More important scientifically, however, were the shorter life cycle required for swine studies and the fact that swine are normally confined to small areas where the electric fields would be uniform, whereas beef cattle normally graze over a large area and would create a considerable problem in calculating the extent of their exposure to the subject fields.

Swine Experiment and Set-Up

Sixty cross-bred pigs of similar breeding were chosen from the herds at Iowa State University Swine Nutrition Research Farm. As nearly as possible, littermate pairs of similar body weight were randomly allotted to the exposed and control groups. Five confinement units housing six pigs each were placed beneath the 345 kV transmission line in the region of maximum electric field ($\cong$ 4.2 kV/m) and an identical five units were placed approximately one-half mile away from the transmission line on the same farm.

The confinement units were typical commercial units with a 6×8-ft shelter, a 6×9-ft feeding floor constructed with oak slats, a nipple