77-0992

solar irrigation workshop proceedings

ALBUQUERQUE, NEW MEXICO
ALBUQUERQUE CONVENTION CENTER

JULY 7–8, 1977

Co-Sponsored by

Energy Research & Development Administration
The State of New Mexico
United States Department of Agriculture
New Mexico State University
ERDA's Sandia Laboratories

Issued by Sandia Laboratories, operated for the United States Energy Research & Development Administration by Sandia Laboratories.

Printed in the United States of America

Available from
National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Price: Printed Copy $4.50
Microfiche $3.00

SAND77-0992
Unlimited Release
Printed June 1977

Distribution
Category UC-62

PROCEEDINGS OF THE SOLAR IRRIGATION WORKSHOP
Albuquerque, New Mexico, July 6-8, 1977

Sponsored by

The Energy Research and Development Administration
Division of Solar Energy
Joseph Weisiger, Program Manager

New Mexico State University

The State of New Mexico

The United States Department of Agriculture

Hosted by

Sandia Laboratories
Advanced Energy Projects Division, 5715
Richard H. Braasch, Supervisor

Lyle Wetherholt, Conference Chairman

ACKNOWLEDGMENT

The conference chairman acknowledges the support of Joe Weisiger, ERDA/DSE, Robert San Martin, New Mexico State University, and Richard Braasch, Sandia Laboratories. Their continued encouragement often provided program direction during times of mounting pressure, frustration and myriad details. Many Sandia employees worked and participated in planning for several weeks, and it is they who deserve all the credit. In particular; Joe Laval, Bob Gall, Shirley Dean, Joan Gillon and Pam Wilkinson, all members of the conference steering committee, were the keystones of a much larger organization. Thanks also to Marylee Adams, secretary to the conference chairman, who often was the first to spot oversights and problem areas.

Lyle Wetherholt
Conference Chairman

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Solar Irrigation Workshop
July 7 & 8

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AGENDA (Cont)

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AGENDA (Cont)

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	Dr. Sam Varnado, Sandia Laboratories, Chairman
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PROCEEDINGS OF THE SOLAR IRRIGATION WORKSHOP

Foreword

The ERDA Solar Irrigation Workshop held in Albuquerque, New Mexico, July 7, 1977, was structured to be a major vehicle for information dissemination and technology transfer. It covered a wide range of subject matter related to crop irrigation including current hardware, economics, experiments, and international requirements. Speakers represented manufacturers, ranchers, governmental entities, universities and research firms. An anticipated heterogeneous attendee population dictated a format of many brief presentations rather than fewer more detailed discussions. This was done to expose the participants to the various expert speakers and to give them a cursory introduction to their particular expertise. These proceedings reflect the same intent. They consist of one page abstracts for each presentation, a brief biographical sketch of each speaker and sources for further information on each subject. The form and format is somewhat loose, but hopefully justified by our goal to publish prior to the conference. This goal was accomplished and served to provide the workshop participants with valuable information enabling them to assess the speakers' subject matter prior to the presentation.

The workshop was followed on July 8 by a Working Demonstration and Dedication of the ERDA/New Mexico shallow-well irrigation pumping experiment at Willard, New Mexico.

ABSTRACT

NATIONAL PROGRAM

An overview of the national energy plan will be presented. The nature of the energy crisis, the national strategy, and the near term, intermediate and long term objectives will be discussed. In this context, the solar irrigation program will be introduced. Emphasis will be given to the role of the participants and their far-reaching challenges and opportunities.

DR. HENRY H. MARVIN

Energy Research & Development Administration
Washington, DC 20545
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Dr. Marvin is Director of the Division of Solar Energy, ERDA. He was born in 1923 in Lincoln, Nebraska, received his BA Degree in The Sciences from the University of Nebraska in 1947, and the PhD Degree in Physical Chemistry from the University of Wisconsin in 1950. He and his wife, June, live in Annandale, Virginia. Their two sons--Dean and Kent--are in school at UCLA and Kent State, respectively.

Dr. Marvin brings to ERDA an extensive background in research, development and business management. He began his career with the General Electric's Research Laboratory in Schenectady, New York, in research and research management in chemical and metallurgical activities. He then served successively as Manager of Engineering, Capacitor Department, Hudson Falls, New York; Manager of the Lighting Research Laboratory, Lamp Business Divisionl Cleveland; and finally in 1967-74, General Manager of the High Intensity and Quartz Lamp Department.

ABSTRACT

ENERGY USED FOR PUMPING IRRIGATION WATER IN THE UNITED STATES, 1974

Gordon Sloggett*

U.S. farmers irrigated over 35 million acres in 1974 with 69 million acre feet of water pumped from wells and surface water. Acres irrigated by type of energy used to pump the water were estimated at 15.6 million for electricity, 10.6 million for natural gas, 3.9 million for diesel, 3.3 million for LPG, and 1.5 million for gasoline. Energy consumed was estimated 19 billion KWH, 132 billion cubic feet of natural gas, 178 million gallons of diesel fuel, 237 million gallons of LPG, and 71 million gallons of gasoline. The combined direct energy in these fuels equals 260 trillion BTUs (does not include the BTUs required to generate the electricity). This represents about 20 percent of all energy used on farms for production of comodities and livestock.

An estimated $594 million was spent in 1974 for energy for on farm pumping of irrigation water. The least expensive source of energy for pumping was natural gas followed by electricity, diesel, LPG, and gasoline.

Serveral factors affect energy used for pumping irrigation water, including acres irrigated, quantity of water applied, method used to apply the water, and height the water must be lifted. These factors explain State and regional differences in energy consumption.

California uses the most electricity among all States for irrigation energy while Texas uses the most natural gas, Nebraska is the largest user of diesel and LPG, and Arkansas is the largest user of gasoline.

*Agricultural Economist, NRED, ERS, USDA. Department of Agricultural Economics, Oklahoma State University. Stillwater, Oklahoma.

BIOGRAPHICAL SKETCH

GORDON SLOGGETT

ERS, USDA

Dept. of Ag. Econ.
Oklahoma State University
Stillwater, OK 74074

(BRIEF BIOGRAPHICAL SKETCH)

Born Nebraska, 1936. Educated in Nebraska Public Schools. BS University of Nebraska 1962, MS University of Nebraska, 1964. Employed as an Agricultural Economist for USDA since 1964, working in the area of Water Resource Economic.

SUGGESTED SOURCES OF FURTHER INFORMATION:

(Publication, reports, etc.) Energy and U.S. Agriculture: Irrigation pumping, 1974. To be published in the near future by ERS, USDA. Washington, D.C.

ABSTRACT

NEEDS FOR SOLAR IRRIGATION-NEBRASKA

Dr. W. E. Splinter P.E.
Ag Eng Dep't, U of Nebr.

Nebraska has over 52,000 irrigation wells irrigating over 5.5 million acres of land. Pumping water for irrigation is highly energy intensive, requiring 53 gallons of diesel fuel per acre for a typical center pivot irrigation system and 31 gallons of diesel fuel per acre for a typical gated pipe irrigation system. For a center pivot, the energy cost per acre is ten times the energy cost of the cultural and harvesting operations. On a statewide basis, irrigation accounts for nearly half of all energy invested in production agriculture.

Because of excellent water resources and the technical development of the center pivot irrigation system, irrigated acreage in Nebraska has increased from 4.1 million acres in 1968 to 6.3 million acres in 1976, accounting for 25% of total lands added to irrigation in the U.S. during this period of time. There were over 11,750 center pivots operating in Nebraska in 1976, as identified by satellite imagery.

At present, 23 per cent of the irrigation pumps are powered by natural gas, 25 per cent are electrically powered, 14 per cent are powered by LP gas and 37 per cent are powered by diesel engines. With limitations on expansion of electrical power and natural gas and the high cost of LP gas, almost all new systems are diesel powered. Since 1968, the proportion of diesel powered systems has increased from 23% to the present 37% and this trend can be expected to continue.

The exhaustion of natural gas and petroleum resources will place great stress on food and fiber production, especially in those areas relying on irrigation from pumping plants. An economic alternative energy source must be developed before economics force major agricultural areas out of production.

BIOGRAPHICAL SKETCH

Dr. W. E. SPLINTER

Dep't of Ag Eng, U of Nebr 68583
(402) 472-1413

Raised on irrigated farm near North Platte, Nebraska

B.Sc. Ag Eng, U of Nebr - 1950

M.Sc. Ag Eng, Mich State Univ - 1951

Ph.D. Ag Eng, Mich State Univ - 1955

Instructor, Mich State Univ, 1953-4

Assoc. Prof, N.C. State Univ, 1954-60

Prof, Biol & Ag Eng Dep't, N.C. State Univ, 1960-68

Prof & Chairman, Ag Eng Dep't, U of Nebr - 1968-

Fellow, Am. Soc. of Ag Eng

SUGGESTED SOURCES OF FURTHER INFORMATION:

Splinter, W. E. Center Pivot Irrigation. Scientific American 234(6) 90-99, 1976.

Splinter, W. E. Power Sources for Center Pivot Irrigation. Soc. of Automotive Eng Earthmoving Industry Conf. Paper No. 770539, 1977.

ABSTRACT

ENERGY PROBLEMS IN TEXAS IRRIGATED AGRICULTURE: THE POTENTIAL DEMAND FOR SOLAR IRRIGATION SYSTEMS

Dr. Milton L. Holloway
Texas Governor's Energy Advisory Council

This paper describes the peculiar problems of Texas irrigated agriculture in an era of rapidly rising energy costs, in the context of widely varying prices for agricultural product prices.

The research program and policy position's of the Texas Governor's Energy Advisory Council are explained as they relate to agriculture and the energy crisis. Expected future activities of the Council are explained and related to the problems of agriculture.

Recent studies supported by the Council concerning the energy problems of Texas agriculture are reviewed and the results summarized. Based upon these studies and the general outlook for agriculture, some judgements about the future potential for solar applications in Texas agriculture are made and explained.

MILTON L. HOLLOWAY

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EDUCATIONAL BACKGROUND:

B.S.	Texas Tech University, 1966 Agricultural Economics Major	
M.S.	Texas Tech University, 1968 Agricultural Economics Major Economics Minor	
Ph.D.	Oregon State University, 1971 Agricultural Economics Major,	

EXPERIENCE:

1966-1967	Research Assistant, Texas Tech University at Lubbock, Texas
1967-1971	Economist, Economic Research Service, U.S. Dept. of Agriculture, Corvallis, Oregon
1971-1972	Economist, Economic Research Service, U.S. Dept. of Agriculture, Pullman, Washington
1972-1973	Economic Consultant and OWRR Project Director, Texas Water Development Board, Austin, Texas
1973-1975	Economist, Governor's Office of Information Services and Governor's Division of Planning Coordination, Austin, Texas
1976-	Director, Forcasting and Policy Analysis Division, Governor's Energy Advisory Council, Austin, Texas

FURTHER SOURCES OF INFORMATION:

Holloway, Milton L. and Lial R. Tishler, "Simulation Techniques for Water Project Analyses," Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, Vol. 100, No. IR3, September, 1974.

Holloway, Milton L. and Joe B. Stevens, An Analysis of Water Resource Productivity in Pacific Northwest Agriculture, Economic Research Service, U.S. Department of Agriculture, Corvallis, Oregon, May 1973.

ABSTRACT

WATER USE IN CALIFORNIA & ENERGY REQUIREMENTS OF ALTERNATIVE SOURCES

Dr. Albert W. Marsh
University of California

For water studies, California has been divided into nine different hydrologic basins. This report presents data for the six most important basins.

California irrigated acreage is about 9,099,000, consisting of 6,186,000 acres of field crops, 1,837,000 acres of trees and vines, and 1,076,000 acres of vegetable crops. The report will present the acreage for each of these crop groups and the water applied in each of the hydrologic basins. It will also report the acreage of different irrigation methods in use.

The total amount of water applied annually for irrigation in California is about 32,000,000 acre/feet, an average of about 3.5 acre/feet per acre. Consumptive use estimates for the State are approximately 20,000,000 acre/feet per year. The difference occurs because some return flow water is repeatedly reused if quality permits. Some is nonrecoverable because of position or poor quality.

Irrigation efficiencies differ among hydrologic basins, depending mainly on their position. Efficiencies of each of the different basins will be shown and also the proposed or optimized efficiency that the State Water Resources Control Board considers as a desirable goal.

Energy costs for different alternative supplies of water in the different portions of the State are to be presented and range from 34 kwh per acre/foot for some of the areas where gravity water is supplied in canals to 3,000 kwh per acre/foot for water supplied by the State Water Plan that is developed in the northern part of the State, transmitted 500 miles to the south through canals and pipes, and lifted 3,000 feet over a mountain range. Consideration is also given to the energy cost of treated waste water, desalting of sea water, and towing of icebergs from Antarctica.

BIOGRAPHICAL SKETCH

ALBERT W. MARSH

University of California
Riverside, California
(714) 787-5101

Native of Minnesota; obtained B.S. in chemical engineering and M.S. in soils at University of Minnesota, 1935 and 1938; soil surveyor with SCS in Southern Great Plains for two years; obtained Ph.D. in soils at Oregon State College in 1942. Did irrigation research with SCS Division of Irrigation and Oregon Agricultural Experiment Station for five years; was Associate Soil Scientist and Associate Professor of Soils, Oregon State College for eight years; was Soil Scientist at U.S. Salinity Laboratory for one year; and Extension Irrigation and Soils Specialist, University of California since November, 1956. Has been responsible for the Annual Turfgrass Sprinkler Irrigation Conference held at Lake Arrowhead since 1967; was Sprinkler Irrigation Association "Man of the Year" in 1971; and in 1974 was one of four co-chairmen of the International Drip Irrigation Congress held in San Diego. Professional work of last few years has been mainly in water use and irrigation management, emphasizing timing, frequency, and amount of irrigation based on soil, water and climatic measurements.

SUGGESTED SOURCES OF FURTHER INFORMATION

"Irrigation in California" by J. Ian Stewart, a report to the State Water Resources Control Board, June 1975.

"Energy Requirements of Alternatives in Water Supply, Use, and Conservation: A Preliminary Report" by Edwin B. Roberts and Robert M. Hagan, Contribution No. 155 to the California Water Resources Center, December, 1975.

"Water Production Functions and Irrigation Programming" by J. Ian Stewart, et al., Report 14-06-D-7329, to the Bureau of Reclamation, U.S. Department of the Interior March, 1973.

"Irrigation Energy Requirements for Crop Production in California" by Gerald D. Knutson and Robert G. Curley, unpublished research, California Agricultural Experiment Station.

Dr. Ishrat H. Usmani

(This paper not received by publication date)

Antonio Murrie Santos

(This paper not received by publication date)

ABSTRACT

ERDA/NEW MEXICO EXPERIMENT

Dr. George H. Abernathy
Agricultural Engineering Department
New Mexico State University

This talk will concentrate on the overall concept of solar-powered irrigation pumping and the integration of solar power with irrigation scheduling.

There are in excess of 10,000 irrigation pumps in New Mexico. More than one-half of them are presently powered by natural gas. The price is increasing rapidly and availability is declining for this use of gas. Some new energy sources must be found if New Mexico farmers are to survive.

Although solar energy is free, the equipment to capture and utilize it is not. Large capital investments will be required of the farm community if solar power is to be utilized for irrigation pumping. Farmers will have to make maximum use of the water pumped with this expensive equipment, indicating that more-efficient water-distribution systems will be required. Also, high value crops will be needed to justify the expense.

Most irrigation pumps operate 24 hours per day during the peak consumptive-use season. Since solar energy is available only during daylight hours, some form of heat storage or alternate power will be needed to make solar energy practical for this application.

BIOGRAPHICAL SKETCH

DR. GEORGE H. ABERNATHY

Agricultural Engineering Department
New Mexico State University
Las Cruces, New Mexico 88003
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Born November 29, 1929 in West Newton, Pa.
Raised on a ranch near Roy, New Mexico.
Education:
- High School Graduation, 1948
- B.S., Ag. Engr., NMSU, 1952
- Mstr. of Engr., Univ. of Calif., Davis, 1956
- Ph.D. Okla. State Univ., 1967
- Registered Professional Engineer

Work Experience:
- U. S. Army CE, Lt., 1952-54
- Summer Employee, International Harvester Co., 1955
- Research Assistant, Univ. of Calif., Davis, 1955-57
- NMSU - Assistant Professor 1957-67
  - Associate Professor 1967-76
  - Professor 1976-present

SUGGESTED SOURCES OF FURTHER INFORMATION:

New Mexico Agricultural Statistics, 1976, New Mexico Department of Agriculture.

Consumptive Use and Water Requirements in New Mexico, Technical Report 32, New Mexico State Engineer

Sources of Irrigation Water and Irrigated and Dry Cropland Acreages in New Mexico, by County. Ag. Exp. Sta. Report 324, R. L. Lansford et al. 1976.

ABSTRACT

ERDA/ARIZONA SOLAR POWERED PUMPING EXPERIMENT

Dennis L. Larson
The Univeristy of Arizona

The Arizona Solar Energy Research Commission is cooperating with ERDA in the development and testing of a 150 kW solar powered pumping facility to be located on a farm in Arizona. The exprimrent will evaluate the solar power plant and its use on-site to drive deep well pumps to provide irrigation water. The University of Arizona is providing information and guidance on agricultural, pumping, and irrigation situations and practices affecting use of solar energy for pumping as directed by the ASERC.

The first objective of the University of Arizona effort was the compilation of information on Arizona agriculture; pumping energy sources and costs; irrigation well costs, pumping rates and depths, water quality and temperature; irrigation water demand and climate to provide a broad picture of the application. This information also assisted task two, site selection.

The University of Arizona participated in site selection by developing selection criteria and procedures and then assisting with area selection candidate farm review. The selected site is the Dalton Cole farm near Coolidge in Central Arizona. Specific site data was subsequently gathered and reported to solar power plant developers.

Successful use and adoption of on-site solar powered pumping plants may require changes in agricultural practices as well as special incentives. The third task during the initial six-month effort was the preparation of a plan to evaluate practices which might increase acceptance and yield most economic utilization of the solar power plant.

An investigation paralleling solar power plant development and use has thus been planned to study the most efficient use of pumping energy to grow crops. Pumping plant efficiency, irrigation management and cropping patterns are three of the factors to be studied. Analyses of the economics of using solar powered pumping of alternative uses for off-season power and of governmental or other incentives required for purchase of a solar powered plant will suggest ways to enhance adoption. Information dissemination, site preparation and project coordination will also be performed as required by the Arizona Solar Energy Research Commission.

Dennis L. Larson

Soils, Water and Engineering Department
The University of Arizona
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(602) 884-3463

I was raised on a grain and dairy farm in north central Iowa. I received B.S., M.S. and PhD degrees in agricultural engineering from Iowa State University, University of Illinois, and Purdue University, respectively. Between degrees, I served as a supply officer with the U.S. Army in Germany and worked as a farm equipment design engineer for John Deere. After receiving the PhD and before coming to Arizona in 1973, I was an advisor to the agricultural engineering teaching program, National University, Medellin and reseach program, ICA, Bogota, both in Columbia, for the University of Nebraska and extension engineer for Michigan State University. I currently teach courses in farm machinery, machine design, and agricultural systems analysis. My research interests include energy conservation and use of alternative energy sources in agriculture, machinery management and analysis and modeling of agricultural systems.

FURTHER SOURCES OF INFORMATION

Larson, D. L., C. D. Sands II, D. Towle, Jr., and D. D. Fangmeier, 1976. " Feasibility of Using Solar Energy to Drive Irrigation Pumps," Paper No. 76-2531, Am. Soc. of Agr. Engineers, St. Joseph, MI.

Larson, D. L. and D. D. Fangmeier, 1977. "Energy Requirements for Irrigated Crop Production," Prepared for the Proc. of First Int. Conf. on Energy Use Mgmt., October 24-28, 1977, Tucson, AZ.

ABSTRACT

A MOTION PICTURE SHOWING A SOLAR WATER PUMP

This film shows and describes a water pump system using solar energy converted to a direct mechanical motion suitable to pump groundwater to usable elevations.

The pumping system is primarily adaptable and practical in areas with groundwater at depths up to 200 feet. Depending on total head, capacities vary from 200 to 600 gallons per hour.

The solar pump was developed to provide water for the development of agricultural and ranchland in remote areas and serves the same purpose as windmills. In arid areas with limited wind conditions, the solar water pump provides a pumping system without electricity or fossil free powered engines.

Only occasional minimal attention is required for the continuous operation of the solar pump. As soon as the sun reaches a certain altitude, the stationary unit starts pumping and continues until approximately 1-1/2 hours before sundown, depending on the seasons. A self-contained tracking system increases the pumping time by approximately 3 hours a day.

The film shows the first unit of its kind operating at the research facilities of Nevada Testing Laboratories in Las Vegas.

Production of the solar pump is scheduled to start shortly.

Although this system includes previous arts, the application and combination into a self-contained pumping unit, as well as special control components, form the basis for the patent applications.

OSCAR J. SCHERER, P.E.
Consulting Engineer
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Las Vegas, Nevada 89102

Born and educated in Switzerland. A Civil Engineering graduate B.S. from the College of Engineering at Burgdorf, Switzerland. Two years after graduation and employment as a Construction Project Engineer, immigrated to the United States in 1926. After six years of progressive employment by Southern California Edison Company, Southwestern Engineering Corporation, and Fluor Corporation, started own consulting engineering and construction firm specializing in Mine and Mill design, industrial and commercial plants in the California Mother Lode area and since 1941 in Las Vegas, Nevada. As owner, started the Nevada Testing Laboratories in 1954 providing customer services in Foundation Engineering, Chemical and Physical Testing and Research.

Licensed Professional Civil and Structural Engineer, Nevada
Licensed Architect, Nevada and Mechanical Engineer, California

Member of Nevada State Board of Registered Professional Engineers

ABSTRACT

PROGRESS REPORT ON A

SOLAR-POWERED 50-HORSEPOWER IRRIGATION PUMP

GEORGE M. McCLURE
BATTELLE'S COLUMBUS LABORATORIES

This talk describes the design and operation of the world's largest known solar-powred irrigation water pump. The solar system was designed and built by the Columbus Laboratories of Battelle Memorial Institute for Northwestern Mutual Life Insurance Company for installation at their Gila Bend Ranch southwest of Phoenix, Arizona. The pump was installed during the early months of 1977 and completed during April, 1977. It is capable of developing 50 HP (3713 kW) and pumping 10,000 gallons (38 m^2) of irrigation water per minute at peak operation.

The irrigation system was conceived, designed, built, and placed in operation over a period of 18 months. A major portion of the program involved system analysis using computer modeling in the design of the components and in optimizing the system. The 50-HP (3713 kW) units. The present system consists of parabolic tracking solar collectors having a total projected area of 6,070 sq ft (564 square meters): a Rankine-cycle power unit comprised of a turbine/gearbox, boiler, condenser, regenerator and preheater; and a low-lift, high-volume-flow propeller pump.

During the longest day of the year in Arizona, the system delivers about 5.6 million gallons (21,000 m^2) of water over a period of 9.5 hours. At night, or during storms, the collector array automatically rotates to a downward-facing position to lessen the chance of damage or soiling of the reflective surface.

BIOGRAPHICAL SKETCH

GEORGE M. McCLURE

BATTELLE'S COLUMBUS LABORATORIES
COLUMBUS, OHIO 43201
(614) 424-7882

Mr. McClure joined Battelle in 1949 after receiving his degree in Engineering Physics from The Ohio State University. Research under his direction since then has been in the general fields of engineering mechanics, metallurgy, aeronautical and space systems, and materials. Much of his work has been in research projects related to natural gas pipelines and pressure vessels.

He is presently Manager of the Engineering and Manufacturing Technology Department at Battelle-Columbus. The development of the Northwestern Mutual/Battelle solar-powered irrigation pump project has been under his general administrative direction.

IRRIGATION PUMPING WITH WIND ENERGY

USDA-ARS PROJECTS[1/]

R. Nolan Clark[2/]

ABSTRACT

The USDA, Agricultural Research Service, in cooperation with ERDA, has initiated a research and development plan for irrigation pumping using wind energy. Objectives of these studies are to: (1) assemble complete wind-powered pumping systems, (2) adapt or modify existing pumping equipment so that it can be effectively powered by a wind turbine, and (3) make economic analyses of wind-powered pumping systems.

The first projects are low-lift and high-lift pumping applications. Pumping from lakes, streams, water reuse systems, and shallow wells comprise the low-lift application. High-lift pumping involves pumping from deep wells as found throughout most of the Great Plains Region.

Because present commercial wind turbines produce less power than that needed for deep wells, a wind assisted concept has been developed. The wind turbine provides supplemental power to the pump and thereby reduces the fuel consumption by the main power plant. A combination gear drive is used so that the two units supply power to the pump at the same time.

An existing deep well turbine pump has been fitted with a combination gear drive to accommodate an electric motor and a mechanically coupled vertical axis wind turbine.

At this time, a 4-kw vertical axis turbine has been installed at the well site and coupled to the combination gear drive. Preliminary data using this small turbine is presented. A 40-kw vertical axis wind turbine, which is near the required power for the well, has been ordered and is scheduled for fall delivery.

1/ Contribution from the Soil, Water, and Air Sciences, Southern Region, Agricultural Research Service, USDA, in cooperation with the Texas Agricultural Experiment Station, Texas A&M University.

2/ Agricultural Engineer, USDA Southwestern Great Plains Research Center, Bushland, Texas 79012.

BIOGRAPHICAL SKETCH

R. Nolan Clark

USDA Southwestern Great Plains Research Center
Bushland, TX 79012
(806) 376-2534

I am a native Texan and received a B.S. in Agricultural Engineering from Texas Tech University in 1964, a M.S. in Agricultural Engineering from Mississippi State University in 1967, and a Ph. D. in Agricultural Engineering from Texas A&M University in 1970. I served as an instructor at Mississippi State University and as a Research Associate at Texas A&M University before joining the U.S. Department of Agriculture, Agricultural Research Service at the USDA Southwestern Great Plains Research Center, Bushland, Texas. My research experience includes wind effects on sprinkler irrigation, irrigation design criteria, microclimate, plant-water relationships, and animal waste management. I am a member of American Society of Agricultural Engineering, American Society of Agronomy, Gamma Sigma Delta, and a Registered Professional Engineer.

SUGGESTED SOURCES OF FURTHER INFORMATION:

1) Dr. L. A. Liljedahl, Program Manager
   Rural and Remote Areas Wind Energy Research
   Bldg. 001, Room 126, BARC-West
   Beltsville, Maryland 20705

2) Mr. Larry J. Hagan, Agricultural Engineer
   USDA-ARS
   Agronomy Department
   Kansas State University
   Manhattan, Kansas 66506

ABSTRACT

In the United States, over 35 million acres are irrigated at an annual cost for fuel in excess of $500,000,000. Price increases in fossil fuels and potential shortages of natural gas have aroused interest in alternate energy sources for irrigation. In the United States, the majority of the energy used in pumping water is quantized in large sizes with respect to both acreage and pumping power (160 acre quarter sections requiring 100-300 kW peak power). This large scale crop irrigation represents one of the most promising areas for solar powered systems to penetrate a large market during the 1980's. An economic analysis concerning the adoption of solar photovoltaic energy systems in irrigation has been made and shows that they will become profitable, compared to conventional fossil fuel energy sources, in the early to middle 1980's if the cost of the solar modules follows ERDA's projections.

The first step towards the realization of large scale irrigation systems utilizing photovoltaics will be made during the summer of 1977 by the construction and operation of a subscale experimental unit of approximately 25 kW peak power. This experiment, jointly developed between MIT/Lincoln Laboratory and the University of Nebraska-Lincoln under the sponsorship of ERDA, will drive a 10 horsepower pump that will be interconnected with a gated pipe irrigation system and a reuse pit of three acre feet capacity.

The use of the photovoltaic power during the non-irrigating portions of the year would add to the economic attractiveness of the system, as well as providing relief for another energy intensive agricultural operation that will be increasingly affected by the growing fossil fuel shortage. It is, therefore, planned to switch the power during the fall and winter from the irrigation system to a nearby corn drying bin where a natural air drying technique will be tested utilizing photovoltaic powered circulation fans.

The design considerations of this photovoltaic power system along with its operational characteristics will be discussed in this paper.

BIOGRAPHICAL SKETCH

R. W. Matlin

MIT-Lincoln Laboratory
Lexington, Massachusetts 02173
617-862-5500 x213

Mr. Matlin received a Bachelor of Science degree from MIT in 1963, a Master of Science degree from Stanford in 1965, and an Engineer's degree from the University of Southern California in 1972 in Mechanical Engineering.

Mr. Matlin has been at MIT-Lincoln Laboratory since 1971 and is currently Assistant Manager of the Photovoltaic Field Tests and Applications Project. This project has the responsibility for field testing photovoltaic systems for ERDA in different economic sectors including agriculture, residential, and service/commercial/institutional. Mr. Matlin is currently a member of the ERDA sponsored Photovoltaic Planning Group and was recently the group leader of the Applications section of the Phoenix Photovoltaic Concentrator Workshop.

Prior to his association with energy related work at MIT, Mr. Matlin contributed to the LES 8/9 satellites at Lincoln Laboratory and the Mariner '71 and Viking '75 space probes at the Jet Propulsion Laboratory.

SUGGESTED SOURCES OF FURTHER INFORMATION

US Energy Use in Irrigation:

Dvoskin, D. and Heady, E.O., "Energy Requirements of Irrigated Crops in the Western United States," Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa, November 1976.

Lane, D.E., Fischbach, P.E. and Teter, N.C., "Energy Uses in Nebraska Agriculture," CC255, Lincoln, Nebraska, November 1973.

Sloggett, Gordon, "Energy Used for Pumping Irrigation Water in the United States" (Supplement), Conference on Energy in Agriculture, Washington University, 17 June 1976.

Irrigation and Crop Drying

The basis for the irrigation and grain drying portions of this paper has been drawn from research projects currently underway at the University of Nebraska by William E. Splinter, Paul E. Fischbach and Thomas L. Thompson and sponsored by the US Department of Agriculture, ERDA and the State of Nebraska.

Photovoltaic Power System

The basis for the photovoltaic power system portion of this paper has been drawn from work currently underway at MIT/Lincoln Laboratory under the sponsorship of ERDA as part of the Photovoltaic Field Tests and Applications Project. Additonal information is currently being prepared in the form of project reports and will be released soon.

ABSTRACT

ERDA/NEW MEXICO PROJECT - SYSTEM DESIGN

Robert L. Alvis
Sandia Laboratories

This project is the first of a planned series of ERDA/State sponsored solar powered irrigation experiments to determine the best system performance for the amount cost when present technology and commercially available components are utilized. The experiment is constructed near Willard, New Mexico. It produces essentially 25 hp continuously during the irrigation season to direct drive a turbine-type well pump which delivers enough water to irrigate 100 acres. It utilizes 6720 sq ft of distributive-type solar collectors to heat an oil heat transfer fluid. The hot fluid produced supplies a Rankine Cycle engine and charges a unique design thermocline thermal storage system. The collector and system controls are discussed.

ROBERT L. ALVIS

Advanced Energy Projects
Sandia Laboratories
Albuquerque, NM 87115

EDUCATION: BSME in 1960 - University of Oklahoma
MSME in 1962 - University of New Mexico

EMPLOYMENT: Sandia Laboratories since 1960

1976 - Present	Solar Energy
1974 - 1976	Drilling Research
1972 - 1974	Exploratory Bomb Design
1966 - 1972	Advanced Reentry System Design
1960 - 1966	Test Equipment Design

SOURCES OF FURTHER INFORMATION:

Robert L. Alvis, "Solar Irrigation Program - Status Report October 1976 through January 1977", SAND77-0380, Sandia Laboratories, April 1977.

Robert L. Alvis, Jerry M. Alcone, "Solar Powered Irrigation System", SAND76-0358, Sandia Laboratories, September 1976.

ABSTRACT

THE ACUREX CONCENTRATING SOLAR COLLECTOR

Robert C. Mawhinney
Acurex Corporation/Aerotherm Division

In this talk, Acurex's experience in solar energy will be discussed, and the Concentrating Solar Collector will be described.

Acurex is involved in a variety of solar energy programs funded by both government and private industry. These programs include research, engineering analysis, and product development.

Acurex has developed a concentrating parabolic trough (line focusing) solar collector for use in solar powered pumping systems and other process applications requiring thermal energy at temperatures up to 600°F. Slides of a subscale test model and a production prototype will be included to show construction details and illustrate the design of an installed, operating collector field.

The construction and materials optimize cost, performance, reliability and longevity, and a single-axis tracking and drive system permits operation with east-west or north-south axial alignment. A variety of fluids can be used, depending on the temperature level and other process requirements. Evaluation of total installed costs over the typical lifetime of both flat plates and concentrating collector systems indicates that, for many process applications, concentrating collectors can be more cost-effective.

BIOGRAPHICAL SKETCH

Robert C. Mawhinney
Acurex Corporation/Aerotherm Division
Mountain View, CA 94042
(415) 964-3200

Mr. Robert Mawhinney is the Manager of Alternate Energy Systems Programs at Acurex Corporation/Aerotherm Division. He has directed all of the activities related to alternate energy systems, and has performed as Program Manager on such programs as the Solar Industrial Process Hot Water for ERDA and the Campbell Soup Company, the Deep and Shallow Well Solar Irrigation project, the Santa Clara International Swim Center, Nuclear Safety Tests, and Conservation/Alternate Energy for the State of California Capitol Mall Complex. In addition, he has extensive experience in systems engineering ordnance design, transportation and the law enforcement systems, and data acquisition systems.

SUGGESTED SOURCES OF FURTHER INFORMATION:

"Solar Energy for Industrial Process Hot Water" Agricultural Engineering, to be published.

Acurex Model 3002 Concentrating Solar Collector, Technical Note, published 1977.

150Kw Solar Powered Deep Well Irrigation Facility, Technical Proposal, published 1976.

DESIGN AND DEVELOPMENT OF THE 25 HP RANKINE ENGINE FOR USE ON THE ESTANCIA VALLEY IRRIGATION PROJECT

Robert E. Barber
Barber-Nichols Engr. Co.
6325 W. 55th Ave.
Arvada, CO 80002
(303) 421-8111

Barber-Nichols had the responsibility to analyze, design, fabricate and test a 25 hp Rankine engine compatable with the design requirements specified by Sandia. The solar collectors and heat storage system supplies hot Caloria HT43 oil to the engine and the engine is cooled with 70 gpm of the pumped water at 65°F. The Rankine cycle operates at a peak temperature of 322°F on Refrigerant 113, which was the result of a cycle optimization of total system cost when considering heat storage cost, solar collector cost, and Rankine engine cost. This optimum results in design point HT43 conditions of a supply of 8.6 gpm of 420°F oil which exits the Rankine engine boiler at 240°F. The Rankine engine had a projected cycle efficiency of 15.4% and a parasitic electrical load of 450 watts for the controls and boost pump. The measured test data shows a cycle efficiency of 15% and a parasitic load of 235 watts.

The engine will operate at temperatures less than 320°F and produce substantial power (i.e. at 300°F, 18 hp @ 13% cycle efficiency; 280°F, 13 hp @ 12% cycle efficiency; 260°F, 8 hp @ 10% cycle efficiency; 240°F, 6 hp @ 8% cycle efficiency). The engine has a mechanical drive to the Rankine feed pump (2 hp) and the condenser water pump (0.5 hp) to reduce electrical parasitic loads. The components are made up primarily of off-the-shelf refrigeration valves, fittings, heat exchangers, etc. The special components are the turbine-gearbox-feed pump (turbine runs at 36,300 rpm, output shaft at 1730 rpm), the regenerator, demister and float tank all of which are made by Barber-Nichols Engineering Co. The engine is approximately 6 feet high, 4 feet wide, and 11 feet long, and weighs 2500 lbs. This project began on August 17, 1976 and the engine was delivered after 36 hours of test time on April 11, 1977.

ROBERT E. BARBER
Barber-Nichols Engr. Co.
Arvada, CO 80002
(303) 421-8111

Mr. Barber has been involved in the development of Rankine engines since 1962 when he was employed at Sundstrand, Denver, in the areas of space and military power system development specializing in thermodynamics and turbo-machinery design. In 1966 Mr. Barber and Mr. Kenneth Nichols formed Barber-Nichols Engineering Co. which has grown to the current size of 30 technical personnel working on Rankine engines for solar, geothermal, and heat recovery applications.

Mr. Barber received a B.S. in Mechanical Engineering from Oregon State University in 1957 and a M.S. from Rensselaer Polytechincs Institute in 1960.

FURTHER SOURCES OF INFORMATION:

"Solar Air Conditioning Systems Using Rankine Power Cycles - Design and Test Results of Prototype Three Ton Unit," presented at the Institute of Environmental Sciences' 1975 Annual Meeting, April 13-16, Los Angeles, California.

"Cooling with the Sun's Heat - Design Considerations and Test Data for a Rankine Cycle Prototype," Solar Energy, Journal of Solar Energy Science and Technology, Volume 17, No. 3, July 1975.

"Potential of Rankine Engines to Produce Power from Waste Heat Streams," 9th Intersociety Energy Conversion Engineering Conference, August 1974, San Francisco, California.

"A Prototype Solar Powered, Rankine Cycle System Providing Residential Air Conditioning and Electricity," 9th Intersociety Energy Conversion Engineering Conference, August 1974, San Francisco, Cal.

"Small Rankine Cycle Total Energy System for Recreation Vehicles: A Comparison of Three Possible Approaches", 8th Intersociety Energy conversion Conference, August 13-17, 1973, Philadelphia, Pa.

"The Design and Development of a Turbine-Gearbox for Use in an Automotive Organic Rankine Cycle System," SAE International Mid-Year Meeting, June 7-11, 1971, Montreal, Canada, SAE Paper No. 710564.

"Effect of Pressure Ratio on the Performance of Supersonic Turbine Nozzles," 4th Intersociety Energy Conversion Conference, September 22-26, 1969, Washington, D.C.

ABSTRACT

150 KW_e SOLAR POWERED DEEP WELL IRRIGATION FACILITY

Guy E. Adams

Energy Resources Center, Honeywell Inc.

This talk describes the system concepts and tradeoffs being investigated by the Energy Resources Center of Honeywell Inc. in a Preliminary Design Study for a 150 KW_e Solar Powered Deep Well Irrigation Facility. This program is funded by ERDA and it is under the technical jurisdiction of the Sandia Laboratories.

The long term objective of the program is the commercial availability of a cost effective deep well irrigation system with various optional subsystems to replace or to supplement commercial electrical power or other conventional power sources. The objectives of the present program are the preliminary design of a cost effective system and a proposal for the detailed design, fabrication and installation of a demonstration system.

The design must be based on existing state-of-the-art components. Honeywell's proposed system consists of a parabolic 2 axis tracking(radar dish) solar heat concentrator with a cavity receiver, a heat engine and an electrical generator mounted at the focal point. The system will include controls, storage capability, associated hardware and the back-up system necessary for a stand alone application.

Selection of major subsystems based on performance and cost will be presented.

The program status and schedule will be presented.

GUY E. ADAMS, Senior Principal Development Engineer

EDUCATION:	BSME, Purdue U	1942
	BSEE, Purdue U	1949
	MSEE, Univ. of MN.	1957

QUALIFICATIONS:

Solar Energy Program

Mr. Adams has been assigned as the Lead Engineer for the Preliminary Design Study for a 150 KWe Solar Powered Deep Well Irrigation Facility. Previously he was program manager responsible for developing digital heat transfer computer programs for a special chemical solidification process simulation and a combustion initiation simulation.

Prior Experience

Since joining Honeywell in 1962, Mr. Adams has been involved in a variety of technology disciplines in aerospace, and industrial automation projects in the capacity of program manager, lead engineer, or design engineer.

Recently he was Program Manager for the design of an automated computer controlled manufacturing plant.

He previously was responsible for similar automated plant study programs.

Other work at Honeywell includes system analysis, design and/or simulation in inertial guidance, tactical missiles, radar fire control and radar bombing.

Prior to joining Honeywell, Mr. Adams was Vice President of the automatic controls division of a small company which designed and commissioned controls for four large scale industrial automation systems. In another small company he was chief engineer of the automatic controls department which was involved in military R&D as well as automated conveyor controls.

Registered Professional Engineer: Minnesota and Indiana

Suggested sources of further information:

Bob Alvis - Sandia Technical Monitor
Porter Grace - ERDA Contract Administrator

ABSTRACT

150 KWE SOLAR POWERED DEEP WELL IRRIGATION FACILITY

G. J. NEUNER
Acurex Corporation/Aerotherm Division

This talk describes the objectives and activities of the 150 kWe Solar Powered Deep Well Irrigation Facility which is currently being designed by Acurex. Acurex Corporation has major responsibility for the program, with support from the Bechtel Corporation and Sunstrand Energy Systems.

The objective of the program is to design an economically viable irrigation system which is solar powered, and operate at 600°F or higher. This discussion will be divided into system requirements, system analysis, and the preliminary design.

The system analysis for the program has been divided into two distinct sections. The first is an overall economics and performance analysis which evaluates different system configurations. The second part of the system analysis is a subsystem optimization. During this part of the analysis each component is evaluated for performance versus total system cost. The resultant data can then be put together in the system analysis for the final system evaluation. Computer modeling is used to determine system sizes and responses using actual weather data. Tradeoffs such as water storage or thermal storage tank size are done during the analysis phase. Major system layouts and their components will be discussed. Rough production costs and economic analyses will also be presented. An economic evaluation of the system is presented based on what can be changed to make the system more economically attractive, and on current financial constraints as viewed by the farmer.

The program status will be discussed, including schedule for the multiphase program.

BIOGRAPHICAL SKETCH

Mr. G. J. Neuner
Acurex Corporation/Aerotherm Division
Mountain View, CA 94042
(415) 964-3200

Mr. Neuner is currently the Program Manager on the 150 kWe Irrigation Program. Other solar programs that Mr. Neuner is, or has been, assigned to include the Solar Total Energy Large Scale Experiment, the 25 Hp Irrigation Collector Field, and the Industrial Process Hot Water Program.

Mr. Neuner joined Acurex in 1972 where he is a Section Leader for Thermal Systems. Previously he worked at the North American Rockwell Corporation in the Space Shuttle thermal protection group. Mr. Neuner graduated from California State Polytechnic College in Pomona, and holds a Masters of Science Degree in Aeronautics from California Institute of Technology.

ABSTRACT

PRELIMINARY DESIGN CONSIDERATIONS FOR A CENTRAL RECEIVER SOLAR POWERED DEEP WELL IRRIGATION FACILITY

Dr. S. L. Levy
Black & Veatch Consulting Engineers

The concepts of central receiver solar-thermal-electric energy conversion systems shall be presented. The applicability of these systems to deep well irrigation energy needs as well as design considerations will be discussed.

The objective of the ERDA funded project is to develop a preliminary design for a 150 kWe central receiver solar-thermal-electric power generating unit. The criterion to have an operating facility by January 1, 1979, requires that esentially all components and systems be commercially available.

Black & Veatch's program includes the analysis of and selecttion from three thermodynamic cycles--the Rankine, the open Brayton and the closed Brayton cylces. Highlights of these analysis and design considerations for heliostat fields will be covered.

A short history of central receiver systems, their development, and their performance will be presented. Current construction of a 5 MW(thermal) central receiver test facility and preliminary designs of megawatt sized solar thermal plants will be discussed.

Dr. S. L. Levy

Black & Veatch Consulting Engineers
Kansas City, Missouri 64114
(913) 967-2037

Dr. Sheldon L. Levy is a member of the Project Management Staff in the Solar Energy Group, Power Division. Dr. Levy is responsible for the Preliminary Design of a Solar Powered Deep Well Irrigation Facility for the Energy Research and Development Administration. He has been involved in the analysis of solar energy conversion of solar thermal facilities and has provided criteria on energy collection and radiative heat transfer for EPRI's Open Cycle Gas Turbine Solar Electric Conversion System. He was the Project Engineer for the Conceptual Design of a Solar Materials and Components Test Facility and its related requirements for the Electric Power Research Institute. He also is participating in the environmental assessment of five solar energy concepts for EPRI, and is responsible for establishing impacts of wind patterns data on turbine spacing.

During 1968-1975, Dr. Levy was President of TransTech, Inc. From 1954-1968, he was associated with Midwest Research Institute as Director of its Mathematics and Physics Division. During that time he had responsibility for research in materials, engineering mechanics, applied mathematics, operations research, and computer science activities.

His academic training inludes:

Illinois Institute of Technology, B.S., Electrical Engineering, 1946

M.S., Mathematics, 1948

Brown University, Ph.D., Applied Mathematics, 1952

Honorary Societies: Eta Kappa Nu, Sigma Xi, Sigma Pi Sigma

SUGGESTED SOURCES OF FURTHER INFORMATION

G. Francia, "The University of Genoa Solar Furnace," Presented at the NSF International Seminar on Large Scale Solar Energy Test Facilities, New Mexico State University, Las Cruces, Nov. 18-20, 1974

"5 Megawatt Solar Thermal Test Facility", Facility Capabilities Defintion, Dec. 8, 1975, U.S. Energy Research and Development Administration, Contract No. E(04-3)-1078, Black & Veatch, Honeywell, Inc., and Georgia Institute of technology

"10 MWe Solar Pilot Plant Phase I", Preliminary Design Report, Six Volumes, Contract No. F3419-DR-302-1, Honeywell, Black & Veatch, Babcock & Wilcox May 1, 1977

"Dynamic Conversion of Solar Generated Heat to Electricity", Report No. NASA CR-134724, Aug. 1974, Honeywell, Black & Veatch, Contract No. NAS 3-18014

ABSTRACT

FARMING OPERATION AT WILLARD SOLAR PLANT

Greg Alpers

This talk describes the farm operation at Willard, New Mexico and the energy related problems pertaining to it.

The farm contains 5,000 acres of ground, however, only 3,000 acres are being irrigated. Without an economical source of energy, this farm would consist of dryland grass capable of supporting 8 - 10 animal units per section. With water, the farm has turned into lush, green fields capable of growing 250 sacks of potatoes per acre, 150 bushels of corn per acre and 6 tons of alfalfa hay per acre.

Since 1974 the cost of gas and electricity has increased at a tremendous rate. The cost adjustment of gas per MCF has gone from .00¢ in 1974 to a high of $1.07, with a current rate of .32¢. Electric fuel cost adjustment has risen from .00¢ in 1969 to $1.37 per KWH. At the same time, the prices a farmer receives for his crops has not increased proportionately, which places him in a terrific cost-price squeeze.

Of possible help to this farming operation, is the solar irrigation plant. The practicability of this plant is questionable at present, as the project is for experience, not profit. New and more sophisticated equipment will be added in the near future to further experiment with solar energy as a source of power for irrigation systems.

BIOGRAPHICAL SKETCH

Greg Alpers

Born September 24, 1953 in Great Bend, Kansas. Grew up on a dryland wheat and dairy farm. Graduated from Goddard High School, Roswell, New Mexico in June 1971. B.S. in Agronomy, New Mexico State University, 1975. One year graduate work, New Mexico State University. Worked two years as a Biological Specialist for The Bureau of Reclaimation, Las Cruces, New Mexico, researched Glyphosate. Co-arthur of Perrenial Weed Control on Irrigation Distribution Systems with Glyphosate, published January 19, 1977, Southern Weed Science Society, Dallas, Texas.

SUGGESTED SOURCES OF FURTHER INFORMATION:

Abernathy, George H., New Mexico State University, Associate Professor, Agricultural Engineering.

Alvis, Robert L., Sandia Laboratories, Project Engineer, Solar Plant.

Arhend, Tim J., The Energy Crises Effects Upon Irrigated Farming in Southwestern New Mexico; Southwestern School of Banking, Graduate School, Dallas, Texas.

Schrimsher, Cecil, Smith Machinery Co., Inc., Manager, Roswell, New Mexico.

ABSTRACT

Dalton Cole, Jr.
Coolidge, Arizona

Agriculture is big business in Arizona, bigger than mining, exceeded only by tourism and manufacturing in dollar volume. Less than twenty percent of the state is privately owned; the remainder of the land is controlled by the state and federal government including BIA and BLM. Crops are grown on only about 1.4 million acres, but cropland agriculture generates more than half the agricultural revenue, with livestock accounting for the rest. Crops grown include cotton, grain, alfalfa, lettuce and citrus.

The climate in the areas best suited for growing crops is arid desert. Daily temperatures in the summer surpass 100°F and rainfall ranges from 6 to 12 inches per year; therefore, crops must be irrigated. The water is provided by surface or underground sources depending on location.

Where groundwater must be pumped, pumping energy constitutes 70-90 percent of the total crop associated energy expended on the farm. In Pinal County, water is lifted 300 feet or more while in other areas pumping depths are greater and increasing annually.

My farm is located a few miles outside of Coolidge, approximately midway between Phoenix and Tucson in one of the major agricultural regions of the state. Major crops grown on the 1100 acres are cotton and grain (wheat and barley). Crops are irrigated from a series of 8 wells pumping from approximately 300 feet, ranging in size from 70 to 120 HP, which are connected by canals which distribute the water throughout the farm. Power in the area is distributed by an electrical management district (ED-2) formed by the farmers.

Even with existing low-cost hydroelectric contracts, pumping costs run from $10 to $20 per acre-foot of water. Escalating electrical rates and natural gas cutoff threats are forcing major changes in agricultural practices. A continuing and economical source of pumping energy is needed. We hope solar energy will be this source.

BIOGRAPHY

Dalton Cole, Jr. Coolidge, Arizona Third Generation Arizonian

Graduate of U of A - 1957
B.S. Business Administration
Football Quarterback

Joined the Air Force for three years - Flew B-57 as a Bombadier-Navigator

1962 returned to Arizona and bought a 480 acre farm and presently owns and farms 1120 acres. Lives on the farm with his wife Beth and three children:

Ann - Colorado College
Skip - University of Arizona
Douglas - High School

Chairman of the Ho'Ho' Cam Irrig. & Drainage District

Board of Directors of:

- South Side Gin, Inc.
- Coolidge Grain and Warehouse, Inc.
- Grower's Pest Mgt. Corp.
- Central Arizona Project Assn.
- Florence Coolidge Natural Resources Conservation District

Vestryman - St. Michaels Episcopal Church

Hobies:

- Water and Snow Skiing
- Back Packing
- Camping

ABSTRACT

Preliminary Economic Analysis of Solar
Irrigation Systems for Selected Locations

This paper describes a preliminary analysis of the economic feasibility of stand-alone solar irrigation systems in various locations. The system configuration used is similar to that being used in the ERDA/N.M. solar irrigation experiment. Locations were chosen on the basis of the 1969 Census of Agriculture and on the irrigation energy weight ranking of the western states. The crops considered were chosen from the principal crops in each region. System costs were based on industry estimates of production costs. The system components were sized to minimize capital cost and meet the specific crop demand identified for each location. The economic feasibility was determined by comparing the life cycle costs of the solar system versus the life cycle costs of fossil fuel powered systems.

Based on the above assumptions, the results show the year in which a stand-alone solar irrigation system will become economically feasible in each location. Future work is identified which will explore the effect of government incentives, hybrid systems, and alternative uses in advancing the economic feasibility of solar powered irrigation.

Audrey M. Perino

Education:

B.A., Math and Economics, Oberlin College, 1975

M.A., Applied Economics, University of Michigan, 1976

Work History:

Employed at Sandia Laboratories since September, 1976. Currently an economist for Sandia's Energy Systems Analysis Division. Responsibilities include economic analysis work in solar irrigation, solar heating and cooling, solar total energy and electron beam fusion. Presently participating as a member of the Systems Simulation and Economic Analysis Working Group of ERDA's Solar Heating and Cooling Program.

ABSTRACT

FARMER ADJUSTMENT POTENTIALS TO HIGHER ENERGY PRICES

by
Melvin D. Skold
Economic Research Service, USDA
Fort Collins, Colorado

Higher energy prices cause farmers using pump irrigation systems to consider several adjustment possibilities. Given the nature of agricultural product markets and the general lack of differentiation between products from pump irrigated farms and other products in the market, opportunities to pass higher energy input costs on to consumers are small. Consequently, higher energy prices will result in changes in production processes in the firm.

Attempts to adjust to the new energy cost situation include, (a) shifts to less energy intensive crops, (b) substitution of other inputs for the more expensive energy inputs, and/or (c) reductions in the intensity of input use. Under pump irrigation conditions, water and energy become joint inputs; higher priced energy makes water more costly and farmers adjust to the higher water costs. While some crops are irrigated which are less responsive to water than others, the more water (energy) responsive crops are irrigated. Limited potentials exist for substituting other inputs for more expensive energy inputs. Such may include using less water (energy) and more fertilizer in crop production or the adoption of reduced tillage practices. Production response research indicates that water use intensity will respond very little to higher energy (water) prices.

Conservation offers potentials for sizable savings in energy use. However, the investment or fixed costs associated with improving the efficiencies of existing irrigation systems or changing to more energy efficient systems are difficult to offset even at relatively high energy prices. Unless inexpensive energy sources are developed which are capable of meeting the highly seasonal demand of pump irrigations, high energy costs will force an increasing cost disadvantage upon pump irrigators relative to other agricultural producers.

BIOGRAPHICAL SKETCH

Dr. Melvin D. Skold

NRED, ERS, U.S. Department of Agriculture
Department of Economics
Colorado State University
(303) 482-9279

(BRIEF BIOGRAPHICAL SKETCH)

Melvin D. Skold

Born Colorado, 1936. Married, 3 children. B.S. (1958), M.S. (1959) Colorado State University, Ph.D. (1963) Iowa State University. 1963-64 Agricultural Economist, FPED-ERS, Lincoln,Neb.; 1965-67, Assistant Professor, Kansas State University; 1967-70 Assistant-Associate Professor, Colorado State University; 1970-72 Western Field Group Head, FPED-ERS, Ft. Collins, Colorado; 1972-74 Deputy Director, CED, ERS, Washington, D.C.; 1974-date, NRED-ERS, Ft. Collins. Publications in agricultural production and natural resource economics. Chairman, WAERC Commercial Agriculture Committee, 1970; WAEA responsibilities: Council Member, 1968-69; Chairman, Published research awards, 1972; Session chairman, 1975. Foreign experience in Argentina and Pakistan. Honorable Mention, Published research awards on Quality of Communication, AAEA, 1974; Vice-President WAEA, 1976-77; Outstanding Doctoral Dissertation Committee, AAEA, 1977-80.

SUGGESTED SOURCES OF FURTHER INFORMATION:

(Publications, reports, etc.)

Chen, Kuei-Lin, R. B. Wensink, and J.W. Wolfe, "A Model to Predict Total Energy Requirements and Economic Costs of Irrigation Systems." American Society of Agricultural Engineers. Paper No. 76-2527. St. Joseph, Michigan. 1976.

Economic Research Service. "Crop Enterprise Budgets: Firm Enterprise Data System," Commodity Economics Division, ERS, U.S. Department of Agriculture. Washington, 1977.

Huszar, Paul C., M.D. Skold, and R.E. Danielson, "Evaluation of Irrigation Water and Nitrogen Fertilizer in Corn Production." Colorado State University Experiment Station Technical Bulletin 107. Ft. Collins. 1970.

Skold, Melvin D., " Great Plains Agricultural Production Under Limited Energy Supplies," Proceedings, Great Plains Agricultural Council. Lincoln, Nebraska. 1975.

ABSTRACT

ECONOMICS OF SOLAR IRRIGATION

Mr. Paul D. Maycock
Energy Research & Development Administration

An overview of several technical approaches to the irrigation problem will be presented. The economic issues will be developed and an attempt will be made to forecast possible improvements. A broad discussion of innovation in irrigation and agriculture will be merged with the solar options to provide an overall perspective. The importance of solar irrigation to the national program will be discussed and the audience will be challenged to participate as active partners in this important endeavor.

MR. PAUL D. MAYCOCK

Energy Research & Development Administration
Washington, DC 20545
(202) 376-4476

B.S. in Physics, Iowa State University, 1957
M.S. in Physics, Iowa State University, 1962

Mr. Maycock is Director of Planning and Program Implementation, Division of Solar Energy, ERDA (FY 77 Budget $300 Million). He served as Manager, Product Planning, Consumer Products, for Texas Instruments (TI), Inc. from 1974-1975. The key product from this effort is the $19.95 digital watch. He was (1971-74) Senior Business Analyst for Corporate Research & Engineering, TI, where he created approaches to strategic planning, performed venture studies, and developed business models. Formerly, from 1969 to 1971, he was Senior Business Analyst for the Materials Group of TI, where he analyzed and established several new products in the clad metal and specialty chemical areas. From 1967 to 1969, Mr. Maycock was Manager, New Business Development, for the Chemical Materials Division of TI. Primary emphasis was on specialty chemicals. From 1966 to 1967, he served the U.S. Navy in London as Liaison Scientist GS-13, where he wrote 16 reviews of applied technology in Europe, including fuel cells, computers in Great Britain, and operations research in Italy. From 1964 to 1966, he was manager of Marketing Intelligence for Corporate Research & Engineering, TI, and from 1962 to 1963, he was head of the Technical Intelligence Center. Prior to joining TI in 1962, he was a Research Assistant in the Ames Laboratory of the AEC from 1961 to 1962. During 1960 to 1961, Mr. Maycock served as a solid state physicist in the Office of Naval Research, Washington, D.C., GS-11, and administered research contracts in solid state physics, infrared detectors and systems, and energy conversion. He has published in The Physical Review, Journal of Applied Physics, Journal of Metals, Naval Research Reviews, Solid State Electronics, Journal of International Planning, USAEC Reports, and U.S. Navy Reports.

Member: American Physical Society, Institute of Electrical and Electronics Engineers, Phi Kappa Phi

ABSTRACT

AGRICULTURAL ENERGY RESEARCH DEVELOPMENT AND DEMONSTRATION

M. Rupert Cutler
Assistant Secretary
for
Conservation, Research and Education
U.S. Department of Agriculture

The development and implementation of energy policies and programs have major implications for agriculture. Our food, fiber and forest products system is energy intensive and energy dependent. Producing, harvesting, processing, distributing and using these products consumes 22 percent of the energy used in the U.S. Since agriculture in its broadest sense is the backbone of the Nation's economy, things that impact upon it affect us all.

The President's Energy Program involves major strategies for energy conservation, conversion to coal and other more abundant fuels, and the harnessing of renewable and essentially inexaustible energy resources. Agriculture has a vital interest in successfully implementing these strategies, particularly through research, development and demonstration.

Agricultural science must draw upon its in-depth understanding of and involvement in all aspects of the private and public sectors of our food, fiber and forest products system to make required contributions to solving the Nation's energy problems. It must work even more closely with ERDA in helping to meet objectives of conserving available energy and obtaining new supplies. It must generate new knowledge and technology to assist in the adjustments necessary to maintain a healthy agricultural system under different energy scenarios. It must do these things in addition to serving its basic missions relating to supplying high quality and reasonably priced food, fiber and forest products; developing rural America; and protecting and enhancing the quality of the environment.

History tells us that given the necessary support, the agricultural research and technology transfer system will provide major inputs to the solution of our energy problems.

M. RUPERT CUTLER

ASSISTANT SECRETARY OF AGRICULTURE FOR CONSERVATION, RESEARCH AND EDUCATION

M. Rupert Cutler was nominated March 18, 1977, by President Carter to be assistant secretary for conservation, research and education of the U.S. Department of Agriculture. He was confirmed by the Senate on April 6 and sworn into office April 8.

As assistant secretary, Dr. Cutler supervises the Agricultural Research Service, the National Agricultural Library, and the Soil Conservation Service. He also serves as a director of the department's Commodity Credit Corporation.

Dr. Cutler was born in Plymouth, Michigan, Oct. 28, 1933. He grew up in Detroit, Michigan, and attended Heidelburg College, Tiffin, Ohio, and Wayne University, Detroit, before transferring to the University of Michigan where he received an undergraduate degree in wildlife management and forestry.

After his graduation, Dr. Cutler became a consumer publications writer with a Michigan camera firm. In 1956, he accepted the position of editor of the Winslow (Ariz.) Mail, a weekly newspaper.

Since 1957, Dr. Cutler has worked with conservation, wildlife and resource development organizations. From 1957 until 1958, he was executive secretary of Wildlife Conservation, Inc., Boston, Mass; from 1958 until 1962, chief of the education division, Virginia Commission of Game and Inland Fisheries; from 1962-1964, assistant chief of the coservation education division of the National Wildlife Federation; from 1964-1965, managing editor of National Wildlife magazine, and from 1965-1969, assistant executive director of The Wilderness Society.

In 1969, he entered Michigan State University, earning M.S. and Ph.D. degrees in MSU's department of resource development. The subject of his doctoral dissertation was Forest Service litigation and its impact on policy. He joined the staff at Michigan State in 1973, serving as assistant professor of resource development and extension specialist in natural resources policy until receiving his USDA appointment.

In 1974 and 1975, Dr. Cutler was a consultant to the environmental coordinator of USDA's Forest Service. In 1976 he was appointed by Gov. William Milliken to the Michigan Environmental Review Board which approves state environmental impact statements. He is a member of The Wildlife Society and the Society of American Foresters.

Dr. Cutler is married to the former Gladys Rothenbecker of Ann Arbor, Michigan. They have three children and reside in Washington, DC.

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