

ENERGY STUDIES

special edition
April 26, 1976

CES MEETS NATIONAL NEED

Our nation today is faced with a host of grave difficulties arising from the fact that the energy which had always been inexpensive and plentiful is now scarce and expensive. In attempting to cope with this situation, people too often forget that energy is more than ergs and BTU's and kilowatt hours. In a very real sense to the people of our nation, energy is jobs and food and security and comfort, and even human dignity.

Given the tremendous importance of energy in every phase of our daily lives, it is mandatory that the best minds in the nation — scientists, engineers, sociologists, marketing specialists, political scientists, lawyers, systems analysts, and a myriad of others — work in concert to meet our critical energy needs.

Over the past 70 years, The University of Texas at Austin has established an international reputation as a leader in energy research, education, and public service. In January, 1974, the Center for Energy Studies (CES) joined the ranks of the 20 University academic departments and 17 research organizations already studying various aspects of energy.

CES recognized that the nature of energy dictated that it be approached in a strong, interdisciplinary manner. Thus, in creating its organization Center leaders gathered experts not only from the traditional ranks of scientists and engineers, but also from the social, political, and management sciences. All these individuals pool their talents through CES to focus necessary attention on the relevant aspects of each energy problem.

Two current projects are especially indicative of the CES approach.

A policy assessment of the proposed California Nuclear Initiative, funded by the Federal Energy Administration, is looking at the economic, social, and environmental impacts of both constrained and unconstrained nuclear power development in California as well as several neighboring Western states. This project, perhaps one of the most important energy policy studies of 1976, involves a

systematic and dispassionate assessment by a special CES team of a sensitive political issue which is infinitely complex. To meet this challenge, CES is employing several of this nation's most sophisticated energy policy analyses models and is utilizing the talents of a group of specialists which includes engineers, economists, sociologists, environmentalists, geologists, and political scientists.

The Texas Gulf Coast Geopressed Geothermal Feasibility Analysis, funded primarily by the Energy Research and Development Administration but with significant contributions from private industrial sources in Texas, is the first of its kind worldwide. This massive project will try to determine the optimum sites for geothermal wells, develop the technology required to extract the unique geopressed energy, analyze the legal and environmental constraints of geothermal energy usage, and determine the best ways to utilize this potential energy resource.

To help meet the special information needs of university researchers, governmental representatives, businessmen, and others, CES created the Energy Information Service (EIS). EIS now houses over 5,000 current energy-related periodicals and technical reports and has access to over 35 national energy data bases.

Various public information programs are directed towards disseminating information on both energy in general and the work of CES in particular to all segments of society. This effort includes the production of ENERGY STUDIES and other informational materials, and provides prompt and appropriate answers to questions from the general public.

For too long, energy research has been conducted by engineers, scientists, and economists in a piecemeal fashion. As a result, the findings too often proved to be of limited usefulness to decisionmakers.

The University of Texas at Austin Center for Energy Studies provides a medium through which diverse energy specialists can work together to assess today's energy problems and plot tomorrow's energy strategies.

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THE CES APPROACH

UNIVERSITY SETTING

It is most appropriate that a research organization of the magnitude of the Center for Energy Studies be located within a university environment. Such a setting provides positive proof of the group's objectivity and timeliness, and allows for continuity and specialization. A university environment further affords researchers the opportunity to study past histories and future projections of energy problems.

The primary objective of CES is to provide an interdisciplinary approach to various energy questions, thus producing solutions which address both the technical and nontechnical aspects. To facilitate this approach, the Center calls on the talents of experts from the scientific, sociological, and engineering arenas, as well as from business and government. No aspect of an energy problem is taken for granted. Both conventional and unconventional energy sources are examined.

CES research is especially relevant because it is carried out through the combined efforts of researchers, educators, and students. The proper mixture of these groups, available only in a university environment, is able to focus a productive amount of time and effort on the problems the Center is trying to solve. Further, the student input is especially valuable because it bridges the transition to the vital future energy programs of this nation.

Finally, the work of the CES should prove even more valuable because it is carefully interfaced with governmental, public, and industrial institutions. By maintaining close liaison with other public and private agencies, the Center encourages proper consideration of the "real world" aspects of energy problems, as well as assists in the rapid dissemination of research results into society where it can be put to practical use.

In the words of the Center's director, Dr. Herbert H. Woodson, "There are no instant solutions to our energy dilemma. CES, quite simply, seeks to give people a realistic view of their energy future."

MULTIFACETED GOALS

All Center research activities and programs are keyed to a multifaceted set of goals:

- (1) To reduce the inefficient use of energy.
- (2) To determine new sources of energy
- (3) To increase the ability of decisionmakers to cope with complex and intricate energy policy alternatives.

The Center's educational responsibilities are addressed primarily by the development of specialized energy coursework and, where appropriate, by modification of existing curriculum to reflect rapidly changing realities.

Concurrent with its research and education tasks, the Center places prime emphasis on efforts to contribute to improving the public's understanding of energy-related subjects. Included in this effort are short courses, public briefings and other talks, newspaper columns, responses to public inquiries, etc. Additionally, the Center strives to provide timely and accurate counsel to governmental organizations to help meet its public service responsibilities.

The Center for Energy Studies is the natural expansion of the University's mandate to provide leadership in energy research, education, and public service. Its program content is a reflection of this mandate.

UNIVERSITY-WIDE INTERACTION

Over \$6 million of energy-related research is in progress on the University of Texas at Austin campus for the academic year 1975-1976. Of this, about \$2.5 million is under the management of the Center for Energy Studies.

In order to coordinate the Center's efforts with those of other parts of the University community, and to strengthen the interdisciplinary approach, CES receives overall guidance from a Board of Advisors comprised of the University assistant vice president for research and the deans of seven colleges and schools:

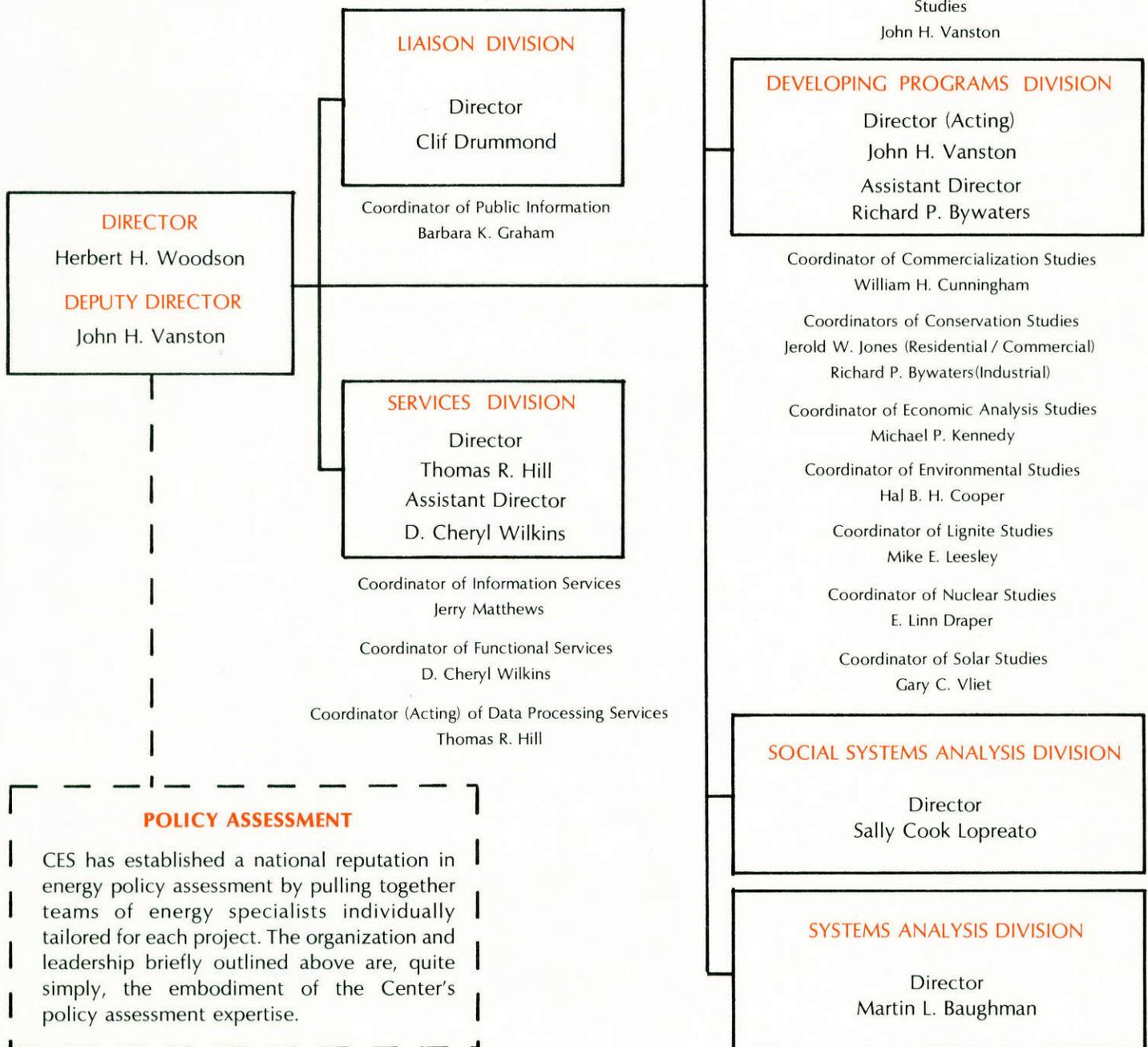
Graduate School of Business and College of Business Administration
School of Architecture
Lyndon B. Johnson School of Public Affairs
College of Engineering
College of Social and Behavioral Sciences
College of Natural Sciences
Graduate School of Library Science

CES constantly calls upon the large reservoir of energy talent found throughout the University faculty. This talent emanates from the University's academic departments as well as from such distinguished research units as The Bureau of Economic Geology, the Fusion Research Center, and others. Overall, the University-wide effort in energy research encompasses the natural, management, and social sciences; and all the engineering disciplines. Together, the University and the Center continue to apply this talent to meeting the extraordinary energy challenges faced by this nation today.

ORGANIZATION

OVERVIEW

CES work is accomplished through the efforts of approximately 40 faculty members, 35 professional and support staff, and 65 graduate students. To effectively organize the work of these groups, the internal administration of the Center is divided among a director, deputy director, and six division directors. While each subdivision is organized around a lead discipline, numerous other academic professions play major support roles.



GEOTHERMAL DIVISION

The Geothermal Division provides principal management assistance to the Energy Research and Development Administration (ERDA) for the Texas Gulf Coast Geopressed Geothermal Feasibility Project. This project is the first major analysis worldwide of a geopressed area, and involves that stretch of coastal land from Brownsville to Louisiana. Over \$1 million in funding has been provided by ERDA with another half-million added by investor-owned electric and gas utilities in Texas.

The project is being managed by CES with initial research conducted by the Bureau of Economic Geology (BEG) and the mechanical engineering and petroleum engineering departments. The division director is a member of the petroleum engineering faculty.

Geopressed geothermal energy is available in large bodies of overpressured hot water which have been trapped in deep sands along the Gulf Coast. Research thus far indicates temperatures in the range of 325° F, pressures as high as 10,000 psi, and significant quantities of dissolved natural gas. Although the exact nature and extent of this resource have not been finally determined, informed estimates indicate that these deposits may someday make a major contribution to the nation's beleaguered energy supply picture.

Because of the size and complexity of the project, the work is divided into four major components:

RESOURCE ASSESSMENT

The resource assessment phase of the project was begun in early 1974 by the Bureau of Economic Geology, and is scheduled for completion in 1977. This assessment will identify the location and all geologic characteristics of individual geopressed sands. A primary task in this phase is to map the areas at least 10,000 feet underground where the best potential exists for geopressed energy production.

ADVANCED RESEARCH and TECHNOLOGY

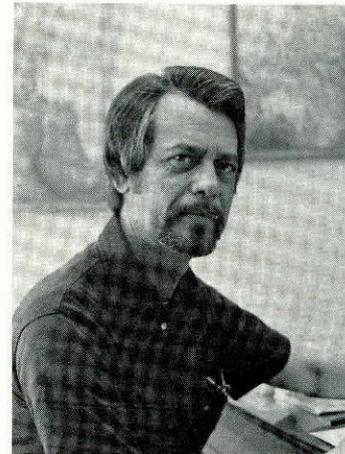
The development of sophisticated test wells and techniques to tap the unique geopressed formations is well under way under the direction of petroleum engineering personnel. The first test well is to be drilled by early 1977, with continued testing extending through 1978.

RESOURCE UTILIZATION

Geopressed geothermal resources include, in fact, three types of energy: thermal energy, mechanical energy, and natural gas. The efforts in this research area, directed by mechanical engineering faculty, are leading to a test-bed facility and small pilot plant operation scheduled for sometime in 1978. A demonstration plant which will produce electricity is slated for operation in 1980 should technical and engineering barriers be overcome.

LEGAL, INSTITUTIONAL, and ENVIRONMENTAL

The analysis of the many nontechnical challenges indigenous to a new energy source is under the direct supervision of the CES deputy director, who is also a mechanical engineering faculty member. Much remains to be addressed by local, state, and federal lawmakers in terms of resource definition, extraction rights, and regulatory guidelines. The environmental challenges of geopressed geothermal energy are major and will require the best technology possible. Institutional or social considerations may prove to be the most difficult to cope with in the long run.

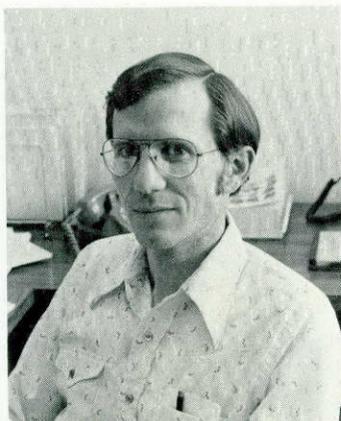


Dr. Myron Dorfman
Director of Geothermal Division

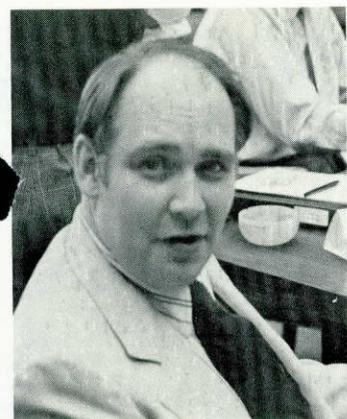


Dr. Don Bebout (right) of the Bureau of Economic Geology prepares one of many geothermal mapping sequences for interpretation.

DEVELOPING PROGRAMS DIVISION



Dr. Richard Bywaters
Assistant Director of Developing
Programs Division



Dr. Hal Cooper
Coordinator of Environmental Studies

The developing programs division directs research in seven emerging CES program areas by establishing liaison among investigators, providing early funding for projects as necessary, and assisting project personnel in locating and securing outside support. Additionally, this division will identify and add other program areas as events change.

Each of the seven programs now in this division are identified, operational, and rapidly moving to self-sufficiency.

COMMERCIALIZATION STUDIES

Research in this area seeks to identify and analyze markets for new energy products and to promote the widespread use of new technologies. To this end, the research attempts to identify barriers to the adoption of new ideas and products and to determine methods for overcoming these obstacles.

Commercialization studies are coordinated by a marketing administration professor. One project which was originated in this subdivision, a weekly newspaper column on energy topics, is now being distributed to 40 Texas daily newspapers whose combined circulation is approximately three million. Entitled "The Energy Forum", the column has the dual purpose of reporting new developments in all energy fields, and of providing the public with specific information on conserving energy in homes and automobiles.

CONSERVATION STUDIES

CES conservation research emphasizes the development and implementation of techniques and policies which will decrease inefficient energy use and thus conserve valuable supplies, before adversely affecting consumer lifestyles. Conservation projects are divided into two areas: residential and commercial applications, under the direction of an architectural engineering professor, and industrial applications, under the direction of a former industry executive.

In the *residential/commercial* area, two

studies in particular have received widespread attention locally as well as across the nation. A report commissioned by the City of Austin last year examines the effects of variations in design, construction materials, equipment, and consumption patterns on residential energy requirements to identify and evaluate energy conservation opportunities. Another study, cosponsored by the Texas State Board of Control and the Federal Energy Administration, has completed the first phase of research which will identify those areas in the Texas Capitol Complex where conservation efforts can both save valuable energy and control spiraling cost.

The coordinator of the *industrial conservation* effort joined the CES staff early in 1976 and is currently organizing a program which will involve both the educational and R&D aspects of industrial energy conservation. Energy conservation in this sector of the US is especially important because industry now is responsible for about 34 per cent of total national consumption.

ECONOMIC ANALYSIS

Economic energy research involves the modeling of key energy economics phenomena such as energy supply and demand, the relationship between energy availability and cost as it relates to economic growth, and the role of new technologies and institutions in future energy circumstances. The coordinator of this recently-defined program area is an economics professor who is a pioneer in the analysis of world oil and economic interrelationships.

ENVIRONMENTAL STUDIES

An environmental health engineering professor directs research aimed at the assessment of environmental impacts of energy production, minimization of adverse environmental problems of energy technologies, and the development of control systems to enhance environmental quality.

DEVELOPING PROGRAMS DIVISION

This type of research is vitally important to an energy research center because of the often varied but always important environmental impacts of mineral production, electric power generation, and ultimately, energy consumption.

Major projects in this area include an environmental assessment of impacts from the proposed California Nuclear Initiative, energy and environmental tradeoffs of air pollution control equipment, and the environmental and energy impact of intercity railroad electrification.

LIGNITE STUDIES

CES lignite research efforts are currently aimed at designing, building, and testing new equipment for the collection of more accurate information on the behavior of lignite from Texas and other Gulf States during combustion, carbonization, and gasification.

A chemical engineering faculty member has developed the "UT Process" as a possible method of stripping off valuable chemicals from lignite prior to its combustion. These chemicals are a rich source of feedstocks for a very wide spectrum of the petrochemical industry. The "UT Process" is in essence a self-contained operation for utilizing the chemicals with virtually no waste.

The entire research program has been structured to insure industrial input early-on to smooth the transition from university research to an industrially-oriented pilot demonstration plant, and hence, to speed the eventual development of this important resource.

NUCLEAR STUDIES

The nuclear studies program has been established to research questions relevant to generation of electric power by means of nuclear fission and nuclear fusion. Under the direction of a nuclear engineer, the following areas are under investigation: Operational safety, waste disposal systems, uranium min-

ing techniques, national policy assessments, and nuclear economics.

An added dimension to the nuclear program is its effort to disseminate nuclear power information through numerous presentations to state legislators, members of congress, union officials, media representatives, and others on nuclear reactor safety, economics, and radioactive waste management.

SOLAR STUDIES

Coordinated by a mechanical engineering professor, research is concentrated on solar-driven heating and cooling systems for residential and commercial applications, with particular emphasis on solid desiccant (drying) cooling systems.

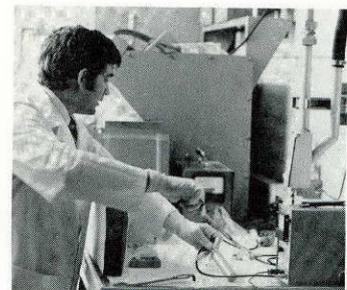
Solar research at CES is primarily directed towards developing air-conditioning systems which can operate on solar energy, probably with natural gas or propane as the necessary auxiliary energy source for times when solar is not available.

CES research efforts in heat driven systems includes work on desiccant dehumidification-cooling systems. A project of this type, designed and constructed by UT Austin engineering students, won a national energy resources alternatives award for combined solar cooling and hot water production at the Student Competition on Relevant Engineering (SCORE).

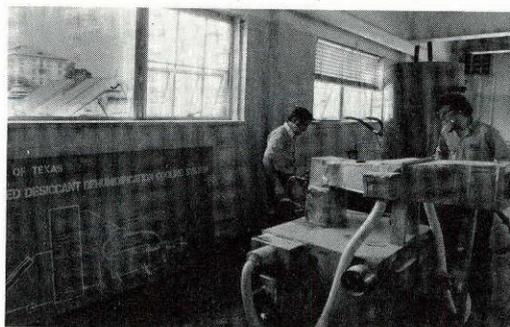
Other CES research involves developing a more efficient absorption system with a combined solar/gas energy input.



Dr. Mike Leesley, coordinator of lignite studies, in a chemical engineering laboratory.



Roland Henry, researcher at the University's Nuclear Reactor Teaching Laboratory, works with samples in the Radiochemistry Lab.



Dr. Gary Vliet (left), coordinator of solar studies, helps prepare the SCORE solar equipment for testing on the UT Austin campus.

SOCIAL SYSTEMS ANALYSIS DIVISION

This division determines and analyzes the social, cultural, psychological, and demographic impacts of energy resource developments. These analyses serve as critical complements to the technical research results of CES energy projects, thereby providing a more comprehensive understanding of the problems addressed. Under the direction of a full-time Center sociologist, this research focuses on the impacts which various technology developments and governmental energy policies have on consumer attitudes and practices.

The work of the Social Systems Analysis Division pervades throughout all CES projects as evidenced by the following examples of input provided to research conducted by various other CES components:

- (1) Assessment of potential outcomes of alternative Texas nuclear power policies.
- (2) Scope-of-work and planning study of potential geopressured geothermal resources on the Texas Gulf Coast.
- (3) Assessment of potential sociocultural impacts of the California Nuclear Initiative.
- (4) Participation in the US Office of Technology Assessment review of the Energy Research and Development Administration budget for the coming fiscal year.



Dr. Sally Cook Lopreato
Director of Social Systems Analysis
Division

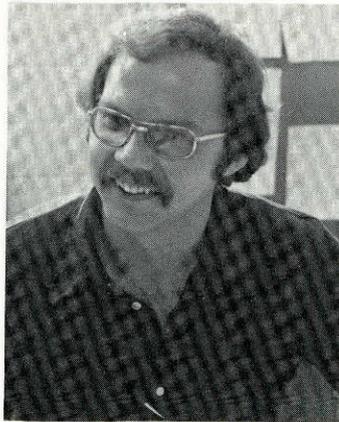
SYSTEMS ANALYSIS DIVISION

A Center-based policy analyst is in charge of the Systems Analysis Division which develops and utilizes analytical computerized planning models for the evaluation of supply-demand balances, resource inventories, economic and environmental costs, and the impacts of various other energy policy alternatives.

The Systems Analysis staff employs several of the most sophisticated models currently in use in this country to assess the consequences of present energy-related decisions, trends, and events. Existing energy computer simulation models are continually refined and new models are developed as required.

The integrated analyses thus formulated are extremely useful tools for the energy policymaker. To this end, the goal of this division is to develop and apply programs directed toward (a) understanding the behavior of energy markets and analyzing the effects of energy policy, and (b) conducting research into the relationships among energy, economic welfare, and environmental quality.

The California Nuclear Initiative study is being conducted under the leadership of the Systems Analysis Division. The special research team gathered for this project is composed of professionals from seven unique disciplines. The team is utilizing such models as the Regionalized Electricity Model, the Mathematical Programming Model of World Oil Supply and Demand, a Multisectoral Growth Model of the US Economy, and an Input/Output Model, in a special integrated manner developed by CES personnel.



Dr. Martin Baughman
Director of Systems Analysis
Division

SERVICES DIVISION



Thomas R. Hill
Director of Services Division



Dr. Jerry Matthews, coordinator of information services, prepares to access one of the many energy data base systems available to CES researchers.

The director of the Services Division has the responsibility for providing functional and data processing services to the Center and for maintaining a technical Energy Information Service accessible to individual researchers, government agencies, and the public in general.

THE ENERGY INFORMATION SERVICE

The Energy Information Service (EIS) was established to meet the energy information needs of the university community as well as those of the nation, state, and local community. To help satisfy individual information needs, EIS: (1) makes source materials available; (2) assists in answering specific questions by telephone, mail, or in person; (3) helps locate energy information in the EIS library, the UT libraries, or off-campus sources; (4) publishes quarterly lists of new books and documents received; (5) provides bibliographies on selected topics; (6) provides names and addresses of individuals and organizations specializing in various energy-related areas; (7) provides general background information, detailed information for research, and current awareness materials; (8) assists in the use of EIS resources; and (9) maintains a bibliography of UT theses and dissertations related to energy.

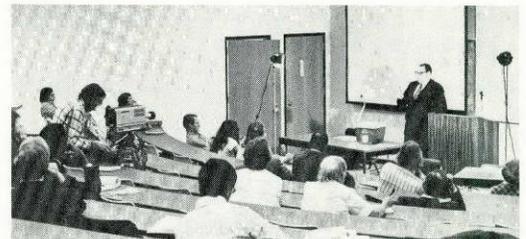
EIS also conducts biweekly energy briefings open to the public during the Fall and Spring semesters in which guest speakers review the latest information available on various aspects of energy. As an extended education and public service effort, the Spring 1976 series of briefings inaugurated a system for videotaping the sessions for replay over the University's closed circuit television network. The program then prepared for broadcast is made available to the general University community as well as to three other area universities, and to individual instructors within these schools.

DATA PROCESSING SERVICES

The division's data processing services maintain an energy research information data base and develop computerized aids for monitoring budgets and progress in the management of the Center and in its various research programs and projects.

FUNCTIONAL SERVICES

Functional services personnel provide support to University energy researchers in preparation of proposals and reports, and by providing editing, secretarial, and clerical services for Center activities.



Dr. Ben Caudle, professor of petroleum engineering, speaks at the first of the Spring, 1976 Energy Briefings on the subject of enhanced oil recovery.



Alison Kyser, Energy Information Service Librarian, aids patrons in selection of materials.

LIAISON DIVISION

The Liaison Division is the primary interface between CES and two communities—the general public, and those governmental agencies and public officials concerned with energy research. This division has the dual responsibility of assisting with energy policy analysis and promoting a better understanding of the complexities of energy.

The liaison director analyzes legislation and other important occurrences relevant to the Center's research program and brings broad-based governmental expertise to the nontechnical aspects of most Center research projects. The director is integrally involved in policy analysis processes both for the Center's programs as a whole and individually in those research projects wherein policy analysis is a definable research activity. Projects in this category include the California Nuclear Initiative Study, the assessment of the national Energy Research and Development Administration program, and an analysis of Texas nuclear power alternatives.

The coordinator of public information works with the liaison director to provide timely energy information to the public concerning general energy subjects in the broad sense and the work of CES and the University in particular. Specific projects under the coordinator's direction include:

- A newsletter distributed to a unique energy-involved group of approximately 1,300 individuals in government, academia, industry, and related fields.
- Planning and staff assistance for the energy briefing series sponsored by the Energy Information Service (including the advent of wide publication of the series, and videotaping and disseminating a closed circuit version).
- Providing answers and resource assistance for specific energy questions from the public in a letter-answering program.

The liaison directorate has made especially significant progress in increasing the general public's awareness of Center activities and of energy in general. Both the liaison director and coordinator of public information respond to direct requests from the media, from governmental representatives, and others to provide both written and verbal information on all aspects of CES work.

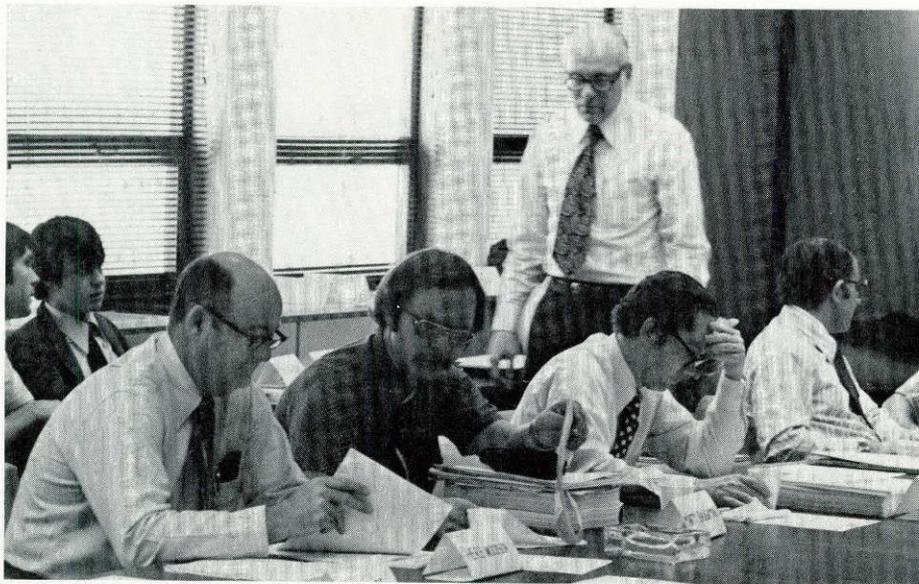


Clif Drummond, Liaison Director, and Barbara Graham, Coordinator of Public Information, discuss procedure during a policy strategy session.

SUMMARY

As reflected throughout this publication, CES research projects and activities, though dealing with vastly different technologies and problems are, however, similar by their complex nature and scope. Energy technologies and policies are generally not as limited or confined as some other types of research. Because of its nature, energy must be approached with a constantly changing set of disciplines and priorities.

CES has established a national reputation in energy technology research and in energy policy assessment. This has been accomplished in a straightforward manner: To begin with, the Center has taken advantage of talents possessed by a diverse group of professionals and energy specialists. Further, it provides a working environment in which these professionals and specialists can most productively function and interact. And finally, CES stays constantly attuned to everchanging energy facts and energy priorities.



Drs. Herb Woodson (left) and Marty Baughman confer at final meeting of CES investigators with the Oversight Committee for the California Nuclear Initiative Study.

THE CES VIEW OF OUR ENERGY FUTURE



EDUCATION

Dr. Herbert H. Woodson,
CES Director

An outstanding university such as The University of Texas at Austin depends upon a very extensive research activity of the nature provided by the Center for Energy Studies to enhance the overall quality of its educational programs. Such research makes the difference, so to speak, between an average educational effort and a truly outstanding one.

Research keeps faculty up-to-date and has a decidedly positive impact on the quality of classroom presentations. In addition, graduate student research is a vital part of their education, and the Center includes these students in its various projects accordingly.

CES does not plan nor does it desire to establish a separate energy curriculum within the University or to grant degrees in energy. Rather, it stands ready to cooperate with traditional schools, colleges, and departments by injecting energy-related components into the already existing curricula in the most effective manner for the particular program involved.

As an example of this, the Center has cooperated with the University's Geography Department by providing funding and assisting in curriculum planning for an interdisciplinary course entitled, "Energy and Society." This course was created in the belief that it is worthwhile to seek to improve the quality of understanding of the energy situation and of its ramifications.

There might very well be an interdisciplinary degree in energy to be offered in the University's future. But if it is to come about, it will probably be offered through some already existing school or college rather than through CES. Many departments already have enough flexibility within their programs to offer such a degree if it seems desirable to the faculty involved. I think it would be the role of CES to assist in the establishment of such a degree.



RESEARCH

Dr. John H. Vanston,
CES Deputy Director

In the short term the most economical, most reliable, and least disruptive answer to our energy quandary is conservation. Although new attitudes concerning energy usage will undoubtedly be required, improvements in efficiency will, in reality, be more effective in reducing energy demand than recommended or enforced alterations in life styles. It will be more productive to develop better insulating materials than to exhort the public to live in colder houses.

Although increased energy conservation is imperative, demographic forces, expanding societal expectations, and decreasing resource accessibility will require continuing increases in energy supply. In the mid-term, the country must utilize its coal and uranium resources. However, technology must alleviate the honest concerns of many people about nuclear safety and radioactive waste disposal and minimize the environmental impacts of mining, transporting, and burning coal.

For the long term, solar systems, the breeder reactor, and fusion power promise the eventual return of abundant, relatively cheap energy. Obviously, carefully planned and aggressively executed research programs are needed in all of the above areas, as well as in the more specialized areas such as geothermal energy and wind power, to insure that each can be developed to its fullest practical utility.

On the other hand, technical advances by themselves will not insure solution of our energy problems. Many of our energy difficulties have legal, regulatory, and institutional foundations, and research is needed in motivation analysis, cross impact evaluation, and similar fields, if these difficulties are to be mitigated. In a society as complex and interrelated as ours, policy actions may have results very different from those intended unless system mechanics are clearly understood.

To effectively analyze policy implications, broad-based, multidisciplinary research is not only desirable but essential.



PUBLIC SERVICE

Clif Drummond,
Director of Liaison Division

There is a compelling need for the work of an energy research organization to be translated—for the lawmaker, the industry decisionmaker, the concerned citizen.

We are dealing with both words and issues which are often very technical and almost always difficult for the uninitiated to understand. But yet, the ultimate arbitrator is the public and its elected officials. Good research is less than useful if it is not understood by the layman. A good researcher is less than effective for society if the members of that society do not listen to him.

Fulfilling our public service goals means first that we must remember who employs us, and that is the public. The University of Texas at Austin is a public institution supported by public taxes, both state and federal, and CES researchers are thus public servants. We are not, however, elected servants. Too often the demarcation lines between these two roles can become obscured, and that situation must be diligently avoided.

Second, meeting our public service responsibilities means that all our work needs to be structured to help provide answers, that is, workable solutions, for society's energy problems. More directly, that translates into reducing energy consumption, increasing energy supplies, and providing policy alternatives which are credible rather than subjective.

Third, public service is not, by nature, distinct from education or research. Each of the three contains elements of the remaining two. A university research organization must maintain a delicate balance between independence from society's day-to-day pressures and service to society's pressing needs.

Thus, in its public service role, CES devotes considerable energies to translating the results and implications of our research into a communicative format for the elected official, for the decisionmaker in industry, and especially for the citizen who wants to better understand his energy environment.