THE FINAL REPORT

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1976 Energy Resource Alternatives II Competition

Student Competitions On Relevant Engineering, Inc.

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FOREWORD

The Energy Resource Alternatives II (ERA II) Competition called for student teams to develop a means of producing enough electrical power to meet the needs of a single family home, using an energy source other than oil or natural gas. In addition, the students had to produce this electrical power in a manner which was economically realistic in view of present energy sources. These combined demands proved to be both extremely challenging and difficult to implement. Every approach used had both advantages and disadvantages in one or the other category.

The competition placed a great deal of emphasis on the economic aspects of the projects since it is economics that will determine future consumer utilization of any of these systems. As it turned out, developing an adequate means of evaluating the busbar cost of electricity produced by a production-line version of the students' prototypes was one of the most difficult problems for the Coordinating Committee.

This ERA II Final Report documents what happened during the competition. While we cannot predict the overall effect of ERA II on future energy production, the competition will serve as a sound building block for the future both in the area of technology and in the professional development of participating students. When reading the design proposals and talking to students at the first Symposium, I was aware of a great deal of uncertainty among participants in

approaching such a complex engineering problem for the first time. In contrast, at the final competition, these same students discussed their projects with confidence and authority. Most of these students are now employed engineers contributing to diverse areas of America's technology.

In addition, as a direct result of their experience with ERA II, several students are now working for firms contributing directly to the application of alternative energy sources in the production of power.

The Coordinating Committee at Washington State University provided the framework upon which the competition operated. Their responsibilities demanded considerable imagination, independence, and enormous amounts of time but they always tried to do the best possible job on each phase of the competition. Of particular satisfaction to me was watching the way they worked as a team, dividing labor, scheduling times to the best benefit of SCORE and fellow committee members, and to see their rapidly increasing sophistication in handling management problems that would tax many experienced engineers.

In summary, I feel that ERA II was a tremendous success and will have positive benefits in the future on all involved in the competition.

David E. Stock
Faculty Advisor for the
ERA II Coordinating Committee

PREFACE

The severity of the problems produced by the industrialized world's dependence on petroleum based energy has been well documented and publicized in recent years. SCORE's Energy Resource Alternatives II Competition sought to combine the interest and urgency of this global problem with a productive educational experience for engineering students, to demonstrate the potential for compact, on-site alternative energy systems.

As in all our programs, our primary purpose was educational. Any substantial contributions to component development, or system improvement, are simply added dividends. The success of our programs are not measured by what is built by the students, but by what is learned by the student. By that measure, ERA II was certainly a success.

For many of us involved with SCORE, ERA II represented the completion of almost a decade of related programs initiated by the Great Electric Car Race of 1968. It is not easy to measure the overall impact these efforts may have had, but the dedication, enthusiasm, and capability demonstrated by the students at the Final Test Events keep stimulating us to continue these activities.

Their commitment and performance certainly justify the generous support given these programs by industry, foundations, and government agencies over these past ten years.

John H. Sununu
Chairman
Board of Directors
SCORE, Inc.

CHAPTER 1

**SCORE:
Development
and Objectives**

Student Competitions on Relevant Engineering, Inc. (SCORE) is a student-run, non-profit corporation whose members are U. S. and Canadian engineering colleges. SCORE was organized in May of 1971, as stated in the Corporate By-Laws, to "engage in, assist, and contribute to the support of student inter-university events and projects which advance education and engineering."

The SCORE concept developed from the experience gained in two inter-collegiate engineering competitions and the growing need for a project-oriented approach to engineering education.

The Great Electric Car Race - 1968

In 1968, a student at the California Institute of Technology (Caltech) challenged the Massachusetts Institute of Technology (MIT) to a cross-country electric-powered vehicle race. The Caltech student had converted his Volkswagen bus to electric propulsion during the previous year and conceived of the race as a means to promote electric

vehicles as a smog-free transportation alternative. The challenge was accepted by a team of MIT undergraduate students, mainly from the engineering school, with an engineering professor as a faculty advisor.

To prepare his entry for the race, the Caltech student also assembled a team of undergraduate and graduate engineering students. With financial backing from a local newspaper, the Caltech team installed a new motor and batteries in the VW bus, along with a standard but "proven" student-built control system.

The MIT team decided to base their electric vehicle on a Chevrolet Corvair which was subsequently donated. Exotic nickel-cadmium batteries were also donated which were charged by a sophisticated student-designed and built controller. Extensive alterations were made to the Corvair body to adapt the automobile to electric power.

Since the two vehicles would have to be recharged every sixty miles or so

MIT's "Tech I" crosses the Great Electric Car Race finish line in Pasadena, California on September 1, 1968. (Photo courtesy of MIT Historical Collections)

along the race route, a cross-country network of charging stations was set up for the race by electric utility companies.

The race got underway on August 26, 1968 with the Caltech car heading for MIT in Cambridge, Massachusetts, and the MIT car bound for Caltech in Pasadena, California, both cars traveling over the same route. Each vehicle suffered from a variety of mechanical and electrical problems, including burnt-out motors which had to be replaced, and were at times recharged from a portable unit or towed, incurring penalty points. The MIT Corvair crossed the finish line in Pasadena 7½ days after the start, with Caltech pulling into Cambridge 40½ hours later. After the assessment of penalties, Caltech was declared the winner with a corrected time of 210 hours, 30 minutes less than MIT's.

The Great Electric Car Race, as this contest was called, generated a great deal of national publicity with many reporters equating it to the classic Peking-to-Paris automobile race of 1907. Unfortunately, where the latter race had helped establish the automobile as a feasible and practical means of transportation, the difficulties encountered by the vehicles in the Great Electric Car Race showed that practical electric propulsion was still years down the road. Yet the national attention helped alert the

public to the fact that alternatives to the internal combustion engine were being explored by the engineering community.

The Great Electric Car Race also proved to be an extraordinary educational experience, particularly for the undergraduate students involved. For them, engineering education had been based on theory and design, generally restricted to the blackboard and homework assignments. Being able to build a working prototype electric vehicle gave them a taste of "real world" engineering, forcing them to confront the various trade-offs (such as cost, reliability, and availability of materials) that the practicing engineer faces daily. As noted at the end of the race by the MIT faculty advisor, Professor Richard Thornton, "In one week, these students have learned the equivalent of reliability engineering that might otherwise have taken them years to acquire. They see clearly that shortcuts taken in the laboratory can cost hours of problems in the field."

The Clean Air Car Race - 1970

The following year, a sequel to the Great Electric Car Race was organized by faculty members at MIT and Caltech. Christened the Clean Air Car Race (CACR), this automotive competition was open to all forms of low-pollution vehicles. While entries could be designed and built by any group of

The Caltech challenger arrives in Cambridge, Massachusetts 40½ hours later but is declared the winner on the basis of its point score. (Photo courtesy of MIT Historical Collections)

One MIT team completely rebuilt Tech I as a hybrid electric for the Clean Air Car Race. (Photo courtesy of MIT Historical Collections)

individuals, including teams from commercial companies, only college students could drive them in the race.

The faculty coordinators initially expected fifteen to twenty CACR entries. When over fifteen teams had entered by mid-January, 1970, with the actual cross-country race still seven months away, the faculty coordinators could no longer effectively handle the administrative load required to organize the competition. This responsibility was turned over to a student coordinating committee, composed of students from MIT and Caltech, with a faculty advisor.

The CACR coordinating committee assumed all duties necessary to plan and carry out the competition program. It developed and administered the race rules, vehicle testing procedures and scoring system, directed the logistics of the cross-country travel of the CACR participants, handled all communications with the entrant teams, raised and allocated funds, and conducted a public communications campaign to arouse the public's interest in the problem of automotive air

pollution and the possible solutions demonstrated by the CACR vehicles.

The entrant vehicles were divided into five competition categories according to their power plants: internal combustion engines; pure battery-powered vehicles (electrics); hybrid-electrics; power plants using either liquified natural gas or liquified petroleum gas for fuel; and turbines using a Brayton cycle of operation.

The Clean Air Car Race program was divided into three parts: vehicle performance and emission testing at MIT; the cross-country rally from Cambridge to Pasadena; and a final emissions testing at Caltech.

The pre-race activity at MIT took place during the week of August 17, 1970. The CACR vehicles were tested and evaluated for hot-start exhaust emissions, acceleration, braking, noise, road handling and maneuverability. Two days were also devoted to seminars in which the entrant teams presented technical papers on

their vehicle power plants. In addition, there were public showings of the CACR vehicles, a parade through Boston, and evening meetings of the team captains with the coordinating committee.

Forty-three vehicles qualified for the race, having passed the rigorous week-long testing program.

The cross-country rally got underway at 3 a.m. on August 24, when the first vehicles left MIT bound for California. The 3600 mile race route was divided into seven legs with the following destinations: Toronto; Detroit; Champaign, Illinois; Oklahoma City; Odessa, Texas; Tucson; and Pasadena. Cold-start exhaust emissions testing was performed in Detroit, and vehicle fuel consumption was measured over the two-day, 1071-mile run from Ann Arbor, Michigan to Oklahoma City.

Thirty-six vehicles, eighty-five per cent of the starting field, completed the week-long transcontinental journey to Pasadena. While at Caltech, the vehicles underwent a final hot-start emissions test. The results of this test were combined with the earlier MIT hot-start test to provide a deterioration factor for overall vehicular emissions. Teams were also given a chance to discuss complaints or protests with the coordinating committee, and at the same time penalties for rule infractions were levied. Other committee activities included the final tabulation of race scores.

A final awards banquet was held on the evening of September 2 for all CACR participants. Trophies were presented to the five class winners and the overall winner. The overall winner was selected by an impartial board of judges composed

Starting early in the morning of August 24, 1970, the forty-three Clean Air Car Race vehicles left the starting line at the rate of one every three minutes. Shown here is one of the five Worcester Polytechnic Institute CACR entries. (Photo courtesy of MIT Historical Collections)

of representatives from academia, state and federal government, and a professional engineering society. A final seminar was held the next day in which the judging panel discussed their reasons for choosing the Wayne State University internal combustion engine-powered vehicle as the overall winner.

The Clean Air Car Race proved to be highly significant in several respects. For one, it was the first national intercollegiate engineering competition conducted by students. Other engineering competitions for students had been either sponsored nationally under the auspices of one of the professional engineering societies, or regionally by a university. CACR was the first time a program of this magnitude had been undertaken by the students themselves. It was also the first national intercollegiate engineering design competition to require that full-scale hardware be built and tested. Previous national competitions had called for either paper designs or small-scale models.

As was the case with the Great Electric Car Race, the impact of CACR on the participants and the general public was considerable. The educational benefits of translating a paper design to actual hardware was demonstrated again on a much larger scale. The media's coverage of the cross-country rally was extensive and helped to inform the public of the various technical approaches being considered to reduce automotive exhaust emissions. The Clean Air Car Race had an impact in Washington as well where the results were read into the Congressional Record.

Establishment of SCORE

Encouraged by the success of the program, CACR members began planning another competition in early 1971. Building on their background in motor vehicle research, they decided the new competition should tackle the problem of designing a motor vehicle particularly suited to the urban environment. A successor committee composed of engineering students from five universities was formed at MIT to coordinate the Urban Vehicle Design Competition (UVDC), as the new program was called. In order to assess potential interest in UVDC, a questionnaire was mailed to 200 deans of engineering. Encouraged by 100

favorable responses, the new committee began to actively promote UVDC.

At the same time, a group of engineering deans from universities that had participated in CACR and who recognized the need for such hardware oriented programs was moving to create a permanent "parent" organization to sponsor UVDC and future CACR-like intercollegiate engineering competitions. Working together, the deans and members of the CACR/UVDC committee designed an organization to take advantage of the strengths and avoid the weaknesses evident in the CACR organization.

The new organization, to be called Student Competitions on Relevant Engineering, Inc. (SCORE), would be staffed by students and recent graduates. CACR had shown that they were capable of handling such administrative responsibilities, and that they brought a high level of enthusiasm and imagination to the job. A Board of Directors composed of engineering deans (later expanded to include representatives from industry and government) would be concerned with SCORE's long-range goals and would not become involved in the day-to-day activities.

The national fund-raising for the competition would be conducted by SCORE. Funds solicited from corporations, foundations, and the government would provide development grants for the teams and support the operating costs of the programs. The decision to centralize the national fund-raising in SCORE was made in response to a problem that arose during CACR. In addition to finding local sponsors, the CACR teams were all approaching the same federal agencies, large corporations and foundations for grants. Many of these national organizations were interested in funding the teams, but their granting systems were not designed to make numerous small awards. They suggested that the national fund-raising for future competitions be centralized so that they could make one large grant to the competition's organizer and it, in turn, could make the individual team grants.

The grants SCORE would provide to the competing teams would be used to support the purchase of expendable equipment, materials and supplies needed to construct an entry. SCORE team grants would be seed-money awards intended to provide major but not complete project funding. One of the

educational benefits for the team members would be learning how to raise donations of funds, equipment and supplies from local sponsors.

SCORE was legally established in Massachusetts in May, 1971, as a non-profit, tax-exempt corporation. The members of the corporation are U. S. and Canadian engineering colleges.

Each member school has a designated SCORE representative from the faculty who is the SCORE contact and who represents the school at the SCORE annual meeting. While every engineering school is encouraged to join SCORE, membership is not a requirement for participation in SCORE competitions.

The Urban Vehicle Design Competition 1971-1972

The Urban Vehicle Design Competition (UVDC), organized as the sequel to the Clean Air Car Race, was the first intercollegiate engineering program sponsored by SCORE. Where CACR had allowed any type of vehicle utilizing a low-emission powerplant, UVDC focused on small, quiet, safety-oriented automobiles that were also fuel-efficient and low-polluting.

A comprehensive set of rules and guidelines were written by the UVDC coordinating committee based on the rules developed for CACR. The UVDC rules gave design specifications for the entrant vehicles (outlining minimum performance characteristics and requiring certain features such as headlights, windshield wipers, seat belts, etc.), designated the different vehicle competition classes (based as in CACR on the type of power plant), detailed certain required reports and gave a timetable for their submission, and presented a scoring system for the final testing program.

The rules also defined who could enter the competition, and gave guidelines for team sponsorship and advertising. To prevent a recurrence of the relatively small amount of commercialism that caused some problems in CACR and to firmly establish the educational nature of the program, only student teams (with a faculty advisor) from accredited educational institutions were allowed to enter UVDC. Companies and other organizations were encouraged to sponsor individual

teams in a manner that fostered the educational objectives of the program, and to promote their sponsorship in as discreet a fashion as possible.

The organization of the UVDC program was also a refinement of CACR. UVDC was organized as a two-year competition with a design phase, a hardware construction phase, and a final testing program.

In the design phase, the UVDC teams studied the hardware specifications outlined in the rules and developed a design for their urban vehicle. In doing so, the teams were expected to seek technical advice from companies and other organizations in their community as well as from faculty members at their university. Totally new designs for the vehicle and its sub-systems or innovative modifications of commercially available hardware were encouraged. The results of this work were presented to the coordinating committee in a professional-quality design proposal which included a technical and economic analysis of the vehicle design, and a project budget and funding request. After evaluating the design proposals, the coordinating committee recommended the award of SCORE grants to help the teams finance the actual construction of their vehicles during the construction phase of the competition.

Both the design and the construction phases of the UVDC program included a symposium to assist the teams in the development of their vehicles. The first (design phase) symposium was held at the University of Toronto. Here, speakers from industry, the government and academia presented background information for the students to consider in their design work by examining the technological and social aspects of urban transportation. The second (construction phase) symposium was held in May, 1972 at Catholic University in Washington, D. C. This meeting was designed around workshop sessions on vehicle sub-systems which were directed by leaders from industry and the government. Here, team members had the opportunity to direct specific questions to the experts on design and construction problems that they had thus far encountered. Both symposia also included business meetings run by the committee to discuss such matters as the rules, team

finances, and preparations for final testing.

The teams were required to keep the coordinating committee informed of their progress through the submission of two progress reports during the course of the competition. A comprehensive team final report was also due at the end of the program.

The Urban Vehicle Design Competition concluded with the final test event held the week of August 6, 1972. Sixty-six teams from sixty-two U. S. and Canadian colleges participated in the final testing at the General Motors Proving Grounds in Milford, Michigan. The vehicles were technically tested and evaluated (using the Proving Grounds test equipment and General Motors personnel and other leading automotive experts) for their exhaust emissions, acceleration, braking, handling, noise, five-mile-

per-hour crash resistance, energy efficiency, and space utilization. The vehicles were also subjectively evaluated in the areas of safety features, mass-production cost, and drivability by panels of experts. For the cost and safety features tests, the team members made presentations to the judging panels in which they discussed the salient features of their design. Finally, the vehicles were evaluated for innovative design and the degree of student fabrication of their powerplant, drivetrain, emission controls, suspension, frame, body, five-mile-per-hour bumpers, and interior and exterior safety features.

The total score received by each entry was achieved by summing the products of the score received in each test by that test's weighting factor, and multiplying this sum-

Northwestern University's LPG-powered Subaru undergoing the Federal Mass Emissions Test at the UVDC final test event held at the General Motors Proving Grounds.

The University of British Columbia vehicle, built from the ground up, took the UVDC Grand Award by achieving high safety, driveability and innovation scores.

mation by the vehicle's overall innovation and student fabrication coefficient. The University of British Columbia received the highest total score and won the UVDC Grand Award.

Students Against Fires 1973-1974

UVDC firmly established the format for SCORE competitions. Students Against Fires was its first application to a non-automotive program. SCORE selected fire-fighting technology as the topic for its second program because it is an area where technological innovation is urgently needed. The United States has the worst fire-safety record of any industrialized nation (with over 12,000 fire-related deaths, 400,000 injuries, and \$2.75 billion in property damage annually), and Students Against Fires (SAF) focused on innovative ways to detect and extinguish fires, and rescue people from burning structures.

SCORE, in November 1972, selected the Georgia Institute of Technology

(Georgia Tech) in Atlanta, Georgia to host the SAF Coordinating Committee. Georgia Tech students staffed the SAF committee which was based in the Department of Aerospace Engineering with an aerospace engineering faculty advisor.

To assist in defining the scope and objectives of the SAF competition, the Coordinating Committee assembled an SAF Advisory Board of national authorities in the fire field.

The SAF program was organized like UVDC with a design phase, a construction phase, and a final testing event.

The first draft of the SAF rules were mailed to interested schools in September, 1972. The design phase (background information) symposium was held at Georgia Tech in April, 1973. The construction phase (workshop session) symposium took place at the University of Maryland in October, 1973.

It proved to be more difficult to interest students in the SAF program than UVDC. This was not un-

expected since students generally have a greater inherent interest in automobiles than fires, and many more schools offer design courses on automotive systems than fire-fighting hardware. Nonetheless, forty-three teams from twenty-three universities participated in the SAF final test event held May 1-4, 1974 at the Ansul Company's Fire Technology Center in Marinette, Wisconsin. The SAF projects ranged from innovative fire trucks to inexpensive home fire detectors, and included a remote controlled fire-fighting vehicle, devices to rescue people trapped in burning high-rise buildings, new

protective suit designs for firemen, and devices to fight fires in automobiles, kitchens, warehouses, forests, and grain storage elevators.

The SAF projects were tested at the Ansul Fire Technology Center on actual fires. The tests were observed and evaluated by panels of judges who also heard presentations given by team members on the innovation, mass production cost, and marketability aspects of their projects. A team from Pennsylvania State University won the SAF Grand Award for its portable fire fighter's data retrieval systems.

A high-powered nozzle on wheels, the Iowa State University "Firecat" here directs its 500 gallon-per-minute stream on a spectacular blaze at the Ansul Fire Technology Center during the Students Against Fires final test event.

Student-built, applying NASA technology, these life-support suits for fighting high-intensity fires were developed by an SAF team at the University of Texas-Arlington.

Energy Resource Alternatives 1974-1975

The Energy Resource Alternatives (ERA) competition challenged engineering students to develop systems able to provide a portion of the energy needs of homes, farms, and small commercial operations. Using such energy source inputs as solar energy, wind energy, biological wastes, and coal, the students were asked to design and build an energy system which could provide all or some of the following outputs: space heating and cooling; domestic hot water; and electricity. The

emphasis in the design and construction of these systems was on developing innovative ways to make them relatively low in cost and practical for the homeowner or small businessman to install and use. Totally new designs or innovative modifications of commercially-available hardware were encouraged.

In June, 1974, SCORE selected the College of Engineering of the University of Wisconsin to host the ERA Coordinating Committee. Three engineering undergraduates were ini-

tially chosen to head the committee along with a faculty advisor from the Mechanical Engineering Department.

The ERA competition was officially announced in July through a mailing to the Deans of the 334 Engineering College Members and Affiliate Members of the American Society for Engineering Education. The remainder of the summer was spent refining the scope and objectives of the competition and drafting the "ERA Rules and Guidelines." An ERA Advisory Board was also established to assist with these activities. The first Advisory Board meeting was held on September 9, 1974 at the National Science Foundation in Washington, D.C.

The "ERA Rules and Guidelines" were published and mailed in August. Teams began to enter the competition in September by submitting an entry form or project design proposal. SCORE's early team recruitment effort consisted primarily of letters to Deans of Engineering and posters describing the competition. It was evident in early October, with the ERA Symposium I rapidly approaching, that a relatively small number of schools were

aware of the competition. In response, the Coordinating Committee launched a nationwide telephone campaign directed toward potential team faculty advisors.

The first issue of a semi-regular newsletter was also sent out in early October to all teams that had entered and anyone else who had expressed an interest in the competition.

Twenty-five schools were represented at the ERA Symposium I held October 18-20 at the University of Texas at Arlington. Speakers from the Southwestern Research Institute, National Science Foundation, Electric Power Research Institute, Institute of Gas Technology, and University of Wisconsin spoke on the state-of-the-art of wind turbines, solar collectors, energy storage systems, coal technology, and methane production. SCORE personnel also gave presentations outlining the goals of the competition. Team member participants pointed out during discussions that the design specifications stated in the rules were incomplete and that the output goals were relatively large in magnitude.

The horizontal Savonius wind turbine developed by the University of Houston's ERA team gets more power from a small package by utilizing the slope of a roof to increase its effective area.

In November, new design specifications were drawn up based on the energy demands of an average home in mid-continental U.S.A. Twentyfour hour input data was given for an average day in both summer and winter. A demand curve for each of the desired outputs was also given for both a summer and winter day. Scaling of projects was acceptable and expected by team entries. The main reasons for this were that the projects had to be transportable to the final testing site and the teams' financial resources were limited.

A new team recruitment drive was also started in November. The new mailing list consisted of over 5,000 names from the American Society for Engineering Education files of academic department heads. Fliers and leaflets were mailed for distribution at the classroom level. A promotional film on alternative energy sources was also obtained and lent to schools free of charge.

Team design proposal evaluation started in early December. The Design Proposal Evaluation Board rated the proposals on their feasibility, technical content, and professional

quality. Based on these evaluations, a seed money grant was recommended for each team ranging from two hundred fifty to two thousand dollars.

During the competition, two additional rounds of grants were issued. Design proposal quality continued to be the basis for evaluating new entries and progress update reports the basis for established teams. Special funding requests were considered as they arrived.

In January 1975, the Coordinating Committee settled on an organizational structure that it remained with for the rest of the competition. Two divisions were formed to handle each of the two large areas of work expected in the upcoming months. A Technical staff took the responsibilities for reviewing new proposals and team progress reports, and for developing the testing criteria that would be essential for comparative project evaluation at the final test event. The Communications staff had the responsibility of handling all correspondence from the committee and managing logistics for the ERA office, Symposium II, and the final test event.

The variable pitch prop of the University of Oklahoma's "Windy Sooner" is teamed with a voltage control system to provide maximum electrical power output in all wind conditions.

Suspended high above a bank of 352 heliostats, a boiler receives a final adjustment by Bill Rogers the captain of the Rensselaer Polytechnic Institute team.

During January, the Communications staff waged a second telephone campaign. Two hundred and fifty engineering schools were contacted and ten more teams were added to the forty earlier entries.

To obtain additional project performance data, the Technical staff decided to use home site testing as a major evaluation method. The original specifications required preliminary testing results, while a more formal evaluation procedure was specified in the Revised Specifications. The relative scoring value of home site data was not specified until much later.

Twenty-five teams sent representatives to the ERA Symposium II held at the University of Wisconsin at Madison on March 21-23, 1975. This symposium was built around workshop sessions which allowed team members to discuss construction and material problems. Business meetings were held to discuss further ways SCORE could help teams raise funds and other related competition problems. In addition, field trips allowed participants to visit a number of alternative energy

pilot projects in the area. The Technical staff introduced the testing and scoring procedures they had developed by that time. Team feedback and a valuable exchange of information developed at the symposium.

The selection of the final test event site was accomplished in May. A SCORE selection committee visited three locations which had requested consideration. The Sandia Laboratories in Albuquerque, New Mexico was chosen and work was immediately begun on logistic arrangements and testing equipment specifications for the final testing. SCORE personnel made several trips to Albuquerque over the next three months to work directly with their Sandia counterparts.

In early June, the Home Site Testing materials were sent to the teams. The material included a general home site testing document which described the objectives of the procedure as a means for teams to evaluate their own projects in terms of the ERA competition criteria, prior to final testing, so that modifications could be made to optimize performance at the final test event. It was also intended to pro-

vide the Coordinating Committee with vital information on the physical specifications of the projects which were due to appear at final testing so that proper planning could be made. The Home Site testing allowed the teams up to a month for testing and evaluation in an in-depth manner not possible at the final test site because of the large number of projects to be tested in so short a time span. The Home Site Testing data could also be used for evaluation of projects lost or destroyed in transit to the final test event, or if severe weather conditions prevented actual testing there. In addition, all component (solar collector, wind turbine, decay chamber, etc.) evaluations would be based on Home Site data, with only output testing to be done at the final test site.

The general Home Site Testing document also included definitions of entry categories, additional specifications which had developed in relation to the specific testing site (Sandia Labs,) project performance data sheets, standard output values, and the storage evaluation.

The home site materials contained documents for evaluating solar, wind, and methane-producing equipment (components) as well as documents for evaluating system output performance (space heating and cooling, domestic hot water, and electricity.) These documents were developed by the ERA Technical staff in consultation with faculty members, government agencies, and the ERA Advisory Board. Their development took about five months.

After the Home Site Testing documents were mailed, emphasis shifted to the scoring system development. This scheme, using the testing criteria just developed, emphasized performance, safety, versatility, marketing, and innovation.

The general scoring criteria established the areas of expertise required for the judging panels. By mid-June, a nineteen member judging panel had been formed to aid with the team evaluation at the final test event. Schedules, judging forms, and judge pre-orientation information were developed.

The first of August brought team final reports pouring into the ERA headquarters. Initial evaluations of the reports were made as they arrived.

Teams begin arriving in Albuquerque for the final test event on the 18th of August. Project set up, equipment checking, and initial testing hookup continued up to Monday, August 11th. Over three hundred participants representing forty teams from thirty-three universities were present. The participants, judges, SCORE staff members, and guests were housed in the Visiting Officers' Quarters of Kirtland Air Force Base.

The Final test event officially commenced with a kick-off barbeque on Monday night. Testing and evaluation began the following morning. In addition to the project and team testing programs, the week included two thunderstorms, technical seminars and tours at Sandia Labs, Kirtland Air Force Base, and Los Alamos Labs. There were field trips to local points of interest, and the daily lunch of four hundred and fifty hamburgers was served from back of a pick-up truck.

Saturday Morning was designated an open house for the press and general public. While television cameras ground away on the test field, the Technical staff was grinding the test data into an overall and category team ranking. The results were announced that evening at the Awards Banquet. The keynote speaker, Dr. R. Buckminster Fuller, presented the awards to the happy but exhausted students.

UVDC, SAF and ERA all generated a great deal of national publicity. Newspapers and magazine articles, and television and radio reports focused on the student-built projects and set them against the backdrop of the national problem they were trying to solve. SCORE, through its public communications program, endeavored to see that the news media received technically accurate information for use in their reports.

A complete description of the ERA II competition is given in Chapter 3. More detail on the Urban Vehicle Design Competition, Students Against Fires and Energy Resource Alternatives is contained in the final report of each program. Copies of these reports are available from SCORE (See title page of this report.)

Summary

SCORE's objectives in sponsoring inter-collegiate engineering competitions are threefold: first, to supplement college engineering curricula with hardware design/fabrication projects which give students practical engineering experience; second, to promote new approaches to solving relevant engineering problems; and third, to increase national awareness of the problem the competition addresses.

The goal of the competing SCORE teams (which may be composed of undergraduates and graduate students with at least one faculty advisor) is to design and build innovative hardware solutions to the problem defined by the competition. In doing so, it is expected that the teams will seek technical advice from companies and other organizations in their community as well as from faculty members at their university.

The competition is composed of a design phase, a hardware construction phase, and the final test event.

In the design phase, the student teams study the specifications outlined in the rules and develop a hardware design. Totally new designs or innovative modifications of commercially available hardware is encouraged. The team next submits a design proposal to the coordinating committee. On the basis of the quality of this proposal, the committee will recommend that SCORE provide a seed-money grant to the team to help finance the actual construction of the project.

It is in the hardware construction phase that many students get their first intensive exposure to hands-on engineering. In translating a design from paper to hardware, the student must cope with the various trade-offs (such as cost, availability of materials, and simplicity) that the practicing engineer faces daily. This is a fundamental aspect of engineering often not examined in today's classroom.

Each of the two phases of the competition includes a SCORE sponsored symposium. At the first, leading experts from industry, government and academia discuss the engineering problem addressed by the competition and acquaint the students with the current state of the art technology in that

field. The second symposium gives team members the opportunity to discuss specific problems that they have encountered in their projects with experts in workshop sessions. Both symposia include business meetings to discuss such matters as the rules, team finances, and preparations for final testing.

The culmination of the competition is the final test event in which the teams bring their projects to a single location for a rigorous evaluation program. The location is a testing facility selected for its ability to test the projects under actual performance conditions. During final testing, the team members also give oral presentations before panels of judges. Innovation, economic aspects, and marketability are among the design features discussed. The judging panels are composed of research and practicing engineers, policy makers from government and industry, and other professionals in the field.

The teams' scores are computed on the basis of the objective hardware test and the subjective oral presentations. SCORE awards are trophies and plaques which symbolize the student's outstanding engineering efforts and bring recognition to their schools.

SCORE is a non-profit corporation with a Board of Directors, executive officers, staff, and member schools. The Board of Directors is composed of representatives from academia, industry and the government (see Appendix K). The executive officers and staff members are students and recent graduates. Each member school has a faculty SCORE representative. While every school is encouraged to join SCORE, membership is not a requirement for participation in SCORE competitions.

SCORE provides the team seed-money grants and supports the operating costs of the competition with funds raised from corporations, foundations, and the government.

SCORE History Timetable

August, 1968	Great Electric Car Race, Cambridge, Massachusetts to Pasadena, California
August, 1970	Clean Air Car Race, Cambridge, Massachusetts to Pasadena, California
January, 1971	Announcement of the Urban Vehicle Design Competition (UVDC)
May, 1971	SCORE incorporated in Massachusetts
August 19-22, 1971	"The Motor Vehicle and the Urban Environment" Symposium, University of Toronto
May 5-7, 1972	"The Urban Vehicle in 1980" Symposium, Catholic University, Washington, D. C.
August 6-11, 1972	UVDC Final Testing, General Motors Proving Grounds, Milford, Michigan
September 1, 1972	Announcement of Students Against Fires (SAF)
April 5-6, 1973	First (SAF) Fire Safety Symposium, Georgia Institute of Technology, Atlanta, Georgia
October 26-27, 1973	Second (SAF) Symposium, University of Maryland, College Park, Maryland
May 1-4, 1974	SAF Final Test Event, Ansul Company Fire Technology Center, Marinette, Wisconsin
July, 1974	Announcement of Energy Resource Alternatives (ERA) Competition
October 18-20, 1974	First (ERA) Symposium, University of Texas, Arlington, Texas
March 21-23, 1975	Second (ERA) Symposium, University of Wisconsin, Madison, Wisconsin
August 12-16, 1975	ERA Final Test Event, Sandia Laboratories, Albuquerque, New Mexico
September, 1975	Announcement of Energy Resource Alternatives II (ERA II)
March 13-14, 1976	First (ERA II) Symposium, University of Oklahoma, Norman, Oklahoma
February 4-5, 1977	Second (ERA II) Symposium, University of Houston, Houston, Texas
June 9-16, 1977	ERA II Final Test Event, U. S. Energy Resource and Development Administration, Richland Operations Office, Richland, Washington

CHAPTER 2

Energy Overview

The search for viable energy resource alternatives begins again with the close of this century much as it did one hundred years ago when the oil supply provided by the whaling industry was replaced by a seemingly endless flow of petroleum. By the turn of the 19th century with the development of a consistent process of drilling and refining crude oil, the transition from one energy source to another had been smoothly accomplished. Our ability and willingness to utilize innovative energy technology will determine how successfully we approach the transition at the turn of this century.

The change in energy source inputs in the United States since 1947 reflects the differences in their cost, convenience, and availability. As illustrated in Figure 1.1, coal declined from 47.9% of the total energy input to the current level of 18.6%, while petroleum increased from 34.6% to 46.6%. Natural gas showed the sharpest increase, moving from 13.6% of the total energy input in 1947 to 30.3% in 1974, but declined to an estimated 28.4% in 1975. Hydro power, due to its limited geographic availability, remained fairly constant in utilization over the period, climbing slightly from 3.9% to an estimated 4.5% in 1975. The recent addition of nuclear power contributed only 1.9% of the total for 1975².

Demand for energy in the United States is expected to triple by the year 2000. At this rate of energy consumption, our oil and natural gas reserves will be totally depleted shortly after 2000 A.D. Our known coal reserves are expected to last for several more centuries before being exhausted³. The United States is currently obtaining 96.3% of its energy from fossil fuel sources which are expected to be exhausted within 300 years.

In addition to the certainty of fossil fuel depletion, there is an increasing awareness of the severe environmental impact of our current methods of energy resource utilization. Combustion of

unrefined fossil fuels, such as coal, releases large amounts of pollutants to the atmosphere. These pollutants will increase as our consumption of these fuels increases, as shown in Figure 1.2. Until 1980, a decrease in pollutants is expected due to the anti-pollution standards that have been established. Beyond 1980, however, the large energy demand increase will cause increased pollution unless the standards are further tightened⁴.

In addition to atmospheric pollution, the ruinous effects of strip mining for coal and the long-term dangers of radio-active nuclear wastes serve as reminders that large-scale development of environmentally acceptable energy sources must be encouraged if we hope to maintain our standard of living. On a small scale, however, alternative energy source utilization technology has already developed to the point where it can make a significant impact in helping to meet our current energy needs.

Figure 1.3 shows a breakdown by sector of energy consumption in the United States for the year 1974. More than one-fourth of the energy available for general use is consumed in the generation of electricity. In recognition of this tremendous energy drain on our available resources, Student Competitions on Relevant Engineering, Inc. (SCORE) sponsored the Energy Resource Alternatives II (ERA II) Competition to help contribute to the development of small-scale electric generating systems for homes, farms, and small commercial operations. These systems utilize such energy source inputs as solar energy, wind energy, biological wastes, and coal. The emphasis in the design and construction of these systems was on developing innovative ways to make them relatively low in cost and practical for the homeowner and small businessman to install and use.

A brief discussion of the four principal energy source inputs used by the ERA II teams is given in the following survey.

Figure 1.1

Figure 1.2

Figure 1.3

Solar Energy

The sun is an ideal source of energy. Its power is clean and the theoretical amount of energy it can provide is staggering. The incidence of solar energy on the earth's atmosphere (on a surface normal to the sun's rays) is approximately 1.35 kW/m^2 . When changes in the weather, the latitudes, and nights are considered, the average ground level solar energy flux incident on the United States is approximately 0.18 kW/m^2 . Figure 1.4 shows the yearly average solar energy incidence on the different regions of the United States.

Assuming a 5 per cent conversion efficiency of solar energy to electricity, it is estimated that only one per cent of the land area in the continental United States would be required to meet our projected electricity needs in the year 2000.⁵

Two standard processes for utilizing solar energy are photovoltaic and thermal conversion systems. In photovoltaic systems, solar energy is converted directly to electricity in a solid-state solar cell. The extremely high cost of photovoltaic systems (currently at \$30-\$50/watt for commercial solar cells) means, however that unless a cost reduction of a factor of 100 is achieved, they will remain too expensive for widespread utilization.

The thermal conversion process is currently more economically feasible. In thermal systems, solar energy is collected in a working fluid that is utilized in a thermodynamic cycle. Electricity can be produced by using a high-temperature working fluid (liquid metal at 1000°F is envisioned for large-scale applications) to produce steam which drives a turbine generator. For home and

Figure 1.4

commercial applications, lower temperature working fluids (such as water at 200-270°F) can be used to produce space heating and cooling and domestic hot water.

Solar water heaters have been used for many years in Japan, Israel, Russia, Australia, and the United States.⁶ Over the past twenty-five years, approximately 1,000 solar-heated homes and laboratory structures have been built⁷ using various combinations of collector design (primarily flat-plate), heat storage (such as hot rocks, hot water, and eutectic salts), and heat distribution techniques. These buildings, while generally successful, did not receive a great deal of attention in the past because their costs were high compared to buildings heated by conventional fuels. Now, as the cost of these fuels rises, solar heating and cooling systems are becoming increasingly economically competitive.

Wind Energy

Wind energy, like solar energy, is widely available, inexhaustable, clean and free. There is also no question that it works since it has been used by man for many hundreds of years.

In Europe and Russia, windmills have successfully generated electricity for some time. The Russians, in 1931, installed a windmill on a bluff near Yalta that produced 270,000 kW-hours of electricity in one year. In the United States, prior to the Rural Electrification Act (1935), windmills were commonly used in small-scale applications to produce electricity. In 1950, there were still approximately 300,000 windmills pumping water and 50,000 windmill-powered units charging batteries in rural areas. A large scale wind energy system was built in 1941 as a joint effort by Palmer Putnam and the S. Morgan Smith Com-

pany (presently Allis-Chalmers). The Smith-Putnam windmill at Grandpa's Knob, Vermont had an output capacity of between 1,000 and 1,400 kW of electricity which was sold to a Vermont electric utility. The U. S. Energy Research and Development Administration currently has a 125-foot diameter, 100-kW windmill under test at the National Aeronautics and Space Administration's Plum Brook Station near Sandusky, Ohio.

Wind energy, while plentiful, is not evenly distributed, as shown in Figure 1.5.

Power available from the wind is proportional to the cube of the wind velocity, and wind velocity increases logarithmically with altitude up to the heights one would consider in windmill use.⁹

Current consideration of wind energy utilization is divided between large-

scale systems for integration into existing power grids and small scale systems to produce supplemental power for residential-commercial applications. Currently marketed small-scale systems, complete with tower structure, windmill, storage batteries, and d.c. to a.c. inverters, are available with ratings of 10 to 1000 kW-hour/month at a cost of approximately \$1,500/kW capacity.¹⁰

Biological Waste Utilization - Methane Production

Any organic material - sewage, animal wastes, organic garbage, or vegetation specifically grown for the purpose - can be used in biological methane production. This process has several advantages. It reduces the waste disposal problem (the digested material is about 40 per cent smaller in volume and is less noxious) and can produce a rich fertilizer and a clean, high-quality fuel.¹¹

Figure 1.5

Because of the problem of collection, methane can only be produced economically where there is a high concentration of waste materials such as in cities, paper mills, and dairy farms. As shown in Figure 1.6, it is estimated that approximately 15 per cent of the dry, ash-free, solid organic wastes produced in the United States in 1971 was readily collectable.

Figure 1.6

AMOUNTS (In Millions of Tons) OF DRY ASH-FREE ORGANIC WASTES PRODUCED IN THE UNITED STATES IN 1971

Source	Wastes generated	Readily collectable
Manure	200	26.0
Urban refuse	129	71.0
Logging and wood manufacturing residues	55	5.0
Agricultural crops and food wastes	390	22.6
Industrial wastes	44	5.2
Municipal sewage solids	12	1.5
Miscellaneous	50	5.0
Total	880	136.3

Source: Hammond, Allen T., et al, Energy and the Future, American Association for the Advancement of Science, Washington, D.C., 1973, p. 74

The biological process by which methane is produced is basically a digestion of the organic material by several kinds of anaerobic bacteria. Acid-producing bacteria liquify the raw materials and convert them into low molecular weight organic acids. Methane-producing bacteria convert these acids (particularly acetic acid which accounts for approximately 70 per cent of the methane produced) into methane.¹²

The crude gas produced by anaerobic digestion contains methane (50-70 per cent), CO₂ and traces of H₂S and N₂. With a heat of combustion of 500-700 Btu/ft.³, this gas can be burned directly in steam power plants. The CO₂ and H₂S can also be easily removed to produce a 1000 Btu/ft.³ pipeline-quality gas.¹³

India is currently the leader in organic digester/bio-gas research.

Each year, India's cows produce over 800 million tons of manure. During the 1940's, the Indian Agricultural Research Institute sponsored studies on the basic chemistry of anaerobic decay which led to the development of simple digester models for village homes that could provide light and heat, and produce a high-quality fertilizer.¹⁴

Coal Utilization

Coal, once the major energy source for the United States, currently ranks third in utilization. During the last twenty years, petroleum and natural gas moved ahead of coal because they were cleaner fuels and lower in cost. Now, however, because of the combination of the price rise, prospects for depletion, and politics of oil, coal is being considered a major alternative energy source for the United States. Conservative estimates of U. S. coal reserves place the depletion time at 200-300 years, while the depletion time for petroleum and natural gas, as shown in Figure 1.7, is expected to be less than 100 years.

With such a large indigenous energy source, it seems logical to use coal as a short-term alternative to petroleum and natural gas while the technology for large-scale utilization of inexhaustible energy sources is developed. Certain problems must be solved, however, before such widespread utilization of coal can occur. First, most of the high-energy coal reserves in the United States have a very high sulfur content which is released to the atmosphere upon combustion. Coal is also costly to transport and is inconvenient to use on the residential-commercial level. As shown in Figure 1.8, coal deposits are also not uniformly distributed across the United States, meaning that distribution becomes a problem.

Coal research is thus concentrating on developing three processes (gasification, pyrolysis, and solvent refining) for converting coal as it comes from the ground into a clean-burning, easily and economically distributed, and convenient-to-use fuel.

Simply stated, coal gasification involves combining coal with steam at very high temperatures to yield a methane-rich gas. This product is

Figure 1.7

Figure 1.8

then purified to remove the CO_2 , H_2S , and organic sulfur still present. The resulting product (a low to medium Btu gas, depending on the original combustion conditions) can be further processed through a catalytic methanation (in which three molecules of hydrogen are combined with one of carbon monoxide) to yield even more methane. After the water is removed, the resulting synthetic natural gas is about 95 to 98 per cent methane with an energy content of 900-1000 Btu/ft.³.¹⁵ The medium-Btu gas resulting from coal gasification can also be converted to a liquid either by conversion to synthetic gasoline in the Fischer-Tropsch process or by conversion to methanol.

In pyrolysis, coal is heated in the absence of oxygen to produce oil and small amounts of char and low-Btu gas. The oil is then treated with hydrogen

to remove the sulfur, yielding a low-sulfur synthetic crude oil.

Solvent refining of coal involves dissolving the organic components of coal in a heavy aromatic solvent. This process, normally carried out in a hydrogen atmosphere, yields a solution which can be filtered to remove fly-ash and insoluble organic materials. The solution is then fractionated to recover the solvent, and the product is a heavy organic material called solvent-refined coal. It is a solid or viscous liquid (depending on the hydrogen pressure under which the reaction is carried out) from which all the inorganic sulfur and 60 to 70 per cent of the organic sulfur has been removed.¹⁶

The coal conversion processes of gasification, pyrolysis, and solvent-refining are summarized in Figure 1.11.

Figure 1.9

Conclusion

The industrialized world is facing an "energy crisis" because it is rapidly depleting its current primary sources of energy. If we hope to preserve our present standard of living, we must develop inexhaustible and environmentally acceptable energy sources. The solution to this problem will be multifaceted since the different alternative energy sources are more available in some areas than in others. In the United States in general, solar energy is more available in the southwest, wind energy is more available along the coasts and in the central states, and methane-producing material is more available at locations (such as cities) producing large quantities of organic wastes.

Coal, converted to a convenient and clean-burning form, will in all probability be the short-term primary alternative energy source while the technologies for large-scale utilization of inexhaustible energy sources is developed. Small-scale alternative energy source-powered systems for the residential-commercial sector have already been shown to be technologically feasible. If they achieve widespread utilization, they will significantly help us to reduce the consumption of our current primary energy sources. It was toward the goal of helping to further develop this small-scale alternative energy source technology that SCORE sponsored the Energy Resource Alternatives II Competition.

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CHAPTER 3

The History Of The ERA II Competition

The Energy Resource Alternatives II (ERA II) competition challenged university students to develop energy systems capable of producing a portion of the electrical energy needs of homes, farms, and small commercial operations by utilizing such non-conventional energy sources as wind, solar, biological wastes and new variations on coal. The technology to produce electricity from alternate sources has been known for decades, however, the cost of the power generated by these systems has been traditionally prohibitive. The ERA II competition emphasized the development of energy systems that produce electrical energy at a relatively low cost. Innovative design and modification of commercially available hardware helped accomplish the ERA II goals.

ERA II is the second energy competition sponsored by the SCORE corporation. The first energy competition, ERA I, began in July 1974 and terminated in August 1975. In contrast to the ERA I competition, ERA I challenged university students to design and build an energy system which could provide a portion of residential or small commercial energy needs in various forms: hot water, space heating, space cooling, and electricity. The ERA II competition focused solely on the production of electricity. To provide the teams with adequate time to attack the difficult design problems, ERA II was organized as a two year competition, from September 1975 to June 1977.

With every SCORE competition, a different university is selected to host the Coordinating Committee. In October 1975, Washington State University was selected as the host for the ERA II competition. The Coordinating Committee was formed in October 1975 by the selection of four engineering undergraduates and a faculty advisor from the Department of Mechanical Engineering. Washington State University supported the Coordinating Committee by providing office space, supplies, and monetary compensation to the individuals on the Coordinating Committee. The Committee's responsibilities were to develop the competition rules, organize the student teams entered in the competition, coordinate two symposia on alternate energy, and organize the competition's Final Test Event.

In December 1975, the Rules and Guide-

lines for the ERA II competition were developed and distributed (appendix C). This document defined the objectives of the competition, gave a schedule of events, specified the competition rules, and stated the responsibilities of the teams as well as what could be expected of the Coordinating Committee. The Rules and Guidelines formed the backbone of the competition.

During the formulation of the Rules and Guidelines, an Advisory Board to the Coordinating Committee was selected. The Advisory Board was composed of individuals from industry, education, and government (appendix B.) Their purpose was to provide assistance and advice to the Coordinating Committee. The two Advisory Board meetings, February 1976 and October 1976, helped with policy decisions, competition logistics, and selection of the final test site.

During the course of the ERA II Competition, SCORE suffered the loss of its former president, Mark Radtke, who had been with SCORE for three competitions. His position was filled by Richard Aseltine, a graduate of the University of Tennessee in Electrical Engineering.

Teams began to enter the competition in January 1976 by submitting an entry form and design proposal on their project. Interestingly, of the 38 universities competing in the ERA I competition, only 15 entered the ERA II competition. Reasons given for the relatively low participation of ERA I schools were numerous and varied, but common explanations noted were: (1) the inability of the faculty advisor to devote time to an additional two year competition, especially since the advisor's research had been neglected already for one year, (2) a different group of students with different interests, and (3) ERA II's commencement halfway through the academic year after design projects had already been undertaken for the year.

To increase participation, a phone campaign was organized in February 1976. Faculty advisors from past SCORE competitions who were not involved in the ERA II competition were contacted, as well as the representatives from nearly every engineering school in the U.S. The phone campaign was successful; 23 additional universities joined in the competition.

Teams were allowed to enter the competition up to October 1, 1976 and with special consideration up to November 15. During that time, 58 teams turned in entry forms.

Regular newsletters (appendix E) were sent out during the competition to keep teams and those interested in ERA II informed of the competition progress. Nine newsletters were produced and mailed during the competition.

ERA II sponsored two symposia. The first took place on March 13 and 14, 1976 at the University of Oklahoma Center for Continuing Education. Over one hundred students and faculty from the U.S., Canada and Puerto Rico attended the two day event.

A variety of topics were covered at this symposium. SCORE staff spoke of SCORE history, Rules and Guidelines for ERA II and the format of design proposals to be used for grant consideration. Speakers representing industry and education made a number of interesting presentations. Topics covered were Innovation, Engineering Economics, Conversion to Electrical Power, and Systems Integration. Alternative Energy Resources (coal, wind, solar energy and synthetic gas) were introduced early in the symposium, and systems utilizing them were discussed more thoroughly in workshops. Other workshops covered heat engines, energy storage, thermionics and solar cells.

Symposium II was held at the University of Houston on February 4 and 5, 1977. There were over one hundred individuals at the symposium. Most participants were members of ERA II teams already well into their projects.

Workshops comprised the major part of the second symposium. Their intent was to point out potential problems in the development of alternative energy resource hardware and solve existing problems teams might be experiencing. Workshops were held on solar energy, wind energy, coal, methane and energy storage. Additional presentations were made by guest speakers on generators, project management and innovation.

Members of the Coordinating Committee spoke about Final Test Event scoring and logistics. Bill Cawley of the ERDA Richland Operations Office spoke

of arrangements made in Richland for the Final Test Event.

A team captain luncheon meeting proved useful for discussing team fund raising efforts. At the luncheon, team captains received second round grants.

Design proposals were submitted by the teams to the Coordinating Committee between May and November, 1976 for evaluation. The proposals were evaluated by a group of engineers representing industry, government, and education. The Design Proposal Evaluation Committee rated the proposals on their feasibility, technical content, and innovation. Based on their evaluations, a seed money grant was recommended for each team ranging from zero to twelve hundred dollars. The SCORE grants were intended to establish the credibility of the student teams to pave the way for additional fund raising efforts by the teams. A team fund raising guide was mailed to teams in September to aid in local fund raising efforts. During the competition, two additional rounds of grants were issued. The evaluation of written and telephone progress reports were the basis for awarding additional seed money grants. Special funding requests were evaluated as they arrived. In all, SCORE contributed approximately \$91,000 directly toward team projects.

The Final Test Event site was selected in October 1976. Information on weather, facilities, and services were compiled by the Coordinating Committee on five potential sites. At the second ERA II Advisory Board Meeting, the Board approved the ERDA installation at Richland, Washington as the host of the ERA II Final Test Event. Work began immediately on logistics for the Final Test Event and continued throughout the next eight months with numerous trips by the Coordinating Committee to Richland.

In March 1977, an extensive Final Test Event questionnaire was sent to the teams. Results of the survey provided the Coordinating Committee with complete information on the physical specifications, and required services for the projects appearing at the Final Test Event.

In late April, the Homesite Testing Document (appendix H) was sent to teams. The document described the procedure for the teams to evaluate

their own projects prior to the Final Test Event in order that modifications could be made to optimize performance. It allowed the teams up to a month for testing and evaluating their projects in an in-depth manner not possible at the Final Test Event. The Homesite data could be used for evaluation of projects in case they were damaged in transit to the Final Test Event, or if adverse environmental conditions prevailed during the test dates.

Work began on the scoring system after the Homesite Testing document was issued. The scoring system consisted of four basic categories: (1) Innovation, (2) Performance, (3) Marketability, i.e., durability, simplicity, environmental impact, etc., and (4) Economics: the cost of power produced, net energy analysis, and material assessment (appendix G). The economics of a project were evaluated by a special computer program using data supplied by the teams, and performance was evaluated from measurements at the Final Test Event. Innovation and Marketability were evaluated by a select panel of 42 judges organized in mid-May 1977.

Team final reports began arriving at the ERA II headquarters by late May. The final reports included sections on: (1) Final Design, (2) Innovation, (3) Economics, (4) Environmental Impact, (5) Homesite Test Results, (6) Marketability, (7) Operating Instructions, (8) Education Impact, (9) a Team Participation Log and, (10) a SCORE Critique.

In reality, only a handful of final reports were received prior to the Final Test Event. All the teams became totally pre-occupied in perfecting their machinery, during the last few weeks prior to the Final Test Event, rather than completing all the paperwork.

The Energy Resource Alternatives II competition culminated in the Final Test Event from June 9-16, 1977, in Richland, Washington. Thirty teams, representing 22 universities, tested and displayed their hardware that had been developed in the last 24 months.

Registration began Thursday, June 9, 1977 at the Joint Center for Graduate Study in Richland, Washington. The Coordinating Committee met with

teams and showed them where to set up their projects. Forklifts, cranes, cherry pickers, shop facilities, and liaison engineers were available to each team during the Final Test Event.

Teams continued to arrive throughout Friday and set up their projects. Breakfast and lunch was provided at the Richland Public Schools Cafeteria beginning Friday and continuing through Tuesday of the competition. The welcoming barbecue for the teams, their Homestays and Liaison Engineers took place Friday evening. The keynote speaker was Congressman Mike McCormack.

Saturday, teams continued setting up and tuning their projects. Team captains received an extensive orientation concerning scoring and the 24 hour performance testing. The 24 hour performance testing began Sunday morning. The test was in conjunction with the Public Open House, and the beginning of innovation and cost judging.

Monday, teams reworked their projects and prepared for the second 24 hour test on Tuesday.

Wednesday was a day of relaxation and anticipation. The second Public Open House occurred and tours were provided of the Hanford Nuclear and Solar Energy Facilities. That evening the Awards Banquet was held at the Hanford House. Donald Anderson, Manager of Communications Resources with Atlantic Richfield Company was the keynote speaker. He discussed "The Energy Crisis: A Problem in Communications."

Although the project set-up took three days to complete, the dismantling and packing for the return trip took less than a day. The Coordinating Committee finished cleaning up the site and returned to Pullman to write the final report.

CALENDAR OF ERA II EVENTS

September 1975	Energy Resource Alternatives II announced
October 1975	Selection of Washington State University to Host Coordinating Committee
December 1975	ERA II Rules and Guidelines distributed
February 6, 1976	First Advisory Board Meeting held at the National Science Foundation in Washington, D. C.
February, 1976	First ERA II Newsletter mailed
March 13-14, 1976	Symposium I held at the University of Oklahoma, Norman, Oklahoma
May 15, 1976	First round of seed money grants awarded
September, 1976	Fund-raising guide mailed to teams
October 22, 1976	Second Advisory Board Meeting held at the American Society of Engineering Educators Headquarters in Washington, D. C.--Final Test Event Site Selected
November 1, 1976	Written Progress Reports due
November 15, 1976	Deadline for entry into the ERA II Competition
February 4-5, 1977	Symposium II held at the University of Houston, Houston, Texas--Second round of seed money grants issued
March 30, 1977	Final round of grants awarded
May, 1977	Scoring and Homesite Test Document sent to teams
May 26, 1977	Team Final Reports due
June 9-16, 1977	ERA II Final Test Event, U.S. E.R.D.A. Richland Operations Office, Richland, Washington

CHAPTER 4

The Projects: Summary & Descriptions

This section contains a description of each project entered in the Energy Resource Alternatives II (ERA II) competition. The project descriptions are composed of four sections: Innovation, Project Summary, Storage, and Output. The Innovation section identifies concepts of operation, and components of the system which the teams consider as innovations upon current technology. The Project Summary section provides the following technical information about each project: Description of major components, construction materials and methods, and physical dimensions of the system. The Storage section identifies the team's means of storing energy for peaking capabilities. And finally, the Output section indicates the project's designed energy output in form and magnitude.

Accompanying each narrative description of the projects is a project schematic and system photograph. The project sketch describes the function of each system component, and indicates the energy flow through the system. The schematics are representations of the systems only and may not depict actual hardware appearance. The photographs of each project were taken at the Final Test Event; hence these are the most accurate documentation of each project available.

The combination of project description, project schematic, and photographs should give the reader an excellent overview of the systems produced by the teams. In nearly all cases, the information for the descriptions was taken from the teams' final reports of their projects, especially from projects that did not attend the Final Test Event. It is not intended that a projects' description be indepth. More information can be obtained by contacting the schools directly.

SCHOOL: University of Houston
Houston, Texas 77004
TEAM NUMBER: 10
TEAM CAPTAIN: Brett Babbitt
FACULTY ADVISOR: Arthur N. Paul
TELEPHONE: (713) 774-5000

PROJECT SUMMARY

This 22 foot diameter prop-type windmill has the capabilities of producing 2 kw of electricity and compressing 175 psi of air. The electricity will be stored in a bank of lead-acid automotive batteries and the compressed air in a 60 gallon tank. The tank storage will be used as a prime energy source to drive a generator with an air motor along with having the versatility of using air motors as any kind of driver.

STORAGE

Battery and compressed air tank storage.

OUTPUT

The system is designed to produce 2 kw, in a 6.7 m/s wind.

INNOVATION

Compressed air storage gives added versatility to the system. The wing tips can be rotated to act as air brakes in a high wind. The turbine can be run upwind or downwind without a tail because a gear drive controls the position. The blades are designed to run with the sharp edge as the leading edge, which produce higher rpm and more energy output.

SCHOOL: University of Houston
Houston, Texas 77004
TEAM NUMBER: 13
TEAM CAPTAIN: Kirk Rosener
FACULTY ADVISOR: K.J. Waldron
TELEPHONE: (713) 749-4455
[NOT AT FINAL TEST EVENT]

PROJECT SUMMARY

This system was to use a floating, semisubmersible platform containing a wave ramp, storage facilities and low-head turbines to convert wave energy into electricity. The project was dropped when preliminary results showed that there was not enough available energy in waves to produce a reasonable amount of electrical energy with this type of device.

STORAGE

Head of water

OUTPUT

Initial calculations showed 0.74 kw of continuous energy from wave 0.91 m high and 5.49 m wide. Test results showed actual energy output would be 0.10 kw.

INNOVATION

Wave energy was to be concentrated by focusing the water waves and utilizing shoals to amplify wave height.

SCHOOL: University of Houston
Houston, Texas 77004
TEAM NUMBER: 16
TEAM CAPTAIN: Herb Douglas
FACULTY ADVISOR: K.J. Waldron
TELEPHONE: (713) 749-4455
[NOT AT FINAL TEST EVENT]

PROJECT SUMMARY

Water was to be circulated from a flat black solar collector to a thermal storage tank. The cooler water at the bottom of the tank would be pumped back through the collector until the water is ready to enter a concentrating trough collector where it would be heated to about 135° C. When the water left the superheating stage it would still be in a liquid state because it was to be kept at superatmospheric pressures. The water would then be "flashed" (dropped to 1 atmosphere pressure) and become steam which would run a turbine and in turn an electrical generator. The entire system was to be controlled by an eight-bit microprocessor which would track the sun and regulate the system by controlling the flow of water between panels to allow the sun to transfer heat at its maximum potential, sending water to the location of the highest temperature differential.

STORAGE

Battery and hot water storage.

OUTPUT

Estimated output was designed to be 20 kwh/day of 115 VDC power.

INNOVATION

A microprocessor was used to channel and regulate water through the different cycles in order to reach the maximum output.

SCHOOL: Washington State University
Pullman, Washington 99163
TEAM NUMBER: 19
TEAM CAPTAIN: Paul Means
FACULTY ADVISOR: Dr. John A. Seevers
TELEPHONE: (509) 332-2085

PROJECT SUMMARY

Coal is delivered to the home and stored in a large bin. From the bin it is fed into the fluidized bed furnace where it is burned. Heat is removed from the furnace by tube bundles of the Stirling engine. The power from the Stirling engine is delivered to a generator where it is converted into electricity for the home.

STORAGE

No storage.

OUTPUT

The system is designed to produce a maximum of 2.5 kw of 110 VAC power.

INNOVATION

This system combines solvent-refined coal, a fluidized-bed furnace and a Stirling engine to produce electricity.

SCHOOL: Rensselaer Polytechnic Institute
 Troy, New York 12181
 TEAM NUMBER: 22
 TEAM CAPTAIN: Bill Rogers
 FACULTY ADVISOR: Prof. F.J. Bordt
 TELEPHONE: (518) 270-6545

PROJECT SUMMARY

This solar collector system uses 24 parabolic reflector columns (37.2 sq m of surface area) to concentrate sunlight to point where a boiler uses the energy to produce steam. The steam is expanded through a turbine providing the mechanical energy to drive an electrical generator. Electrical power is delivered to an electrical distribution system where it can be switched to a load and used to charge batteries or to dissociate water into hydrogen and oxygen. The hydrogen is used in an engine/generator set to produce electrical power as required. Concentrated sunlight is also converted directly into electricity through the use of vertical junction (photovoltaic) solar cells.

STORAGE

Electricity produced is stored in batteries while the hydrogen is stored in tanks.

OUTPUT

The system is designed to produce 2.5 kw, 32 v DC, from the Rankine cycle.

INNOVATION

The system uses modular construction of the solar concentrator out of identical reflector columns and has a unique receiver design. Highly efficient electrolysis cells (95% of electrical power shows up in the heating value of the hydrogen produced) are also part of the system.

SCHOOL: Amarillo College
Amarillo, Texas 79178
TEAM NUMBER: 25
TEAM CAPTAIN: Tomas Bonilla
FACULTY ADVISOR: A.F. Adkins
TELEPHONE: (806) 376-5111

PROJECT SUMMARY

This wind system consists of a 3 bladed rotor (fixed pitch,) chain and belt drive, two alternators, and storage batteries. The generators are connected to produce 24 V. The overspeed is controlled by pulling the rotor out of the wind.

STORAGE

Battery storage.

OUTPUT

The system is designed to produce an average of 10 kwh/day (24 VDC) in an average wind speed of 6.53 m/s.

INNOVATION

The innovative feature of this wind generator is its simplicity. All hardware and components are commercially available.

SCHOOL: Neil Armstrong High School
Neenah, Wisconsin 54911

University of Wisconsin @ Green
Bay; Green Bay, Wisconsin
54302

TEAM NUMBER: 28

TEAM CAPTAIN: Gary Garriott

FACULTY ADVISOR: Dr. Thomas Van
Koevering

TELEPHONE: (414) 465-2252

PROJECT SUMMARY

This system produces direct current electricity by introducing hydrogen produced from the catalytic dehydrogenation of ethanol into a hydrogen-air fuel cell. Heat for the dehydrogenation reaction is obtained by combusting unreacted alcohol along with the acetaldehyde and other products collected from the dehydrogenation process.

STORAGE

Battery storage.

OUTPUT

Expected maximum direct output from the dehydrogenation-fuel cell is approximately 8 W at 6 VDC. Through the storage system, output voltage is between 2-24 V depending on the combination of series and parallel connections.

SCHOOL: Rutgers University
Piscataway, New Jersey 08854
TEAM NUMBER: 31
TEAM CAPTAIN: Hugo Kruesi
FACULTY ADVISOR: Dr. C.E.G. Przirembel
TELEPHONE: (201) 932-3268

PROJECT SUMMARY

A three bladed horizontal axis wind turbine is connected to a double helical gear speed increaser. The speed increaser output shaft drives a generator which produces 24 VDC electrical power.

STORAGE

The DC power produced by the generator is stored in two 12 V car batteries.

OUTPUT

The wind turbine is designed to produce power when the wind speed exceeded 4.5 m/s. The generator produces its peak output of 1.2 kw (24 VDC) when the wind speed reaches 6.7 m/s.

INNOVATION

In order to simplify the overall turbine design and lower the manufacturing costs, a speed control system is employed to eliminate the need for variable pitch blades and their associated components.

SCHOOL: West Virginia University
Morgantown, West Virginia
26505

TEAM NUMBER: 34
TEAM CAPTAIN: J.A. Tompkins
FACULTY ADVISOR: Bill L. Atchley
TELEPHONE: (304) 293-3280

PROJECT SUMMARY

This project is a pyrolysis gas producer. A high temperature reaction vessel produces hydrogen and carbon monoxide, which is burnt in an internal combustion engine. The system is designed to produce energy from municipal wastes, coal, and high density crop and forestry residue.

The project consisted of two 0.208 m³ steel drums flanged together and welded to the top of a rectangular ash box. Inside the drums, there are a feed cone, air inlet ring, tubular reactor, all made from refractory material, and air inlet baffles to facilitate air preheat. A heat exchanger takes heat from producer exit gas for use in air preheat. A cork filter removes entrained ash and water from producer gases.

A 2.24 kw internal combustion engine, using gasoline, starts the main engine on producer fuel. The main engine, a 11.9 kw reciprocating internal combustion engine, runs on

producer gas fed to the engine by a Beam gaseous fuel carburator.

STORAGE

Energy is stored in the form of organic materials and used as needed.

OUTPUT

The system is designed to provide 36 kwh/day from 50 kg of 36000 kiloJ/kg fuel.

INNOVATION

This system employs the use of waste heat from pyrolysis to raise the temperature of inlet air. The benefits are greater fuel economy and cooling of gas producer hardware, which increases hardware life. The project also has a long pyrolyzation zone which allows higher temperatures and more efficient pyrolysis.

SCHOOL: Oklahoma State University
Technical Institute
Oklahoma City, Oklahoma
73107

TEAM NUMBER: 37
TEAM CAPTAIN: Lawrence Miller
FACULTY ADVISOR: Steve Davenport
TELEPHONE: (405) 634-3169
[NOT AT FINAL TEST EVENT]

PROJECT SUMMARY

A vertical axis wind turbine, consisting of three symmetrical air foils rotating around a vertical shaft, was to be used to generate electricity. The turbine was to have a 3.05 m shaft with three 1.83 m arm supports mounted at both ends of the shaft. The air foils were to be NACA-0015 symmetrical wing sections which have a 0.381 m chord. They were to consist of a foam core, aluminum spar, wood trailing edge, and a laminated skin. The micro-computer, interfaced with an anemometer and tachometer, was to control the start-up and shut-down processes, voltage regulation, and fail-safe components.

STORAGE

Battery storage.

OUTPUT

The system was designed to produce 1.5 kw (24 V-60amp)

INNOVATION

The air-foils were to be easily constructed from a foam core and a wood trailing edge. A microprocessor control system was also to be incorporated into the project.

SCHOOL: Christian Brothers College
Memphis, Tennessee 38104
TEAM NUMBER: 40
TEAM CAPTAIN: Dave Knox
FACULTY ADVISOR: I.A. Jefcoat
TELEPHONE: (901) 278-0100
[NOT AT FINAL TEST EVENT]

PROJECT SUMMARY

Flat-plate solar collectors were to use energy from the sun to heat water. The hot water was to be used to vaporize Freon-11, the working fluid in the bottom tank of a multi tank Minto Wheel. Vapor pressure would force liquid Freon-11 to the top tank. The force of gravity in the fluid in the upper tanks would cause the wheel to turn and drive a generator.

STORAGE

Electricity produced was to be stored in batteries while heat would be stored in rocks.

OUTPUT

This system was designed to deliver 20 kwh/day in the form of 24 VDC.

INNOVATION

Innovation was to be in the use of the Minto Wheel to produce electricity.

SCHOOL: Southern Methodist University
Dallas, Texas 75275
TEAM NUMBER: 43
TEAM CAPTAIN: Colby Ross
FACULTY ADVISOR: Hal Watson
TELEPHONE: (214) 692-3126

PROJECT SUMMARY

This system uses a six bladed Darrieus rotor to extract energy from the wind and deliver electrical power. The rotor is unique in its design due to the arrangement of the blades on the arms. The wings are in sharply staggered pairs that resemble a biplane.

STORAGE

A bank of 6 V batteries.

OUTPUT

A 2.5 kw Jacob's Generator, generating 110 VDC, supplies power to the storage batteries. A inverter supplies 115 V, 60 cycle AC power.

INNOVATION

The biplane construction of the rotor is a self-starting system which requires only wind for start up.

SCHOOL: University of Pittsburg
at Johnstown
Johnstown, Pennsylvania 15904
TEAM NUMBER: 49
TEAM CAPTAIN: Russel Tipton
FACULTY ADVISOR: John Klavuhn
and Zane Wade
TELEPHONE: (814) 266-9661
[NOT AT FINAL TEST EVENT]

PROJECT SUMMARY

Manure was to be moved from a barn to a small pit outside, by a chain system typical of conventional barn cleaners. A sewage pump would move the manure to a loading vat for the digester tanks. Anaerobic digestion of the manure is a continuous process on a 40-day cycle. The resulting methane gas would be collected in an inverted floating tank, and the excess gas compressed and stored to meet peak requirements. The gas would then be used as fuel for an internal combustion engine.

STORAGE

The system would include methane storage tanks and battery storage for electrical output produced by the engine.

OUTPUT

Raw manure from 12 cattle would produce 20 kwh/day of 220/110 V 60 cycle electricity and require 42.5 m³ of digester.

INNOVATION

The waste heat from the engine was used to maintain the optimum temperature in the digester.

SCHOOL: Stevens Institute of
Technology
Hobokon, New Jersey 07030
TEAM NUMBER: 58
TEAM CAPTAIN: Bob Schwalbenberg
FACULTY ADVISOR: Richard I. Hires
TELEPHONE: (201) 792-2700
[NOT AT FINAL TEST EVENT]

PROJECT SUMMARY

Modified contouring rafts were used to absorb energy from ocean waves. The rafts were hinged so that the wave motion caused rotation about the hinge axis. A rack-and-pinion gear box with opposing one-way clutches were designed and constructed to convert the random heave and pitch motion of the rafts into a single direction rotation. The rotation was used to drive an electrical DC permanent magnet-type generator rated at 110 V, 1.8 amps at a no load speed of 3550 rpm.

STORAGE

None

OUTPUT

In a tank test, for a 2.44 m long wave (wavelength/barge length = 2) and 0.152 m wave height, the system produced 17.3 w.

INNOVATION

A controlled-passive anti-roll tank was modified so that it was continuously out of tune to amplify raft motion.

SCHOOL: University of Texas
Austin, Texas 78712

TEAM NUMBER: 64

TEAM CAPTAIN: Ahmad Sharif-
Homayoun

FACULTY ADVISOR: Gary Vliet

TELEPHONE: (512) 471-4584

PROJECT SUMMARY

This system uses parabolic solar collectors, 3 reciprocating steam generators, and 3 reciprocating steam engines. The collectors are 8 ft. long and 4 ft. around the perimeter and were made from fiberglass in a pre-fabricated aluminum mold. The steam is produced in receiver tubes which absorb the solar energy. These tubes are enclosed in an evacuated glass jacket to reduce energy losses.

STORAGE

Heat is stored in Therminol and rocks.

OUTPUT

The system is designed to produce 5.31 kwh/day, 115 V DC.

INNOVATION

The innovative features of this system include parabolic-trough reflective collector surfaces, selectively-surfaced double pipe receiver tubes, sensible heat storage unit, and solar cell suntracking mechanism.

SCHOOL: California State University
Long Beach, California 98040
TEAM NUMBER: 67
TEAM CAPTAIN: Milton Michailidis
FACULTY ADVISOR: Hillar Unt
TELEPHONE: (213) 498-4407
[NOT AT FINAL TEST EVENT]

PROJECT SUMMARY

A bank of parabolic-trough concentrators was to track the sun and focus the rays on collecting tubes in which Dowtherm Heat Transfer Fluid was circulating. In a heat exchanger/boiler unit, the heat from the Dowtherm was to be transferred to water within a concentric double-tube heat exchanger. In a throttling process at the exit of the exchanger, the water would be transformed into steam. The steam was to power a reciprocating steam engine which, in turn, would be coupled to an electric generator.

STORAGE

No storage.

OUTPUT

The system was designed to deliver 8-9 kwh/day of electrical power.

INNOVATION

An experimental reflective film was to be used on the collectors. The collector unit was designed with a "modular" concept to allow for adaptation to different regions.

SCHOOL: Washington State University
Pullman, Washington 99164
TEAM NUMBER: 70
TEAM CAPTAIN: Grant Marr
FACULTY ADVISOR: Bill Kennish
TELEPHONE: (509) 335-3224

PROJECT SUMMARY

This system uses a Darrieus wind turbine with a Savonius starter; this runs a generator and the produced electricity is stored in batteries.

STORAGE

Battery storage.

OUTPUT

The system is designed for wind speeds up to 30 m/s. At that wind speed, it is designed to turn 200 rpm and produce 2.6 kw of 24 V DC power.

INNOVATION

An electronic control system senses changes in wind speed relative to the operating speed of the wind turbine, and adjusts the field current on the alternator to prevent the turbine from stalling. This results in maintaining a constant tip speed ratio. The control system also prevents the windmill from operating at dangerous overspeeds. It can produce power in unusually high winds by maintaining a large difference between wind speed and turbine speed by increasing the load before the turbine can speed up.

SCHOOL: West Seneca East Senior High
School and Buffalo State
University
West Seneca, New York 14224

TEAM NUMBER: 76

TEAM CAPTAIN: Russel Fulle

FACULTY ADVISOR: David Gierke

TELEPHONE: (716) 674-5300

PROJECT SUMMARY

This system uses a combination of solar and wind energy sources; the solar collector is an 80 ft. parabolic trough with 1994 2" square pieces of mirror. The wind collector is a 12 volt American wind turbine.

STORAGE

Battery storage.

OUTPUT

The system is designed to produce 2 kw of DC electrical power in a 10 m/s wind. The solar portion of the project produces a nominal amount of power.

INNOVATION

The tracking device is made from photovoltaic sensing cells. Tracking is achieved by sensing voltage differences between the two sets of cells caused by the shadowing effect as the sun moves across the sky. The efficiency of the solar collector is increased by the cone/mirrors which reflect any stray radiation onto the boiler plate. In the electrical system of the wind turbine, a mercury switch is used rather than a spring loaded set of contact points that could corrode in adverse weather conditions.

SCHOOL: Massachusetts Institute of
Technology
Cambridge, Massachusetts 02139
TEAM NUMBER: 79
TEAM CAPTAIN: Tom Davidson
FACULTY ADVISOR: James Felske
TELEPHONE: (617) 253-3790

PROJECT SUMMARY

This system utilizes a solar pond as the collector, which heats water to 200°F. Electric power output is obtained via a generator that is powered by a heat engine. The power cycle is a closed loop 1 kw Rankine cycle, using refrigerant R-11 as the working fluid, and a modified vane type air motor as the expander.

STORAGE

Battery storage.

OUTPUT

The system design output is 1 kw of 24 V DC power.

INNOVATION

The system utilizes an inefficient, but inexpensive "solar pond" approach with hot water as an inexpensive energy storage medium.

SCHOOL: Georgia Institute of Technology
Atlanta, Georgia 30332
TEAM NUMBER: 81
TEAM CAPTAIN: Homer Cochran
FACULTY ADVISOR: Ron Larson
TELEPHONE: (404) 894-2930

PROJECT SUMMARY

This project uses photovoltaic cells, or solar cells, to produce electricity directly from sunlight. Since solar cells have such a high cost in terms of dollars per unit power, a fixed-mirror Russell type concentrating collector is used to increase the incident sunlight on a cell and thus increase the power output. The cells must be water-cooled to avoid an efficiency-reducing temperature rise. The power produced by the cells is stored in batteries and later inverted to standard 110 V AC.

STORAGE

Battery storage.

OUTPUT

The design output is 0.41 kwh/day of 110 V AC.

INNOVATION

Innovation lies in the combination of photovoltaic cells and the Russell-type solar collector. A Russell Collector tracks the focal point of a fixed mirror system rather than tracking the sun.

SCHOOL: Georgia Institute of Technology
Atlanta, Georgia 30332
TEAM NUMBER: 84
TEAM CAPTAIN: Wayne A. Lindskog
FACULTY ADVISOR: Ron Larson
TELEPHONE: (404) 894-2930

PROJECT SUMMARY

This project attempts to utilize the energy potential of the wind and that found in organic waste, which has been anaerobically digested to produce methane gas. The methane is used to power an engine-generator system which produces 110 V AC. A combination Savon-Darrieus wind rotor is utilized as a supplement to the valves and microprocessor which regulate the digester. The digester is heated by waste heat of the engine-generator and from a solar collector.

STORAGE

Battery and hot water storage.

OUTPUT

This system is designed to produce 20 kwh/day (110 V AC).

INNOVATION

Organic waste is anaerobically digested to produce methane gas. The systems use a microprocessor control system.

SCHOOL: Georgia Institute of Technology
 Atlanta, Georgia 30332
 TEAM NUMBER: 90
 TEAM CAPTAIN: Kelly Carter
 FACULTY ADVISOR: Ron Larson
 TELEPHONE: (404) 894-6602

PROJECT SUMMARY

Approximately 500 ft² of concentrating collectors will focus solar radiation to generate heat for boiling water to steam. The steam will drive a reciprocating steam engine which will turn a generator to provide electrical power. Excess power will be used to drive a massive, spinning flywheel for energy storage. The entire system will be controlled by a microcomputer system.

STORAGE

Battery storage.

OUTPUT

The design output is approximately 16 to 20 kwh/day of electricity with a maximum power output of 2.5 kw, in the form of 120 V at 60 Hz.

INNOVATION

The solar concentrator design is innovative in that the mirrors are flexed into a curve to yield a point focus instead of the line focus other slat type concentrators utilize.

SCHOOL. Georgia Institute of Technology
 Atlanta, Georgia 30332
 TEAM NUMBER: 93
 TEAM CAPTAIN: Brad Milner
 FACULTY ADVISOR: Ron Larson
 TELEPHONE: (404) 894 2930

PROJECT SUMMARY

The Georgia Tech MUES (Multiple Unit Energy System) is a Wind System. It uses four separate rotor assemblies to generate the required power. The turntable the blade is mounted on is made from steel. There is a 20-to-1 gearbox in each turntable plus a truck alternator.

STORAGE

Lead acid telephone batteries.

OUTPUT

The test shows each unit can produce 0.95 kw in a 6.7 m/s wind.

INNOVATION

A simple, low-cost rotor and power transmission design produces a cost competitive system. For maximum efficiency of the fixed pitch design, the field current of the alternator is controlled by a microprocessor to keep the tip speed to wind speed ratio constant.

SCHOOL: Midwestern State University
Wichita Falls, Texas 76308
TEAM NUMBER: 97
TEAM CAPTAIN: Jeffrey Johnston
FACULTY ADVISOR: E. L. Holverson
TELEPHONE: (817) 692-6611

PROJECT SUMMARY

This project's goal, to generate electricity from solar energy, is based on modification of the Minto Wheel, a solar-powered water pump. Rotation of this vertical wheel, which is composed of 8-12 pressurized tanks paired and connected diametrically by crosstubes is a result of a weight transfer contained in half the tanks from the bottom-most tank to the top. The torque produced by the rotation of this wheel is sufficient to generate electricity through a gear ratio system.

OUTPUT

The wheel is designed to turn at a rate of 10-12 rpm which would produce 14-16 kw, at 115 V DC.

INNOVATION

Innovation is in the use of the Minto Wheel to produce electricity. A stationary converging mirror system made of 880 mirrors concentrates light through a Fresnel Lens system.

SCHOOL: University of California,
Berkeley
Berkeley, California 94720
TEAM NUMBER: 100
TEAM CAPTAIN: Rick Gavazza
FACULTY ADVISOR: Otto Smith
TELEPHONE: (415) 642-7591

PROJECT SUMMARY

UCB's energy resource alternative system captures the kinetic energy stored in the winds through a conventional and proven windmill. This energy is converted into electricity and is directed into residence in the form of 100 V DC. Energy storage is in the form of an inertia flywheel. A computer-oriented control system assures the availability of constant line voltage to residence; the flywheel is charged and discharged in accordance to wind condition and power demand.

STORAGE

Battery storage.

OUTPUT

Output is designed to approach 1.6 kw, 110 V DC, in a 6.71 m/s wind.

INNOVATION

The rim-wheel power take-off, in conjunction with the rotating tower allows the generator to sit close to the ground.

This avoids the vibrational problems associated with a massive generator on top, removes the gear box and its wear problems, and avoids the tension problems in belt drive windmills.

SCHOOL: Ohio University
Athens, Ohio 45701
TEAM NUMBER: 103
TEAM CAPTAIN: Chris Scheck
FACULTY ADVISOR: Roy Lawrence
TELEPHONE: (614) 594-5862
[NOT AT FINAL TEST EVENT]

PROJECT SUMMARY

A propeller-type windmill was to employ two 4-meter fiberglass blades to drive a DC generator mounted on a turntable at the top of a windmill tower. The tower was to be approximately 15 meters in height and constructed out of standard steel TV antenna tower sections.

STORAGE

Battery storage.

OUTPUT

Estimated output at an average wind speed of 5 m/s is 27.1 kwh/day of 115 V AC power.

INNOVATION

The molded fiberglass blades used in this system could be mass produced relatively cheaply.

SCHOOL: Kansas State University
 Manhattan, Kansas 66506
 TEAM NUMBER: 106
 TEAM CAPTAIN: Lee McQueen
 FACULTY ADVISOR: Richard Hayter
 TELEPHONE: (913) 532-5620

PROJECT SUMMARY

This system converts fermented sorghum to ethanol, which is burned in an internal combustion engine; this, in turn, drives an AC generator. As an auxiliary energy source, a Savonius wind turbine is used also.

STORAGE

Battery and liquid ethanol storage.

OUTPUT

To produce 20 kwh/day for 1 year, 65 acres of sorghum at 2% overall efficiency is needed.

INNOVATION

This system uses a renewable fuel source with a useable by-product. The pulp by-product left after the crushing process can be used as cattle feed.

SCHOOL: University of Evansville
Evansville, Indiana 47714
TEAM NUMBER: 109
TEAM CAPTAIN: John Gaither
FACULTY ADVISOR: William Hartsaw
TELEPHONE: (812) 479-2652
[NOT AT FINAL TEST EVENT]

PROJECT SUMMARY

Focused solar energy was to be collected by 26 sq.m. of fixed parabolic collectors using a water medium which could be stored at high temperature. The high temperature water was to heat the Freon in a heat exchanger. The output from the generator was to be stored in batteries or shifted to the load as required.

STORAGE

Hot water storage tanks (3.785 cu.m.) and batteries.

OUTPUT

The output work of the system was designed to be 24 V DC, 37 kwh per day.

INNOVATION

The concentration factor of the solar collectors which govern the acceptance angle and the trough width and height was to be 5:1. The system was to use a modified steam turbine with Freon as the working fluid.

SCHOOL: University of Wisconsin at
 Madison
 Madison, Wisconsin 53706
 TEAM NUMBER: 112
 TEAM CAPTAIN: Ken Kriesel
 FACULTY ADVISOR: Ali A. Seireg
 TELEPHONE: (608) 262-3594

PROJECT SUMMARY

Wood and coal refuse are combusted in a Brayton cycle engine. Electricity is stored in batteries.

STORAGE

Energy is stored in coal until ready for use.

OUTPUT

Design power output specifications are 1.5 kw of 110 V 60 Hz AC electricity.

INNOVATION

This system uses external combustion of organic fuels to power a Brayton cycle heat engine.

SCHOOL: Illinois Institute of
Technology
Chicago, Illinois 60616
TEAM NUMBER: 115
TEAM CAPTAIN: Jerry King
FACULTY ADVISOR: T. P. Torda
TELEPHONE NUMBER: (312) 567-3190
[NOT AT FINAL TEST EVENT]

PROJECT SUMMARY

The system consists of 48 (approx. 60 sq.m.) parabolic trough collectors that were used in the concentration of solar energy. The concentrated energy heats water in a central pipe up to 204 C. From the collectors, the fluid is cycled through a Tesla Turbine, and then condensed steam is returned to the cycle. The power from the Tesla Turbine was to run a generator which would produce electrical power. A switching circuit was to direct the output to charge the batteries or provide energy for home use. 4 tracking units were attached to the collector rack.

STORAGE

Battery storage.

OUTPUT

The output was designed to be 20 kwh/day of 24-28 V DC power.

INNOVATION

The system design called for the largest molded foam troughs known and a Tesla Turbine for conversion of heat to mechanical power.

SCHOOL: University of Maryland
College Park, Maryland 20742
TEAM NUMBER: 121
TEAM CAPTAIN: Michael Kilpatrick
FACULTY ADVISOR: Larry Gasner
TELEPHONE: (301) 454-4593

PROJECT SUMMARY

This system uses the method of gasifying combustibile solids to power an internal combustion engine which drives an electrical generator.

STORAGE

Battery storage.

OUTPUT

If system were supplied 73 kg of hardwood or 50 kg of charcoal, it should produce 36 kwh/day.

INNOVATION

The system was to involve the gasification of any combustibile solid (wood, charcoal, coal, coke, refuse, straw, corn cobs, cornstalks, or leaves) in a gas producer. The resulting low BTU gas would be cleaned, cooled, and used to fire an internal combustion engine powered electric generator.

SCHOOL: University of Oklahoma
Norman, Oklahoma 73019
TEAM NUMBER: 124
TEAM CAPTAIN: Mike Bergey
FACULTY ADVISORS: Karl H. Bergey
John Fagan
TELEPHONE: (405) 325-5011

PROJECT SUMMARY

The system contains a single large vertical axis, articulated blade, wind turbine. The pitch of the blades is controlled in a manner that gives the turbine a very high efficiency. After passing through a speed increaser, the output torque of the turbine is converted into 115 volts, 60 Hz electrical power by means of a synchronous generator.

STORAGE

Battery storage.

OUTPUT

The turbine is rated at 7.5 kw of 115 V AC electricity in a 10.3 m/s wind.

INNOVATION

The rotor rests on a simplified and improved support structure for vertical axis turbines. The system has cyclical pitch actuators to reduce the normal angle of attack variation through the cycle. Thus, an optimal angle of attack can be maintained for an extended portion of each revolution. This maximizes turbine efficiency.

SCHOOL: University of Oklahoma
Norman, Oklahoma 73019
TEAM NUMBER: 127
TEAM CO-CAPTAINS: Ricky Palmer
Larry Palmer
FACULTY ADVISOR: Robert St. John
TELEPHONE: (405) 321-6861

PROJECT SUMMARY

This system integrates the concepts of the high torque, multi-bladed wind turbine and the high speed, two-bladed impeller into one working unit. Power is obtained by driving alternators via belts around the rims of the multi-blade parts of the entire units.

STORAGE

Battery storage.

OUTPUT

The actual output achieved at average wind speeds is 0.5 to 2 kw at 24 V DC.

INNOVATION

The system integrates the concepts of the low speed, high torque, multiblade wind turbine and a high speed, two-bladed impeller into one working unit.

SCHOOL: University of Florida
Gainesville, Florida 32611
TEAM NUMBER: 130
TEAM CAPTAIN: Mindy Hyatt
FACULTY ADVISOR: Vernon P. Roan
TELEPHONE: (904) 392-0808

PROJECT SUMMARY

Sunlight heats solar collectors which power the Rankine Cycle. The positive displacement expander in the Rankine Cycle provides shaft work which is utilized to run a generator. Electrical power created is eventually stored for later use.

STORAGE

Battery storage.

OUTPUT

The system was to produce 1 kw of 115 V DC power.

INNOVATION

The innovation of this project was to be the use of a positive displacement expander instead of a conventional type turbine.

SCHOOL: University of Wisconsin
 Milwaukee, Wisconsin 53218
 TEAM NUMBER: 133
 TEAM CAPTAIN: William Tyan
 FACULTY ADVISOR: I. Carl Romer
 TELEPHONE: (414) 466-1561

PROJECT SUMMARY

A solar hot water heater is used to warm an anaerobic digester which produces methane gas. The methane gas, in turn, is used in an internal combustion engine to power a generator. Electricity is also produced by a wind-electric generator. The electricity produced by both these systems is then stored in batteries.

STORAGE

Battery and hot water storage.

OUTPUT

The wind turbine is designed to produce .5 kw in a 5.14 m/s wind. The completed digester would be capable of producing 11.5 kwh/day.

INNOVATION

A solar hot water heater is used to warm an anaerobic digester which produces methane gas.

SCHOOL: University of Wisconsin at Stout
Menomonie, Wisconsin 54751
TEAM NUMBER: 136
TEAM CAPTAIN: Alan Zajac
FACULTY ADVISOR: James Collier
TELEPHONE: (715) 232-1250

PROJECT SUMMARY

The system utilizes a 2.5 kw wind generator as its only energy source. Energy produced by the system will be stored in both primary and secondary storage components. The primary storage component will consist of a 24 V DC battery bank and the secondary storage component will consist of a high-speed flywheel.

STORAGE

Battery storage.

OUTPUT

The blades are designed to extract 2.5 kw of energy in an 8.03 m/s wind, 24 V DC.

INNOVATION

Blades for the wind generator are innovative because they are designed for an area where the average wind speed is low. The turbine support tower is of octahedron design constructed from steel tubing.

SCHOOL: Oregon State University
 Corvallis, Oregon 97331
 TEAM NUMBER: 142
 TEAM CAPTAIN: Richard Drollinger
 FACULTY ADVISOR: William E. Holley
 TELEPHONE: (503) 752-4836

PROJECT SUMMARY

This system uses water to absorb the heat from solar radiation and stores the energy as hot water in large tanks. As power is needed, it exchanges this heat energy with pressurized Freon 11 (CCl_3F) turning it into vapor that spins a turbine-generator. In addition, there is a wind-turbine-generator that helps supply power through a set of batteries.

STORAGE

The primary storage component is a 4.5 cu.m. hot-water tank in conjunction with another cold-water tank of equal size. Hot water from the solar collectors is stored in the hot-water tank. The windmill uses 4 12-V batteries connected to produce a 24 V system.

OUTPUT

The system is designed to produce 36 kwh/day of 24 V DC.

INNOVATION

The system has a cascading pond solar collector for preheating, intermediate heating flat-plate solar collectors, and a parabolic trough solar collector for final stage heating. The energy storage system includes a high temperature water storage tank and a low temperature storage tank for used low temperature water. The wind turbine consists of used helicopter blades and a modified helicopter gear box.

SCHOOL: Oregon State University
Corvallis, Oregon 97331
TEAM NUMBER: 151
TEAM CAPTAIN: Eric Vogel
FACULTY ADVISOR: William Holley
TELEPHONE: (503) 753-1261

PROJECT SUMMARY

The foundation of this project is an innovative type of heat exchanger in which a condenser and boiler are assembled back-to-back with a common wall rather than being independent components. This arrangement allows the heat liberated in the condenser to be the heat source for the boiler. The steam from the boiler then goes to the turbine/generator.

STORAGE

Hot concentrated calcium chloride is stored for use at night.

OUTPUT

The system is designed for an output of 1 kw, 115 V DC.

INNOVATION

This solar energy process, desiccant collection, is an integration of basic concepts and hardware well known and widely used in present industrial processes, but not previously applied to use with solar energy. The novel heat exchanger design allows 8 sq.m. of heat exchange area to be packaged into 0.063 cu.m. of volume.

SCHOOL: University of Alabama
Huntsville, Alabama 35807

TEAM NUMBER: 154

TEAM CAPTAIN: Earl Lochrlein

FACULTY ADVISOR: D. B. Wallace
S. T. Wu

TELEPHONE: (205) 895-6323

[NOT AT FINAL TEST EVENT]

PROJECT SUMMARY

The system was to consist of a 3-bladed, horizontal axis windmill. The shaft was to be coupled by pulleys to a generator to produce electricity. The 1.83 m. long blades were to be made from fibreglassed wood.

STORAGE

Battery storage.

OUTPUT

The system output was designed to be 24 V DC with a maximum current of 100 amps.

INNOVATION

The blades were to vary pitch for maximum efficiency in the 2.2 to 8.9 m/s wind range. This would be accomplished by spring-loading the blades along their axes.

SCHOOL: UNIVERSITY OF FLORIDA
Gainesville, Florida 32601
TEAM NUMBER: 157
TEAM CAPTAIN: Bill Misiaszek
FACULTY ADVISOR: Vernon P. Roan
TELEPHONE: (904) 373-6406

PROJECT SUMMARY

Wind turbine to 24 V alternator
to lead acid storage batteries.

STORAGE

Lead acid batteries.

OUTPUT

The system is designed to produce 2.0 kw (24 V DC) in a 9.54 m/s wind.

INNOVATION

Innovation is in the pitch change (for maximizing efficiency) and overspeed device of this system, and the blade partitions which minimized vortex shedding.

SCHOOL: University of Florida
Gainesville, Florida 32601
TEAM NUMBER: 160
TEAM CAPTAIN: Bill Monroe
FACULTY ADVISOR: Vernon P. Roan
TELEPHONE: (904) 375-6441

PROJECT SUMMARY

This system consists of a two cylinder diesel generating plant converted to run on a liquid and powdered coal solution. Power produced is dissipated as heat in a bank of 1000 ohm heating elements. Power output may be varied in 1 kw increments.

STORAGE

No storage.

OUTPUT

The output of this system was designed to be 7.5 kw at 110 or 220 V AC.

INNOVATION

The system was to consist of a two cylinder diesel generating plant converted to run on a solution of carrier liquid and powdered coal.

SCHOOL: University of Alabama
Tuscaloosa, Alabama 35468
TEAM NUMBER: 163
TEAM CAPTAIN: Alan Gunter
FACULTY ADVISOR: Walter J. Schaetzle
TELEPHONE: (205) 345-6507

PROJECT SUMMARY

The project consists of a Darrieus-type vertical axis windmill connected to a DC generator with a battery storage system. The system will self-start with the help of Savonius rotors located on the mast of the Darrieus blades. The control system regulates current and voltage to the batteries as well as automatically stalling the system in case of overspeed. The system can be used with or without a tower, depending on the location.

STORAGE

Battery storage.

OUTPUT

The windmill is designed to produce 20 kw per day (24 V DC) where wind speeds average 4.77 m/s.

INNOVATION

The system is self-starting, with the help of sheet metal flaps attached to the rotor. The tower is an aluminum pole with a crow's mast for easy maintenance.

SCHOOL: KANSAS STATE UNIVERSITY
Manhattan, Kansas 66506
TEAM NUMBER: 181
TEAM CAPTAIN: Reginald Moore
FACULTY ADVISOR: Gary Johnson
TELEPHONE: (913) 532-5600
[HARDWARE NOT BROUGHT TO FINAL TEST
EVENT]

INNOVATION

Rotor modules can be easily added to the system to meet increased power needs.

PROJECT SUMMARY

A Savonius wind turbine made of four rotor modules is used to generate electricity. Each of the 4 rotors are designed to be 3.05 m. high and 1.83 m. in diameter to make standard size metal sheets useable. They are slaved together by placing the upper ones directly over the lower ones, then using a 4.13 cm. square key coupler, the rotor shafts are coupled together. The coupled shafts drive an alternator through 2 gearboxes. The top horizontal beam supports the crane hoods for rotor installation and the automotive drum brakes.

STORAGE

No storage.

OUTPUT

An 11 m/s input wind is designed to produce a 5 kw of 240 V AC electrical power.

CHAPTER 5

Final Testing

The Final Test Event was the climax of the two year Energy Resource Alternatives II Competition. At the week long event, June 9-16, 1977, the time, effort and ideas put forth by student teams were tested and evaluated by experts in the energy field.

In September of 1976, the Coordinating Committee started the search for the Final Test Site. Stringent criteria for facilities, services, and weather were formulated to evaluate the potential sites. These included an average daily wind speed of 4.5 m/s, a minimum solar incidence of 700 W/m², an unobstructed field of at least five acres with electrical and water services, low cost housing and food services, and strong local enthusiasm for the Final Test Event.

Five potential sites were finally considered. Each site was visited by the Coordinating Committee to determine how well the site met the site requirements. This information was presented to the ERA II Advisory Board at its second meeting in October 1976, for a final decision on site selection. By unanimous consent, the Board agreed that the Energy Research and Development Administration-Richland Operations should host the Final Test Event. The Richland, Washington, site exhibited the best combination of weather, facilities, services and enthusiasm of all the sites considered.

The Final Test Event Site was a 7 acre parking lot owned by the Richland Public School District and located across the street from the Joint Center for Graduate Study in Richland. The Coordinating Committee offices and judging rooms were all located in the Joint Center for Graduate Study.

During the ensuing eight months, extensive preparations were made to accommodate the teams and projects at the Final Test Event. In March 1977, a questionnaire was sent to each team to determine the number of people coming to the event, lot size, equipment, and any special support teams needed to assemble and operate their projects. With this information in hand, the Coordinating Committee and the ERDA hosts commenced the task of fulfilling the teams needs.

The site utilities were installed by the City of Richland. Local industry and the city provided equipment to

unload and assemble the projects on the site. A consortium of local professional engineering societies found homestays and liaison engineers for each team. Homestays consisted of Richland residents who opened their homes to team members for sleeping and showering during the event. Liaison engineers were local engineers who volunteered to provide technical assistance and equipment to help teams solve problems encountered during project assembly and operation at the event. A liaison engineer was assigned to each team and often doubled as the team's homestay.

Teams were encouraged to construct, test, and debug their projects prior to the Final Test Event. Last minute improvements, damage to equipment in transit, plus multiple other problems required the availabilities of machine shops for team use. Local industry and the school district volunteered the use of their shops to the ERA II teams, and often provided machinists for difficult jobs. For example, West Seneca High School's trailer overturned while enroute to the Final Test Event. Enthusiastic support from their local community provided funds to replace equipment destroyed in the accident. In Richland, the J. A. Jones Construction Company rebuilt their trailer, the school district shops provided tools and space to rebuild the destroyed equipment, and their liaison engineer located more distilled water so their project could continue to function. Oregon State University manufactured some special tapered pins at the school district shops and had an elbow clamp machined at J. A. Jones Company shops. Gas regulators and methane were obtained by the liaison engineer helping Georgia Institute of Technology. Woodruff keys were lost in the gravel and replaced for the University of Wisconsin at Madison by J. A. Jones and a burned out blower was replaced for Madison by their liaison engineer. The above services and many more were provided to teams during the Final Test Event. Many projects would not have been operational without these varied sources of help.

Team registration began Thursday morning, June 9, 1977 and continued through Saturday, June 11, 1977, at the Joint Center for Graduate Study in Richland. The barbecue on

Friday Evening, held on the banks of the Columbia River, was the first official function of the Final Test Event. The informal outdoor setting gave teams a chance to get acquainted with competing teams, their home-stays, and their liaison engineers. Congressman Mike McCormack gave the Welcoming Address. He talked about the future use and production of energy in the United States and the activities of the government in solving the energy crisis.

From Friday through Tuesday, breakfast and lunch were available from the school district cafeteria for participants and judges. The cafeteria was located next to the testing field and provided convenient and speedy service. The cafeteria was also available for team conferences and the daily team captain meetings.

Saturday afternoon, the logistics of project scoring were discussed with team captains. Projects were judged in four areas: (1) Innovation, (2) Marketability, (3) Economics, and (4) Performance. Actual judging started on Sunday and continued through Tuesday, with Wednesday reserved for analyzing the results.

The Innovation judging took place on Monday and Tuesday. Judges from across the country (appendix I) with expertise in engineering and alternate energy systems evaluated each project's innovation in two categories: (1) Innovative ideas, and (2) Innovative ways of fabricating the system either from original design or by the modification of commercially available components (appendix G.)

Each team provided the judges with an abstract covering the innovations incorporated in the project. With this abstract in hand, one group of judges reviewed all the solar projects on site, while others reviewed wind projects, and organic systems. Team members fielded questions from the judges and the projects were closely scrutinized. After reviewing all projects in one alternate energy division, each specialized group of judges discussed the projects in a group meeting and individually assigned each team their innovation scores: 13 points for innovative ideas, 12 points for innovative fabrication of original design or modification of commer-

cially available components, and 5 points for innovative storage methods. The group discussions aided in removing individual biases and established a common basis of scores within each group. This helped to reduce the tendency for one or more judges to score consistently lower or higher than others.

After each group marked their scores, they assembled in a single large meeting to establish a common basis of scores among all projects at the Final Test Event. By doing so, the problem of one energy group scoring consistently higher or lower was averted.

Upon completion of the renormalization of the team scores, the top half-dozen scores were re-evaluated on site by a heterogeneous group of judges to determine the winners of the particular innovation awards. The individual team scores were retained for their contribution to a team's overall scores.

Marketability judging focused on a one hour formal presentation made by each team to a panel of judges. The judges were divided into groups representing each energy form: wind, solar or organic. Using any audio-visual format desired, each team discussed with the judges the key marketability points considered in scoring: (1) the results of the teams' market analysis in evaluating the potential market for the teams' equipment, (2) the design simplicity of the hardware, (3) the safety considerations employed in the design, (4) the system environmental impact, (5) maintenance requirements and, (6) the durability of the system. In addition to the teams' presentation, the judges reviewed each project on site. Each group of judges scored the individual team by assigning an overall marketability score from a possible of 20 points. The marketability judges also determined the expected economic life of the system in years.

The Economics scoring of projects was divided into three areas: (1) Busbar Electricity Costs, (2) Net Energy Accounting, and (3) Exotic Material Requirements. To evaluate the busbar costs of electrical power generated by the projects, the teams supplied cost data on the projects construction. The project assembly was broken into steps. Each step represented the

construction and/or incorporation of the component into the team's energy system. The cost data for each step was reported as the material costs, the number of labor hours, and labor type required to assemble and incorporate the component into the project. Knowing the material and labor costs for each individual step, the total assembled cost of the team's project could be estimated. Using cost multipliers to reflect manufacturing costs (overhead, profit and working capital charges,) an estimate of the market price of the system was made. Then by amortizing the price of the energy system over the economic life of the system, a rough annual cost of the energy system to the consumer was calculated. Additive costs were included to cover taxes, maintenance, estimated life, etc. and the annual energy produced by the system, by which an estimate of the project's busbar electricity cost was made.

Every project received points for the busbar cost of electricity by its position in the distribution of busbar costs (Figure 1) for all projects. Maximum possible points for a project's energy cost was 12.5 points.

The energy cost of the assembled project was calculated in BTU's by using the list of construction materials utilized in each project. The time period needed to pay back an energy sum equivalent to twice its energy cost was calculated by using the annual energy production of the system. Dependent on the number of years to double its payback, different points were allocated to each team. The maximum points available were 7.5 points.

A comparison was made of the exotic materials demanded by each project to the materials' domestic U.S. supply, and points were allocated contingent on how many times demand exceeded supply for a specific material (appendix G).

The cost data was entered into a special computer program (appendix M) written by the Coordinating Committee to automatically and consistently evaluate the three sections of economic scoring.

Performance scoring was divided into two sections: total energy output

(12.5) points, and peaking energy output (12.5) points. If a team produced 20 kW hours in a 24 hour period, they received full total energy output points. If the team was able to position 16 kW hours of the 20 kW hour total in the peaking region of the ERA II load demand curve, (the region between 6:30 and 22:30 above the 0.75 kW line,) (see the Rules and Guidelines and newsletter no. 4) the team received the additional 12.5 points or a portion thereof for peaking energy output. Energy storage systems were encouraged as a means of meeting the peaking points. Starting in the fully charged mode, any energy discharged from the storage device during peak demand periods had to be made up by system recharging off peak periods.

The 24 hour testing period began Sunday at 8:00 am. Teams were required to supply a resistive load bank, instrumentation to meter electrical energy supplied to the load bank, and instrumentation to measure the energy entering and leaving the teams' storage system. At 15 minute intervals during the 24 hours, team members took readings of electrical energy being produced and electrical energy entering or leaving the storage system. This information was compiled and scored for all the teams by a mobile computer, supplied and manned onsite by the Battelle Northwest Laboratories. Every three hours teams received a graph of their performance, a plot showing how well they were meeting the demand load curve, and their accumulative scores. Overall scores and power produced for each team were updated and posted each hour.

Twelve teams were prepared for the first 24-hour performance test on Sunday, the remaining awaited the second 24 hour performance test period.

Sunday was the first Open House for the public. Over 1500 people visited the site during the day. Several TV stations filmed the projects and interviewed participants for the evening news.

On Monday, teams rested from the 24 hour test and prepared their projects for the second day of testing. On Tuesday, 19 teams participated in the second day of testing. The teams that did not participate had experi-

enced technical difficulties that could not be resolved at the Final Test Event site. At the end of the second day of 24 hour performance testing, each teams' best results from the two days were accepted as provisional test results. For those teams using commercial fuels in lieu of digestion produced gas (these could not be transported across state lines,) a special panel of judges compared their performance testing results to what the gas producer systems were capable of producing.

The teams who had done homesite testing of their projects submitted the homesite data as performance testing results. The homesite data was reviewed by the special panel of judges to verify power output claims. Based on the reviews, their performance results were appropriately adjusted.

The weather was not the most cooperative element of the competition. The sunshine during the competition was excellent. It was always hot, sunny and dry. The wind, however, was far below normal for this period. Although past weather records gave less than a 10% chance that both 24 hour test days would be calm, it remained calm throughout the period.

Wednesday was the second Open House. More than 450 people arrived at the site to inspect the projects. Tours of the nuclear and solar facilities on the Hanford Reservation were available Wednesday morning and afternoon for teams. Enthusiasm and anticipation was high at the Awards Banquet held on Wednesday evening. All the teams, liaison engineers, homestays and people who helped with the competition attended a salmon dinner at the Hanford House Hotel sponsored by the Tri-City Nuclear Industrial Council. Donald E. Anderson, Atlantic Richfield, talked on "The Energy Crisis: A Problem in Communications?"

Following keynote address, the Coordinating Committee presented the awards to the winning teams. Thursday, June 16, 1977, the teams disassembled their projects and packed up their gear for the return trip home.

CHAPTER 6

Scores and Awards

The awards for the competition were based on two scores: (1) the project's total score, and (2) the project's individual innovation score.

The project's total score was the algebraic sum of the four individual scores for each project: (1) Innovation, (2) Marketability, (3) Performance, and (4) Economics.

The Grand Awards were given to the three projects with the largest total score. The receipt of a Grand Award excluded that team from winning other awards to avoid repetition.

For the divisional awards, the projects were divided into categories according to their alternate energy source: solar, wind, organic, and combination. The Combination category contained projects which had multiple energy inputs (i.e., solar and wind, etc.) Within each category, the projects were ranked by total score to determine placement.

The innovation awards were determined by a special judging panel. The First Solar Innovation Award was not given since the Grand Innovation Award went to a solar team.

OVERALL PROJECT SCORES

SCHOOL	TEAM NUMBER	TOTAL SCORE
Kansas State University	106	82.40
University of Oklahoma	124	68.70
West Virginia University	34	68.00
Georgia Institute of Technology	84	63.90
Washington State University	19	59.70
Georgia Institute of Technology	90	58.20
University of Wisconsin at Madison	112	58.10
University of Florida at Gainesville	157	57.90
Midwestern State University	97	56.80
Southern Methodist University	43	55.40
Washington State University	70	54.00
Oregon State University	151	54.00
University of Wisconsin at Stout	136	54.00
University of Oklahoma	127	53.10
University of California at Berkeley	100	53.00
University of Houston	10	51.80
Amarillo College	25	50.50
West Seneca High School and Buffalo State University	76	50.10
Georgia Institute of Technology	93	49.50
Oregon State University	142	49.30
University of Wisconsin at Green Bay	28	48.60
University of Wisconsin at Milwaukee	133	48.40
Rensselaer Polytechnic Institute	22	48.40
Rutgers University	31	42.90
University of Texas at Austin	64	39.50
Georgia Institute of Technology	81	39.30
Kansas State University	181	32.30
Massachusetts Institute of Technology	79	26.90

ENERGY RESOURCE ALTERNATIVES II
AWARDS

GRAND AWARD

Kansas State University, # 106	First Place
University of Oklahoma, # 124	Second Place
West Virginia University, # 34	Third Place

INNOVATION GRAND AWARD

University of Texas @ Austin, # 64	
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WIND DIVISION

University of Florida @ Gainesville, # 157	First Place
Southern Methodist University, # 43	Second Place
Washington State University, # 70	Third Place
University of Wisconsin @ Stout, # 136	Third Place

WIND INNOVATION

University of Oklahoma, # 124	First Place
University of Florida @ Gainesville, # 157	Second Place
Washington State University, # 70	Third Place

SOLAR DIVISION

Georgia Institute of Technology, # 90	First Place
Midwestern State University, # 97	Second Place
Oregon State University, # 151	Third Place

SOLAR INNOVATION

Georgia Institute of Technology, # 90	Second Place
Midwestern State University, # 97	Third Place

ORGANIC DIVISION

Georgia Institute of Technology, # 84	First Place
Washington State University, # 19	Second Place
University of Wisconsin @ Madison, # 112	Third Place

ORGANIC INNOVATION

University of Wisconsin @ Madison, # 112	First Place
Washington State University, # 19	Second Place
University of Wisconsin @ Green Bay, # 28	Third Place

COMBINATION SYSTEMS DIVISION

West Seneca High School & Buffalo State University, # 76	First Place
Oregon State University, # 142	Second Place
University of Wisconsin @ Milwaukee, # 133	Third Place

POWER PRODUCTION AND BUSBAR ELECTRICITY COSTS
OF SYSTEMS AT THE FINAL TEST EVENT

TEAM	ENERGY PRODUCED IN 24 HOURS (kWh)	BUSBAR COST OF ELECTRICITY (\$/kWh)
University of Houston, # 10	00.00	00.31
Washington State University, # 19	00.00	00.10
Rensselaer Polytechnic Institute, # 22	1.00	00.33
Amarillo College, # 25	00.60	00.16
University of Wisconsin @ Green Bay, # 28	00.00	22.67
Rutgers University, # 31	00.35	00.81
West Virginia University, # 34	00.00	00.09
Southern Methodist University, # 43	00.00	00.11
University of Texas @ Austin, # 64	00.00	5.70
Washington State University, # 70	00.00	00.05
West Seneca High School & Buffalo State University, # 76	1.60	2.70
Massachusetts Institute of Technology, # 79	00.00	00.39
Georgia Institute of Technology, # 81	00.00	292.00
Georgia Institute of Technology, # 84	10.00	00.12
Georgia Institute of Technology, # 90	00.00	00.12
Georgia Institute of Technology, # 93	00.00	00.09
Midwestern State University, # 97	00.00	00.15
University of California @ Berkeley, # 100	00.40	00.15
Kansas State University, # 106	20.00	00.19
University of Wisconsin @ Madison, # 112	00.00	00.31
University of Oklahoma, # 124	2.72	00.06
University of Oklahoma, # 127	00.32	00.04
University of Wisconsin @ Milwaukee, # 133	00.10	00.40
University of Wisconsin @ Stout, # 136	00.16	00.07
Oregon State University, # 142	00.00	00.17
Oregon State University, # 151	00.00	00.08
University of Florida @ Gainesville, # 157	00.20	00.16
University of Alabama @ Tuscaloosa, # 163	00.00	00.04
Kansas State University, # 181	00.00	00.32

NOTE: The cost of electricity was computed using the system's designed output. The design output was not necessarily achieved at the Final Test Event.

The amount of energy produced in the 24 hour period represents either the best performance of the system on the two test days, or verified test data taken at the system's homesite location.

SCHOOL	TEAM NUMBER	PERFORMANCE	MARKETABILITY	NET ENERGY ANALYSIS	EXOTIC MATERIALS	BUSBAR COST ELECTRICITY	INNOVATION	TOTAL
Kansas State Univ.	106	21.0	15.1	7.5	5.0	12.5	21.3	82.4
Univ. of Oklahoma	124	1.7	20.0	7.5	5.0	12.5	22.0	68.7
West Virginia Univ.	34	0.0	19.0	7.5	5.0	12.5	24.0	68.0
Georgia Institute of Tech.	84	8.9	15.6	7.5	5.0	12.5	14.4	63.9
Washington State Univ.	19	0.0	12.3	7.5	5.0	12.5	22.4	59.7
Georgia Institute of Tech.	90	0.0	11.9	7.5	5.0	12.5	21.3	58.2
U. of Wisconsin, Madison	112	0.0	14.1	7.5	0.0	12.5	24.0	58.1
U. of Florida, Gainesville	157	0.1	15.9	7.5	5.0	12.5	16.9	57.9
Midwestern State Univ.	97	0.0	13.0	7.5	5.0	12.5	18.8	56.8
Southern Methodist Univ.	43	0.0	17.3	7.5	5.0	12.5	13.1	55.4
Washington State Univ.	70	0.0	15.0	7.5	5.0	12.5	14.0	54.0
Oregon State Univ.	151	0.0	10.4	7.5	5.0	12.5	18.5	54.0
U. of Wisconsin, Stout	136	0.1	17.4	7.5	5.0	12.5	11.5	54.0
Univ. of Oklahoma	127	0.2	15.6	7.5	5.0	12.5	12.3	53.1
U. of California, Berkeley	100	0.3	17.0	7.5	5.0	12.5	10.7	53.0
University of Houston	10	0.0	14.4	7.5	5.0	12.5	12.4	51.8
Amarillo College	25	0.4	17.5	7.5	5.0	12.5	7.6	50.5
West Seneca High School & Buffalo State Univ.	76	3.0	20.9	7.5	5.0	0.0	13.7	50.1
Georgia Institute of Tech.	93	0.0	16.9	7.5	5.0	12.5	7.6	49.5
Oregon State University	142	0.0	10.2	7.5	5.0	12.5	14.1	49.3
U. of Wisconsin, Green Bay	28	0.0	16.8	5.0	5.0	0.0	21.8	48.6
U. of Wisconsin, Milwaukee	133	0.1	17.0	7.5	5.0	6.0	12.8	48.4
Rensselaer Polytechnic Inst.	22	0.7	13.3	5.6	5.0	6.0	17.8	48.4
Rutgers University	31	0.2	19.6	7.5	5.0	3.0	7.6	42.9
Univ. of Texas, Austin	64	0.0	11.5	0.0	5.0	0.0	23.0	39.5
Georgia Institute of Tech.	81	0.0	18.0	0.0	5.0	0.0	16.3	39.3
Kansas State University	181	0.0	0.0	7.5	5.0	6.0	13.8	32.3
Massachusetts Inst. of Tech.	79	0.0	7.6	0.0	5.0	6.0	8.3	26.9

CHAPTER 7

Symposia I & II

The ERA II competition sponsored two symposia. The first symposium served as an introduction to the ERA II competition. Lectures by energy experts introduced the teams to the definitions of alternate energy sources, alternate energy availability, conversion to electricity, and the storage of energy. A special presentation on creative engineering encouraged innovation in the student projects. Meetings were conducted to discuss the responsibilities of teams, the Coordinating Committee, competition finances and the importance of team fund-raising.

The second symposium centered around workshop sessions for the teams with experts from the industrial, governmental and academic fields. The teams discussed problems encountered in the design, construction and assembly of their projects. The logistics of the Final Test Event were presented and the details of project scoring and awards were explained.

Both symposia helped to generate the necessary cohesiveness and esprit de corps that improved team communication and mutual understanding.

A report was issued after the termination of each symposium. Both reports were approximately fifty pages and contained information presented in each lecture or workshop. Their primary use was in relaying information to teams and interested individuals who could not attend the symposiums.

SYMPOSIUM I

The entourage was welcomed to the University of Oklahoma by John Fagan, Professor of Electrical Engineering at the University. Mark Radtke, President of SCORE, gave an interesting review of the history of SCORE, beginning with the pre-SCORE (1970) Clean Air Car Race and concluding with the ERA I Final Test Event.

Joe Eschbach, Chairman of the Coordinating Committee, introduced the Energy Resource Alternatives II (ERA II) Competition. He spoke of the organizational structure of SCORE, the responsibilities of those involved and the objectives of the

competition. Further on in the Symposium, members of the Coordinating Committee gave presentations on the expectations in the project Design Proposals, which teams were to submit for grant consideration. Professor David Stock, Faculty Advisor to the Coordinating Committee, moderated a Faculty Advisor meeting which discussed the effective organization, motivation, and financing of SCORE student teams.

The Keynote Presentation was made by Dr. John Sununu, Chairman of the Board of Directors of SCORE. Dr. Sununu underlined the importance of hardware design and fabrication. He emphasized that the development of a project from an original idea to an operating system is the toughest part of engineering. He stressed that many alternative energy resources (wind, solar, and refuse, for instance) are best suited for use in small energy systems rather than large centralized power plants due to their nearly uniform distribution over the earth's surface. He urged teams to start working immediately in anticipation of the most often heard phrase at any SCORE final test event, "We could have finished if we'd had one more week."

Mr. F. Burton Sellers, Manager of the Patents Division of the Texaco Development Corporation discussed innovative idea generation and the techniques used to promote creative thinking. He examined methods such as brainstorming, which can overcome the roadblocks to new ideas and lead to innovative solutions.

An introductory talk on solar and wind energy was given by Dean Eckhoff, Director of the Center for Energy Study at Kansas State University. He covered the availability of these resources and the ways in which they are utilized. Gerald Parker of Oklahoma State University discussed the details of systems using solar energy and Herman Drees, of the Pinson Energy Corporation, spoke about systems which harness energy from the wind.

A review of organic fuels other than petroleum and natural gas was presented by James Green of the University of Pittsburgh. He compared the availability of the resources, processes which convert them to various useful forms (i.e., solvent refining, digestors, coal gasification, etc.), and systems using these varied forms.

Conversion to Electrical Power was discussed by Dr. William Eaton. Dr. Eaton commented on electrical generators, its advantages and disadvantages, methods of production, storage and conversion efficiencies. He was followed by Martin Smith, of United Engineers, who spoke about economics in Engineering. He used the economics of nuclear power plants as an example.

A presentation on systems integration (how to match system components to each other) was given by Professor Roy Kaplow of the Massachusetts Institute of Technology. He commented that, "what is often called 'common sense'...may not be altogether common." Some of the topics he touched on were unnecessary precision, controls, economics, and problem solving.

A discussion on heat engines was presented by William Martini of the Joint Center for Graduate Study in Richland, Washington. Heat engines of all types were covered with particular attention given to the selection of the proper engine for ERA II projects.

The final presentation of the first symposium was given by Philip O. Jarvinen from the Lincoln Laboratory at the Massachusetts Institute of Technology. The topic was storage techniques for use with electric power. Mechanical, thermal, chemical and electrical storage were reviewed. The potential storage capacity of each type was noted and methods were discussed for conversion of stored energy to electrical power.

SYMPOSIUM II

Symposium II was hosted by the University of Houston at its Center for Continuing Education on February 4 and 5, 1977.

The second symposium opened with a Welcoming Address by the Associate Dean of the Cullen College of Engineering and by Dr. Wallace Honeywell who is on the Board of Directors of SCORE. Richard Aseltine, the new President of SCORE, followed with his thoughts on the competition.

Delbert M. Fowler, Regional Administrator of Region VI for the Federal Energy Administration delivered the Keynote Address. He presented data concerning energy consumption in the U.S. Dave Stock, Professor at Washington State University and advisor to the ERA II Coordinating Committee, succeeded the Keynote Address. He directed himself towards the personal objectives involved with each project, the objectives of Symposium II, and the overall objectives of SCORE.

Innovation was discussed by Hank Wales of the Space Division of the General Electric Company. He looked at innovation as a vehicle of change in order to improve value. Mr. Wales proceeded to identify the common obstacles to creativity and the methods through which innovation is brought forth.

Robert P. Beals, Professor of Industrial Engineering at Texas A & M University, gave a useful talk on project management. Participants were shown how to use the Critical Path Method (CPM) for project planning, the Gantt Chart, and the Program Evaluation and Review Technique (PERT).

Generators were discussed by R. D. Chenoweth, Professor of Electrical Engineering at Texas A & M University. Dr. Chenoweth mentioned the characteristics of various types of generators, particularly those which might be useful for ERA II projects.

Symposium II focused more heavily on Workshop sessions than Symposium I. The intent of the Workshops was to examine the design details of systems using alternative energy resources and to solve design and construction problems that teams might encounter with their projects.

The solar workshop was conducted by James Colthart of the Shell Development Corporation. Dr. Colthart began the session with a discussion on the economics of solar energy and its future potential, followed by an extensive question and answer session.

Running concurrently with the solar workshop was a workshop concerned with the use of coal for energy. The session was led by Paul Scott of the U.S. Energy Research and Development Administration (ERDA)

Fossil Energy Division. After a brief discussion on coal and the steps ERDA is taking in the development of coal as a viable energy source, Dr. Scott fielded a variety of questions.

The wind workshop was conducted by Robert Dodge of Automatic Power Incorporated, a veteran in the field of wind energy. He recounted the history of wind turbines and described the Aerowatt turbine which he had brought with him. He answered a variety of questions pertaining to vibration, controls, and the various types of energy output.

Jack Matson, Professor of Civil Engineering at the University of Houston, gave participants some insight on methane producers. He revealed the potential of methane production by stating that in the U.S. alone, there are covered landfills producing 10,000,000 cubic feet of gas per day. He then turned to such topics as methane storage, limiting nutrients, and the corrosion hazards associated with methane production.

The concluding workshop was directed by Bill Smith, Manager of Battery Product Planning for ESB Batteries. Since most teams intended to store energy in batteries, this workshop concentrated on batteries as a storage system. Through the use of graphs, the characteristics of storage batteries were discussed with particular attention paid to charging. This was followed by a question and answer period.

Bill Cawley, of the U.S. ERDA Richland Operation Office, described the facilities that would be available for use at the ERA II Final Test Event, scheduled for June 9-16, 1977 in Richland, Washington. The Final Test Event was sponsored by the ERDA-Richland Operations Office and supported by numerous local industries. Jon Anson, of the ERA II Coordinating Committee, listed the schedule of events for the week of the Final Test Event, and answered several questions about the event.

Joe Eschbach, Chairman of the ERA II Coordinating Committee, gave details on the scoring of projects. The major categories in the scoring were innovation, performance, economics and marketability. In conjunction

with those topics, the oral presentations required for each team at the Final Test Event were discussed.

CHAPTER 8

The Educational Impact

The primary purpose of the competitions sponsored by SCORE has been to promote, stimulate, and support university engineering curricula. Student designed and built projects offer a hands-on approach to engineering education. It is through this project-oriented approach that students are able to tackle problems which require a systems solution.

Project competitions enable the student engineer to test the application of his or her technical education. Hardware design and construction challenge the students to analyze a complex problem, to determine the various disciplines needed to solve the problem, and to bring people in these disciplines together. Ultimately, teamwork is the key element in providing solutions to the various problems which face the student engineer. SCORE's competitions generally prove to be an interdisciplinary effort with students from both engineering and non-engineering backgrounds. The teams often include mechanical engineers, electrical engineers, chemical engineers, industrial engineers, as well as students from the social sciences and management. The students learn the relationship of their specialty to the other fields represented on the team, and are made aware of the total systems ramification of each decision.

SCORE conducts a questionnaire survey for each competition to help assess the educational impact of each program. For the Energy Resource Alternatives II competition, questionnaires were completed by the team captains and the individual team members. Examples of the questionnaire can be found at the end of this chapter.

Approximately 63% of the team captains and 53% of the team members participating in ERA II returned the questionnaire. The results presented in the following categories are based on these returns and represent the aggregate results for a projected total of 250 students on 40 ERA II teams from 32 universities across the country.

STUDENT INVOLVEMENT

SCORE competitions attract the participation of both undergraduate and graduate engineering students. Since graduate engineering students are usually provided with opportunities

for research while undergraduates are not, SCORE tries to deliberately gear its programs toward the undergraduate. On the undergraduate level, engineering curricula allow for the greatest flexibility in the final year. The largest percentage of ERA II participants was seniors, as shown in Figure 1.

Figure 8.1- Year in School

Because SCORE competitions are strongly hardware oriented, the area that has traditionally provided the largest number of participants is mechanical engineering. However, the interdisciplinary nature of the projects often means the SCORE teams are composed of a variety of technical and non-technical students. Figure 2 shows the distribution of disciplines represented on the ERA II teams. The "other" category includes students majoring in computer science, chem tech, physics, education, and vocational rehabilitation.

Figure 8.2- College Major

Since participation on a SCORE team is voluntary, students decide on the amount of time they spend working on their projects. When asked what percentage of their total academic time was devoted to ERA II, 20% said they were spending most of their time, while 30% indicated they were spending less than 20% of their time on the project. The average ERA II student's time commitment to the competition was between 30-50%.

The majority of the ERA II students had grade point averages between A and C+ as shown in Figure 4. The majority of students felt that ERA II had no real effect on their grade point average. (See Figure 3)

Figure 8.3-
"How has ERAII affected your GPA?"

Figure 8.4- Grade Point Average

Student response to the question "What is the main reason for your participation in the ERA II competition?" is given in Figure 5. Approximately 45% of the students took part in the com-

petition because of a desire for experience in "hands-on" engineering. Thirty-nine percent expressed an interest in developing alternative energy sources.

Figure 8.5-
Reason for Participating in ERA II

FACULTY INVOLVEMENT

SCORE competitions are dependent on a high level of faculty involvement for their successfulness. ERA II was again fortunate to have strong support from its faculty participants. The faculty advisors worked closely with their teams, with over 82% meeting with their ERA II students on an informal basis. The advisors were of varied academic rank and came from several different departments, as shown by Figure 6.

Figure 8.6- Faculty Advisor's Department

SCHOOL SUPPORT

ERA II's competition had the strong support of the universities involved. The value that the schools placed on the program is reflected in Figure 7. Over 70% of the students involved were able to receive academic credit for the work on their projects.

Figure 8.7- Academic Credit Received

THE ERA II TEAMS

The average ERA II team consisted of 5 students, 2 of whom were "hard core" members, devoting an average of 20 hours per week to their project. Team size was extremely variable for ERA II. The smallest team had one member, the largest had 12 members. The average team spent a total of 1,100 hours on their project; 70% of this time was on construction, 23% on design, 27% on publicity. Over 50% of the teams held regularly scheduled meetings at least once per month.

CONCLUSIONS

The educational importance of a SCORE program is measured in its long term effect on the student team members and on the engineering curricula of the participating colleges and universities. SCORE competitions, based on the results of the ERA II survey, do give some indication of the advantages of sponsoring such a program.

Over 85% of the students said that their personal motives for entering were satisfied. This is another indication of ERA II's success. Approximately 59% of the students felt they were making a significant contribution toward the solution of the nation's energy problems.

A current issue in engineering education is the representation of women and minority students in the field. In 1974, the Engineering Manpower Commission revealed that the total U.S. Engineering enrollments of women and minorities were 4.9% and 5.9% respectively of all undergraduate and graduate engineering students. The statistics for ERA II teams show women minorities to be represented at 8% and 11% respectively.

The impact of ERA II on engineering curricula is more difficult to assess in the short period since the end of the program. However, it is apparent that previous SCORE programs have been instrumental in the introduction of project-oriented design and construction courses prior to ERA. Of the team captains who answered a subsequent question as to why these courses were offered, 26% said they were started in response to previous SCORE competitions, i.e., the Clean Air Car Race, Urban Vehicle Design Competition, and Students Against Fires.

In conclusion, the ERA II competition again appears to have fulfilled the educational goals established for it as a SCORE program. Having been evaluated by statistics and the subjective analysis of its participants, ERA II did have a significant impact on the participating universities and their students.

STUDENT PROFILE QUESTIONNAIRE

Please complete this questionnaire and return it to your team captain.

The data from this survey will be used in the composition of the aggregate profile of ERA II team members and the results will be published in the ERA II Final Report.

* Note: Team captains are asked to fill out this questionnaire as well as the EDUCATIONAL IMPACT QUESTIONNAIRE

Major _____₁ Age _____₂ Sex _____₃

4 Classification as of January 1, 1977 (circle) F S J S 5 G

5 Do you consider yourself

- ☐ Afro-american
- ☐ American Indian
- ☐ Caucasian
- ☐ Oriental
- ☐ Spanish surname
- ☐ Other

6 Have you received academic credit for your work on ERA II?

☐ Yes ☐ No

7 Have you received wages for your work?

☐ Yes ☐ No

8 What are the main reasons for your participation in ERA II?

(rank the three most important: circle 1, 2 & 3)

1	2	3	"hands-on" experience
1	2	3	academic credit
1	2	3	interest in the field
1	2	3	need for a job
1	2	3	other

9 Do you feel the motivation you ranked #1 was satisfied through your experience?

☐ Yes ☐ No

If No, why? _____

10 Have you participated in a previous SCORE program?

(if yes, circle the appropriate program)

ERA SAF UVDC

11 If the answer to # 10 was no, how did you become aware of ERA II?

- 12 If you assume time spent on normal schoolwork plus time spent on ERA to be 100%, what percent of your time over the past term was spent on ERA II? Approximately (circle)
- 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
- 13 During the school term, how many hours per week (averaged over the duration of the ERA II program) did you spend on your project?
- _____ average hours. How many man-hours is this? _____ total hours
- 14 Has your ERA II experience caused any change in your career goals?
- ___ Yes ___ No If yes, what? _____
- 15 Do you feel you made a significant contribution to energy research through your work on ERA II?
- ___ Yes ___ No
- 16 If you were to be in school for the duration of another SCORE competition, would you enter?
- ___ Yes ___ No ___ Depends on the topic
- 17 What effect has working on your ERA II project had on your GPA?
- ___ Helped ___ Hurt ___ No effect
- 18 What is your composite GPA? (circle)
- A A- B+ B B- C+ C C- D+ D D- P/F System: P F

Please feel free to make any other comments or constructive criticism of SCORE or ERA II below:

THANK YOU FOR YOUR ASSISTANCE IN COMPLETING THIS QUESTIONNAIRE.
I SINCERELY HOPE THAT YOUR INVOLVEMENT WITH THE PROGRAM HAS BEEN
A MEANINGFUL EXPERIENCE.

RICHARD ASELTINE

EDUCATIONAL IMPACT QUESTIONNAIRE

This questionnaire is to be filled out by the team captain and submitted with the ERA II Student Profile Questionnaires.

**** Note:** ALL QUESTIONNAIRES ARE TO BE POSTMARKED NO LATER THAN **MAY** 31, 1977.

Sponsored University's name _____ Team # _____

Team Captain's name: _____ Year (circle): F S J 4 5 G

Have you been the team captain since the beginning?
(circle) Yes No

For the duration of	
the past term	the ERA II program

- How many team members did you/do you have that you consider:
 - hardcore _____
 - active _____
 - occasional _____
 - total of above _____
- How many hours did these respective groups average working?
 - hardcore _____
 - active _____
 - occasional _____
- In your estimation, how many total hours were spent by the team on:
 - design _____
 - fundraising _____
 - construction _____
 - publicity _____
 - overall total _____
- How many times per month were regularly scheduled meetings held? _____
- Did you actively solicit funds from sources other than your university and SCORE? (circle) Y N Y N
- Did you conduct an organized publicity campaign? Y N Y N
- How many team members attended the symposium held in
 - Norman, Oklahoma _____
 - Houston, Texas _____

8. In what department was your ERA II project based?
 mechanical engineering _____
 electrical engineering _____
 civil engineering _____
 chemical engineering _____
 industrial engineering _____
 other - please specify _____
9. In what department was your faculty advisor?
 mechanical engineering _____
 electrical engineering _____
 civil engineering _____
 chemical engineering _____
 industrial engineering _____
 other - please specify _____
10. What is your faculty advisor's status?
 full professor _____
 associate professor _____
 assistant professor _____
 other - please specify _____
11. How many times per month did your faculty advisor meet with
 your team on a: regularly scheduled basis _____
 informal basis _____
12. How many times per month did your faculty advisor visit your
 lab/test site _____
13. How many of your team members received academic credit for
 their work from a: standard classroom course _____
 a lab course _____
 a seminar _____
 an independent study course _____
 a specially created course _____
 other - please specify _____
14. Please list the monetary value of materials, supplies and
 services or cash donations your team received from
 SCORE \$ _____
 companies/corporations \$ _____
 foundations \$ _____
 private individuals \$ _____
 government agencies \$ _____
 other - please specify \$ _____
 _____ \$ _____
 total \$ _____
15. Please indicate the form of support you received from your
 department/college and your estimate of the dollar value:
 office space \$ _____
 lab space \$ _____
 equipment \$ _____
 materials \$ _____
 funds \$ _____
 wages \$ _____
 computer time \$ _____
 secretarial support \$ _____
 other - please specify \$ _____

CHAPTER 9

Media Coverage

SCORE's media effort had two goals: first, to obtain national recognition for the efforts of the ERA II students; and second, to increase public awareness of the potential role of alternative energy sources in the solution of the nation's energy problem. It was emphasized that the ERA II teams were developing small-scale alternative energy systems to supply household electrical needs and that the technology for such systems had already been shown to be feasible. It was explained that ERA II was concentrating on innovative ways to make such systems lower in cost and more practical for the homeowner or small businessman to install and use.

The media effort was based on press releases and personal contacts with reporters from the national media. During the course of the competition, seven national releases were distributed to the country's major newspapers, magazines, technical journals, television, and radio networks, as well as foreign news services. A press release was also prepared for each of the forty-three ERA II teams and sent to their school's news office, local and state media, and the hometown newspaper of the team members.

Press representatives from SCORE visited national media reporters in New York City to generate interest in the competition and encourage the media to cover the Final Test Event in Richland, Washington. It soon became apparent that convincing reporters to make the trip to Richland was not going to be a trivial undertaking. Nevertheless, the resulting media coverage of the ERA II Final Test Event was excellent.

The rest of this chapter contains a representative selection of the national, regional, and local articles written on the competition.

In addition to this print coverage, the television networks were well represented at the ERA II final testing held at the Energy Research Development Administration regional operations office in Richland. NBC filmed a special report which was distributed nationally through its News Program Service to its 140 affiliate stations. Regional coverage in the northwest was provided by the local television stations.

Oklahoma's vertical axis wind turbine.

Georgia's concentrating solar collector.

Tomorrow's Engineers Tackle Today's Energy Problems

Besides pursuing regular studies, scores of engineering students have spent two years trying to extract electrical power from wind, sunshine, and biological material. The teams of future engineers converged on Richland, Wash., at mid-year to test their prototype designs under the scrutiny of researchers and practicing engineers from industry, government, and academia.

Winning designs in the week-long competition have added numerous wrinkles to the alternative-energy field. For example, grain sorghum is the primary fuel of the grand-prize-winning design, and variable-pitch blades are featured in a modified Darrieus wind turbine, the first runner-up design. A biogas generator using waste material received the third-place overall award.

Grand awards were won by student teams from Kansas State University, University of Oklahoma, and West Virginia University, respectively. The top overall award for innovation went to the Univer-

sity of Texas-Austin for a collector system in which 18 trough-like parabolic mirrors focus solar radiation on water-filled tubes to produce steam.

Oklahoma's vertical-axis wind turbine, mounted atop a four-story tower, won overall and innovation prizes in the wind category by surviving an afternoon of strong gusts amidst a week of calm weather.

Teams from Georgia Tech won first-place overall prizes in both

solar and organic fuels divisions. The solar team used a minicomputer to focus a 15-panel collector in a system that included a single-piston, double-acting steam engine. The biogas team used a microprocessor to control the anaerobic decay of organic waste within a digester. Gas production is enhanced by recycling heat from the system's methane-burning engine.

The energy hardware was developed under ERA II, a 1976-77 program sponsored by Student Competitions for Relevant Engineering (SCORE), which is headquartered at M.I.T., Cambridge, Mass.

MD

Kansas' engine-generator set fueled by sorghum-derived ethanol.

Courtesy of SHELL NEWS, Shell Oil Company.

As contests go, it was no breeze

For the second year, Energy Resource Alternatives was the theme of the annual SCORE competition for student engineers, but how do you show what your windmill can do in a dead calm?

Story and photography by JAY STULLER

It was the kind of day that Don Quixote de la Mancha, the literary tilter at Renaissance windmills, would have appreciated. The sun was hot enough to keep his aging muscles supple, but hardly a whisper of a breeze stirred the collection of wind machines gathered on a plain in Richland, Washington, at the confluence of the Yakima and Columbia Rivers. And as everyone knows, it may be unsportsmanlike to tilt at motionless windmills, but it's certainly easier to score a hit.

The pun is unintentional, but as long as it's there let it serve to explain the facts: SCORE, an acronym for Student Competitions on Relevant Engineering, is a non-profit organization established in 1971 "to give students an opportunity to design and build equipment to address real-world engineering problems." Under the sponsorship of Washington State University and on the grounds of Richland's Joint Center for Graduate Studies, teams from 28 colleges and one high school were hoping their engineering creations

would score with the judges in a competition called Energy Resources Alternatives II.

The object of this year's contest, once again supported financially by Shell, was to produce electricity from any energy source, other than oil or natural gas, to meet the needs of the home, farm or light industry — "juice to keep the cows away from the fence," is the way one observer put it. This was a follow-up to last year's ERA I, and once more the entries featured wind-, solar- and combustion-powered contraptions that would warm the cockles of a hardware salesman's heart. Or a junkman's: There was even a special prize called the "grand innovation award."

But don't scoff, even though the wind machines drooped in the doldrums and other devices looked as if somebody had wiped out the local supply of aluminum foil wrap. "What we've got here," said John Sununu, a Tufts University professor and chairman of SCORE's board of directors, "are laboratory prototypes which generate engineering data. In fact, what these kids are coming up with is about as good as you'd see in an industry- or government-sponsored project. And they do it cheaper and quicker, with a success rate about equal. That says a lot about how good these kids really are."

"It's really too bad the wind isn't blowing," said Bob Coit of Shell's Environmental Affairs Department, who was serving on the advisory board for ERA II, "especially after the problems some of the teams had getting their entries out here and set up." The experience of the team from West Seneca High School in upstate New York provided a

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Left, top: Eight-foot parabolic trough mirrors from the University of Texas. Bob Coit of Shell in helmet views Oklahoma wind turbine. Right: Grounds at Richland looked like a carnival.

good example of what Coit was talking about. The trailer carrying the group's windmill and parabolic dish solar collector, an extremely fragile device, flipped on the cross-country trip, almost wrecking its cargo. It took a hard-sell pitch for funds by a New York radio station to get the team back on the trail.

Sitting in the shade of a U-Haul trailer to escape the punishing sun, Coit continued: "But the point to remember is that this affair isn't meant to be a big competition. Winning isn't — or shouldn't be — the main consideration. It's more a part of the educational process. Even the teams that don't win an award don't really lose, because they learn of the problems that exist in the gap between an idea on paper and applied engineering, which is the ultimate aim of SCORE. One of the problems the students have to handle, for example, is getting things done in time. They don't always complete everything at home to see if it works, so they have to bring it here untested and try to get it operating. That's why you see so many of the devices broken."

It did indeed seem as if the gremlins that attack so many scientific projects were having a field day. One group, for example, was using glue to attach solar reflectors to stands, and the glue ruined the mirrors. Elsewhere, rotor blades were falling like autumn leaves — and with nary a Don Quixote in sight.

The team from the University of Texas, Austin, had its share of attention from the little trouble-makers. "What happened?" repeated grease-smeared senior Clay Fulcher. "Simple — our pump broke." The Longhorn's solar collection system consisted of 18 eight-foot parabolic trough mirrors which focused the sun's rays on water-filled tubes to produce steam, which in turn drove a turbine-generator to produce electricity. "If this pump had only worked," Fulcher said sadly, "this whole place would have been filled with steam."

"We spent 18 months in the design phase and only two months building it," added Ahmad Sharif-Homayoun, team captain. "It's really not a commercially feasible device, since we lose about 96 percent of our energy through the steam engines, which are only four percent efficient. But it would work — if it wasn't for that pump."

If you know how gremlins usually carry on, you've probably guessed that the Texans finally got the pump to working — at sunset. Still, the contraption with its homemade pipes wrapped in reams of aluminum foil was considered ingenious enough by the judges to win the grand innovation award.

One solar collector that did produce electricity was entered by Rensselaer Polytechnic Institute of Troy, New York. The blue-and-white collector, which looked something like a Viking ship with an oddly fanned tail, tracked the sun across the sky as it produced 1.2 kilowatts of electricity photovoltaically. Its major weakness seemed to be its need for constant attention — broiling in the sun, an underclassman (naturally) wielded a mop to dust the plates.

"The energy shortage was the obvious catalyst for projects such as this," said Jeff Hersh, a senior physics major. "Even though there may be a lot going on in the area of alternative energy research, basic ideas such as this can lead to twists which might result in unforeseen benefits. We don't know what they will be, but you can be sure we'll come up with something!"

Another entry that worked the way it was supposed to, Kansas State University's electricity-generating internal combustion engine, won the grand award. The innovative engine used as its only fuel ethanol produced by distillation of juices extracted from the stalks of sorghum, an abundant crop in Kansas.

By far the largest delegation of young Wrights and Edisons was sent by the Georgia Institute of Technology — four teams, consisting of 28 students, in two trucks and five cars. Proving that you can ramble unwrecked across country with most of the comforts of home, the Tech engineers brought with them their own

swimming pool, volleyball equipment, and a large tent, dubbed Club West, which for a week was the liveliest night spot in Richland. Georgia Tech clearly had arrived in town to win big in this Rose Bowl of collegiate engineering.

"We came 2,900 miles," said outspoken George Jones, senior and coordinator of Tech's four projects, "and frankly, I'm disappointed. We came for the competition, and we expected more schools to be represented here. I also think we put a lot more effort into our work than some other teams."

More money, too. Handing over a frosty Olympia beer, Jones pointed out that the Georgia group had raised \$22,000 to spend on its projects, and was using donated equipment worth \$25,000 besides. Enthusiasm was high on the 9,000-student campus, he added, and a weekly newsletter outlining the progress of the GITSET (Georgia Institute of Technology Student Energy Team) was devoured by 150 subscribers.

Jones was happy with the showing of his four teams — which included first place finishes in the solar energy and organic fuels divisions and a second in the solar innovation competition, not to mention an unofficial standing-by-itself first in fund-raising, even though he felt that some of the objectives of the program were difficult to meet in the time allotted. "We're taking on projects that engineers in the United States have been working on for 50 years," he said. "But I guess a lot of learning did go into all this," he added, gesturing at the surrounding array of machinery. "After all, the people here are what you'd have to call the All-Americans of the student engineering world."

Taking first place in the wind innovation category and second overall was the University of Oklahoma's wind-powered turbine, one of the most sophisticated pieces of hardware at the event. Mounted on a four-story-tall tower, the vertical axis articulated blade wind turbine (in its short form, VAABWT, pronounced sort of the way Elmer Fudd says rabbit) uses a unique control system which constantly monitors the angle of the vertical blades and holds them in

Left: Rensselaer's solar collector. Right: Top, Berkeley student monitors electricity produced by a windmill. Middle: Aluminum foil manufacturers loved the competition. Bottom: Georgia Tech students frolic in their swimming pool.

their optimum performance position. It didn't do well in the calm that hovered over Richland, because it was designed for the Great Plains or coastal areas, where the wind blows most of the time.

"A steady 12-mph breeze would keep it going," said Mike Bergey, one of the three-man team that traveled to the contest with his father, a professor at Oklahoma and faculty advisor. "At that rate, the system would last for about 35 years. But it can operate in winds up to 80 mph, and survive a 150-mph storm if it's shut down quick enough. The system will provide only supplemental power, but it can be hooked directly into any existing set-up and feed juice into it as long as the wind keeps on blowing. Right now it could be profitably installed in East Coast areas where power rates are high. We figure this unit will produce energy for about six and a half cents per kilowatt hour, with an initial cost, including installation, of about \$6,000."

Relaxing in the air-conditioned cool of his team's camper, Bergey described himself as more entrepreneur than scientist. "I want to make money from my ideas," he said, "and I don't see anything wrong with that. Of course I'm interested in helping people, but there's room for both that and making a buck, too. That's why using economics and marketability as part of the criteria is the best way to run a competition like this. If you set it up too loosely, you'd get mostly far-out things that would never work. Economics runs the world, and economics is spurring the alternative energy field. New devices and systems have to prove their worth — but it has to be worthwhile to build them, too."

On second thought, the Man from la Mancha would not have fit in at all in this eastern Washington scene, no matter how hot and windless the day. The only interest the young people gathered here would have in tilting a windmill would be to see if it worked better that way. □

Ethanol Made From Sorghum

RICHLAND, Wash. (UPI) — Kansas State University has won the nationwide Energy Resource Alternatives II competition with its power producing turbine fueled by extracts of sorghum, the state's abundant cereal crop.

The Kansas State Engineering students, led by team captain Reginald Moore, produced ethanol from sorghum stalk

strainings and then used the fuel to drive an internal combustion engine which in turn drives an electrical generator.

While it may not become the economical fuel of the future for all mankind, Kansans now have a new use for their sorghum crop and can save energy and money in the process.

The Kansas State entry outscored 28 others in the

week long competition at the 100 square mile Hanford Atomic Works near this central Washington community.

The windmills and various energy producing contraptions brought here from throughout the nation by tomorrow's scientists contrasted sharply with the sleek, multibillion dollar nuclear powered plants operating or under con-

struction at this massive government energy compound.

The Energy Research and Development Administration, which used to be known as the Atomic Energy Commission, manages Hanford, where a portion of the Manhattan plan that ultimately created the atomic bomb, was created not many decades ago.

Student engineers were

tested on their ability to use any energy other than oil or natural gas to produce power.

The testing came in four phases: innovation, performance, the economics of each idea and its marketability.

Entries included solar ponds, solar cells, horizontal axis windmills and a vertical axis darrius.

Buffalo, New York, *COURIER EXPRESS*, May 23, 1977

Solar-Power Scholars Competing in Big League

By PATRICK J. RYAN

Courier-Express Staff Reporter

A high-powered group from West Seneca East Senior High School is preparing for a trip to the State of Washington.

The group, a team that has been working on wind and solar power projects for the last year, is the only high school group invited to a Student Competition on Relevant Engineering (SCORE) being held in Richland, Wash., in mid-June.

And, as if that were not enough, they were ranked fifth in a field of 80, besting all but four of the 79 engineering college competitors on the basis of their written briefs.

Built Solar Collector

Under the tutelage of teacher David Girke and several assistants, the eight students have built an eight-foot diameter solar collector that runs a steam engine, and a wind turbine which they hope will generate 2,000 watts in a 20 mile per hour wind.

"We've had the equipment set up here for tests," Dave Orzel, one of the students said. "There were a couple of bugs in the wind turbine, and we had some calm days, but everything seems to be working just as we expected now."

The group began dismantling the equipment Saturday to pack it for the truck

trip west. Ronald DesRoche, a graduate student from Buffalo State College, and James Twist, an industrial arts student teacher interested in wind power, who have been working with the high school students, will drive the tank to the coast in a donated rental truck.

The eight students and Girke plan to leave on June 8 and return on June 17. They hope to raise the \$1,000 they need for traveling expenses before then.

Financing Problem Occurs

The group has raised \$7,000 to date and believed that they had reached their goal of \$8,000. But one pledge of \$1,000 from a local oil refinery "fell through" and the group is looking for funds to replace that amount.

"But we're still going to go even if we all have to come up with \$50 of our own money," Orzel said.

The competition may involve a cash prize for the winners, but the West Seneca group doesn't know. They are happy enough to be the only high school in the country to be invited to the affair.

Students involved in the team besides Orzell are Russell Fulle, team captain, Steven Fachko, Ronald Fisher, John Hornbuckle, Paul Barone, Lloyd Jones and Mark Taylor.

Richland, Washington, *TRI-CITIES HERALD*, June 9, 1977

Reflections

Paul Barone, left, and John Hornbuckle, students from West Seneca East Senior High School in Buffalo, N.Y., cleaned the surface of their parabolic solar collector. The two are part of the only high school team in the final competition test event in the S.C.O.R.E. (Student Competitions on Relevant Engineering, Inc.) competitions to be held this weekend through Wednesday at the north parking lot of Hanford School in Richland. (Herald photo by Lon Martin)

Four-Story 'Egg-Beater' Windmill To Be Shown Monday At University

NORMAN, Okla. (AP) — A four-story windmill which could produce energy for homes and industry will be unveiled Monday at the University of Oklahoma.

The vertical axis windmill, which bears no resemblance to the type which still appears in rural areas, was designed and built by OU engineering students.

The result of more than a year of analysis and 4,000 manhours of labor, the windmill is being installed for initial testing at OU's Aerospace, Mechanical and Nuclear Engineering lab.

School officials say its most stringent test will come next month in a national contest in Richland, Wash., called Student Competitions on Relevant Engineering (SCORE), June 9-16.

"This windmill certainly has potential for both homes and industry," said Karl Bergey. The professor is project coordinator and instructor in the special projects course that has been building the windmill.

Mike Bergey, OU senior from Norman, led a group of 12 undergraduate students in the college of engineering which constructed the windmill.

Bergey also promoted the project, found the money and convinced other students to enrol in the course.

The structure was built with funds

provided by the Kerr Foundation of Oklahoma City, SCORE and the OU college of engineering.

"Numerous studies have estimated that by the year 2000, as much as 15 per cent of our total energy requirements could be supplied by wind energy conversion systems," Bergey said.

Energy researchers have been testing both horizontal-axis, propeller-type windmills and the vertical-axis type to see which is most efficient.

Bergey watched construction of a vertical-axis windmill, with blades which resembled a huge egg-beater, called the Darreius.

"It was not a success, so I started looking into the design," he said. "In the beginning, it seemed there were some inherent problems. The curved blades led to inefficiencies."

After more than eight months analyzing the design, he adapted it to feature three

straight blades.

"It will be a very efficient windmill because we've optimized its performance to increase the energy conversion performance," Bergey said. "It is more sophisticated than the Darreius and it is up to par with the state of the technology displayed in the horizontal axis."

The OU windmill will be dedicated and demonstrated in public ceremonies at 2 p.m. Monday at the engineering lab on OU's north campus.

Orange, Texas, *LEADER*, June 17, 1977

Sorghum Power Wins Contest

RICHLAND, Wash. (AP) — Neither wind nor sun nor earthheated water propels the grand award-winning design for an alternative energy source in a recent national contest.

The winning electricity generator runs on sorghum.

Twenty-eight college teams and one from a Buffalo, N.Y., high school participated in the Student Competitions for Relevant Engineering (SCORE) Inc., which ended Thursday after a one-week run. The top design came from engineering students at Kansas State University who produced a combustion turbine fueled by sorghum, a cereal grass.

Lee McQueen, team leader of the Kansas State contingent, said the device uses ethanol from fermented sorghum as fuel for an internal-combustion engine to drive an electric generator.

He said it was designed for use in the Great Plains where irrigators use center-pivot irrigation.

He said he envisioned a farmer planting sorghum in the far reaches of an irrigation circle and using it to drive a generator for power.

A wind turbine from the University of Oklahoma team won second place overall and first place in wind innovation.

Judging was done on power output, innovation and economic practicality of the designs. Most were built from the ground up by finalists.

An eight-member delegation from West Seneca East Senior High School of Buffalo claimed first place in the combined systems division.

The prep team, which pooled the power output of a solar reflector and a wind turbine, nearly didn't make the SCORE meet.

It took a whirlwind fundraising drive in Buffalo to raise \$1,500 for a second turbine after the first was wrecked in a freeway collision at Cleveland, Ohio.

University of Texas claimed the overall innovation award, with University of Wisconsin getting the nod for innovation in organic power applications.

Georgia Tech swept solar and organic division titles and also was first in solar innovation.

The University of Florida was first in the wind division.

Wichita Falls, Texas, *RECORD NEWS*, July 1, 1977

Reception Honors MSU Solar Energy Team

By TOM OVERTON
Staff Writer

A reception Thursday honored the Student Competitions on Relevant Engineering (SCORE) team of Midwestern State University in Clark Student Center.

The team entered a Minto wheel, an energy-producing device that uses solar power, in a national contest in Richland, Wash. The entry won second place in over-all solar competition and third place in solar innovation, competing against some of the best-known engineering departments in the United States. Midwestern State University does not have an engineering department.

Helen Burt, a team member from Holliday, Tex., said some schools spent as much as \$20,000

for their projects and did research more than four years. The six MSU students and their faculty adviser, Dr. Ed Holverson of the physics department, spent about \$3,200.

Ex-Students Association, Regent Sherrill Burba of Olney, Tex., Russell Altmiller of Olney and Hal Yeager of Wichita Falls made donations to the team.

Other persons and companies that contributed include Syd Gaines of United Electric Co., Kaiser Aluminum, Jack Hammond of Lone Star Tool, Bailey Meissner and Ciba-Geigy.

Other contributors include Walker-Neer Manufacturing Co., Fresnel Optics of Rochester, N.Y., MSU maintenance department and Jeter Magneto and Electric Co.

Texas Electric Service Co.

also contributed to the team's effort. Dr. Bob Harmel, dean of the School of Business Administration and Accounting, and Dr. Robert Clark of the sociology department assisted in the project.

Team members include the captain, Jeff Johnston of Wichita Falls, Ellen Janzen of Isabella, Okla., Chris Malone of Wichita Falls, Morgan Moore of Burkburnett and David Parker of Seymour, Tex.

Lee McQueen's Kansas State University team won first place in the energy alternatives com-

petitions with a sorghum-fueled electric turbine.

At Energy Alternative contest

Sorghum power tops windmills

By TODD CROWELL
Herald Staff Writer

Wind power has been praised as the wave of the future, but it took a backseat to sorghum at the fourth annual national energy alternatives contest in Richland this past week.

Many of the college students who had dragged their elaborate prototype wind turbines across the country for the competition sat in frustration as nearly calm winds hardly budged a blade.

And the brief gusts that did appear Saturday apparently did little except knock down a Darrius wind turbine brought here by the University of Alabama.

Whether or not the lack of wind had anything to do with it, the grand award went not to one of the eye-catching wind turbines or elaborate solar engines but to a combustion turbine fueled by Sorghum.

The relatively simple device created by engineering students at Kansas State University converts fermented sorghum into ethanol, which in turn is burned in an internal combustion engine to drive an

electric generator.

According to team leader Lee McQueen, the device was designed for use in the plains of Kansas which, like the Mid-Columbia region, make extensive use of center-pivot irrigation.

McQueen said he envisioned a farmer planting sorghum in the far reaches of an irrigation circle, which don't get much water, and using it to fuel his electric power generator.

These arguments apparently impressed the judges, who made their decisions on the basis of power output, innovation and economic practicality.

Other top awards went to the University of Oklahoma's wind turbine, which won second place in the overall grand award, and the University of Texas, which won first place in innovation with its parabolic solar collectors.

Washington State University picked up two second place awards in the organic and organic innovation categories, third places in wind and wind innovation divisions. Oregon State University picked up a

second place in the combined systems division.

West Seneca High School, Buffalo, N.Y., the only secondary school in the competition, won the first place award in the combined systems division.

Can you expect to see some of these alternative energy devices in your backyard soon? Not likely, said several of the contestants.

Turning solar or wind energy into heat and then into electrical current — especially the alternating current used in most households — is too complex, said Bob Niemer of Oregon State University.

"Your average person doesn't want to have to go out

and clean the solar mirrors every day," he added.

Still Niemer is enthusiastic about his idea to recycle used helicopter blades for large wind turbines, which he said might be practical in the Boardman area.

Unfortunately, he didn't get a chance to try them out. The judges refused to let him install them for safety reasons.

One of the judges, John Fox of Battelle Northwest, said most of the students came to realize from their "hands-on" experience, that adopting wind or solar energy to produce electricity is still pretty remote.

"But they had fun trying," he said.

Energy contest winners

Grand Award: Kansas State University (1), University of Oklahoma (2).
Innovation: University of Texas.
Wind Division: University of Florida (1), Southern Methodist University (2), Washington State University (3).
Solar Division (Georgia Institute of Technology (1), Midwestern University (2), University of Wisconsin (3).
Organic Division: Georgia Institute of Technology (1), Washington State University (2), University of Wisconsin (3).

Combined Systems Division: West Seneca High School (1), Oregon State University (2), University of Wisconsin (3).
Storage Innovation: No award.
Wind Innovation: University of Oklahoma (1), University of Florida (2), Washington State University (3).
Solar Innovation: No first place, Georgia Institute of Technology (2), Midwestern University (3).
Organic Innovation: University of Wisconsin (1), Washington State University (2), University of Wisconsin at Green Bay (3).

4-story windmill at Norman; test as generator

NORMAN, Okla. (AP) — A four-story windmill which could produce energy for homes and industry will be unveiled Monday at the University of Oklahoma.

The vertical axis windmill, which bears no resemblance to the type which still appears in rural areas, was designed and built by OU engineering students.

The result of more than a year of analysis and 4,000 man-hours of labor, the windmill is being installed for initial testing at OU's Aerospace, Mechanical and Nuclear Engineering lab.

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The structure was built with

funds provided by the Kerr Foundation of Oklahoma City, SCORE and the OU college of engineering.

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"It will be a very efficient windmill because we've optimized its performance to increase the energy conversion performance," Bergey said. "It is more sophisticated than the Darreius and it is up to par with the state of the technology displayed in the horizontal axis."

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KSU team's sorghum turbine is top winner

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Richland, Washington, TRI-CITIES HERALD, June 9, 1977

Wind-turbine crash fails to halt Buffalo energy team

By JINI DALEN

Herald Staff Writer

A not-very-funny thing happened to the kids from Buffalo, N.Y., on their way to the national energy alternatives contest in Richland.

Their trailer overturned outside Cleveland, Ohio, demolishing the wind turbine that was an integral part of their solar-wind contest entry.

They were out of money. In addition, the company that manufactured the wind turbine had gone out of business.

But a year of hard work by the eight students from West Seneca East Senior High School — the only non-collegiate group accepted for the final tests — won't be in vain.

They went on tv in Buffalo a week ago, recited their plight and within a day raised the needed \$1,500.

Then the defunct turbine manufacturer agreed to locate a duplicate turbine. "If we don't have one, we'll build one," he promised.

It's expected to arrive by air freight today, in time for project set-up in the north parking lot at Hanford School on Thursday.

"It was a godsend," said Ron Des Roches, University

National energy alternatives contest in Richland is open to the public. Page 17.

of Buffalo graduate student and advisor to the group. "The whole community banded together to help."

His team is one of 29 accepted for the final test event of the Energy Resource Alternatives II competition sponsored by S.C.O.R.E. (Student Competitions on Relevant Engineering, Inc.).

When there were still 87 proposals in the running, the high school project ranked fifth, said Des Roches, despite competition from such engineering powerhouses as M.I.T., Georgia Tech and other universities.

"That ranking says something for the thought put into this project," said Des Roches. "We ran full performance tests on it and the results were excellent."

It will take a lot of hard work, he said, to assemble the new turbine from a kit, "but Dave Gierke, the team's industrial arts teacher, and I still feel we'll be right up there in the competition."

Des Roches drove the elec-

tricity-producing device here in a 24-foot U-Haul truck with a trailer behind. "It rode well. We changed drivers every hour and a half and checked the apparatus each time."

They were told after the accident that a number of tractor-trailers also had overturned at the same curve in the road outside Cleveland.

Looking on the bright side, Des Roches said it was fortunate it wasn't the eight-foot parabolic solar collector that broke. "We'd have been done. The students built that from scratch. It's not something you can buy in a store."

All the teams will begin setting up their projects Thursday, with performance testing Sunday, judging Monday and Tuesday and awards presented next Wednesday.

There will be public openhouses Sunday and Wednesday.

Examiner Photo by Bob Palmer

A windmill designed to provide sufficient energy for the average U.S. household

San Francisco, California, *SAN FRANCISCO EXAMINER*, June 8, 1977

Group of UC students believes in giving power to the people

By Walter Barney
Science Writer

With scrap steel from a junkyard, leftover pipe, plate from the side of a ship and other scrounged materials, a few engineering students at UC-Berkeley have built a novel windmill that generates enough electricity to satisfy the average household.

Their creation is an entry in the SCORE (Student Competition on Relevant Energy) exhibition supported by the Energy Research and Development Administration June 9-16 at Richland, Wash.

Thirty-five college teams have shipped hardware to Richland, where it will be judged for originality, performance, cost and marketability. The SCORE meetings have been a yearly fixture since the clean-air car competition of five years ago. This year's theme is small scale production of electricity.

The Cal windmill is controlled by a space-age microcomputer, but its basic operation is simple.

The wind is caught by two dozen twisted aluminum vanes of what looks like a huge bicycle wheel, 20 feet in diameter. As the wheel revolves, its rim turns an ordinary four-ply nylon tire.

The wheel is mounted on the same axle as an old five kilowatt generator. The wind blows, the wheels turn and the electrons flow.

Because the wind is variable, so is the output of the generator. To obtain a regular power supply, output is stored in a flywheel, or

a chain of batteries, or both. (The flywheel can charge up to 5 kw in half an hour. The batteries might take 12 hours, but hold the charge longer.)

The tire coupling with the windmill (technically, a "wind turbine") runs efficiently, and replaces more complicated systems of belts, pulleys or gears.

Prof. Otto Smith, adviser to the student group, calls the windmill "the best in the world," because it's cheap, efficient and sturdy.

The Cal team, under student leader Rick Gavazza, spent sev-

Propeller windmills have inherent stability problems because the blades are mounted on a tall pole, with a heavy generator also, necessarily, at the top of the pole. The Cal windmill sits on the ground, and the generator is mounted at the bottom.

The windmill is designed to operate in the relatively light winds — 10 to 15 m.p.h. — that prevail in the Bay Area. A tail vane that stabilizes the wheel at these velocities unhooks at higher speeds, so that the big wheel gradually turns edge-on to the wind.

The wheel itself could withstand 100 m.p.h. winds, Smith says, but at these speeds it would spin so fast that the generator would burn out.

Within the accepted range of wind velocities, the computer controls the speed at which the turbine is allowed to spin.

At Richland, the Cal windmill will compete with solar generators, windmills of several designs and "garbage digesters" — devices for producing electricity by decomposing organic material.

The idea is to design a power source for homes or farms. "ERDA won't fund this kind of work," Smith says, "so they ask the students to do it."

ERDA provides logistic support for the competition. The winners' rewards are prestige and satisfaction, rather than cash. Successful designs, however, may be picked up by private companies, which are providing some judges for the event.

Their baby entered in nationwide competition

eral thousand hours of work and about \$2,200 for materials.

A commercial 10-kw version might cost \$5,000, Smith estimates, plus another \$5,000 to install. In contrast, ERDA spent nearly a million dollars on a three-bladed high-speed generator that self-destructed due to vibration in high winds last February in Colorado.

The Rutgers University entry in the S.C.O.R.E. competition loomed high on its 30-foot pole, left. Members of the West Seneca High School team from Buffalo, N.Y., placed a 12-foot diameter spoked wind turbine wheel on temporary stands prior to installation, above.

Richland, Washington, *TRI-CITIES HERALD*, June 12, 1977

Students vie for energy alternatives

By JINI DALEN
Herald Staff Writer

The scene at Energy Resource Alternatives II in Richland bears a close resemblance to the hydroplane pits just before the Water Follies race:

- Intense, dirty-fingernailed mechanics whanging on cranky equipment and muttering oaths to the hot sun when it refuses to start.

- Lampson cranes hovering huge apparatuses overhead and gently setting them in place.

- Frantic scroungers

trying to beg or borrow a vital part that just broke apart.

The fourth annual S.C.O.R.E. (Student Competitions on Relevant Engineering) is a carnival of windmills, solar collectors, towers, mirrors and all sorts of mechanical contraptions to create electrical power in unusual ways.

Each project is accompanied by a team of hard-hatted young engineering students, eager to explain why what they're doing is superior to everyone else's.

The public can visit Rube

Goldberg World in the North parking lot of Hanford School from noon until 5 p.m. today and from 9 a.m. to 4 p.m. on Wednesday.

To get there, turn off George Washington Way at Sprout Road, heading toward the Joint Center for Graduate Study. (You'd need an all-terrain vehicle to wind your way along the route around the school.)

Goal of the contest is to give engineering students "hands-on" experience in developing innovative small-scale electricity-producers,

practical enough for the homeowner or small businessman to install and use.

Most contestants have been working on their projects for more than a year.

"It's a fantastic way of seeing what everybody else is doing," said Craig McGahey, member of one of four teams here from Georgia Tech in Atlanta.

They traveled the 3,000 miles in a convoy of five cars and two 20-foot trucks.

In McGahey's project, solar energy is used to create

steam to drive an 1880s steam engine.

Why such an antique?

"It was given to us," explained teammate Bob Gaar. "The most difficult part was finding what pieces we could scrounge — then design the project around them."

The crew from the University of Texas at Austin was a bit more fortunate. "The steam engine that spins our generator and turns it into direct current electricity is an 1890 model," reported Jim Lappresti on this team's solar project.

Jim Frazier of the Univer-

sity of Oklahoma at Norman believes the selling point of this team's wind machine is its efficiency.

A modified vertical-axis Darrius wind turbine is set on a 24-foot tower. "It turns like crazy," said Frazier.

The windmill blades have flaps which raise and lower as they rotate — similar to those on airplane wings — giving optimum performance.

But today will be the big test. All the devices will be judged on their electricity-producing performance over a 24-hour period. Winners will be announced Wednesday.

This 20-foot diameter spoked wind-wheel is the University of California's entry, with a power output of 1.5 kilowatts in a 15 mile-an-hour

wind. The six-man team from Berkeley has to true the wheel much like you would a bicycle wheel in order to keep it from warping.

Wiley Holcombe, left and John Durbetaki worked on their 1880 steam engine which is powered by steam generated from two solar

collectors. Both are with the Georgia Institute of Technology team.

Windmill? MSU couldn't get it up

(Editor's note: While intercollegiate competition at MSU usually refers to athletic events, the term has taken on a wider meaning for all other colleges which took part in the SCORE competition described below. MSU was not represented in last year's Energy Resource Alternatives competition or any of the previous competitions.)

Events of the last two years have demonstrated that continued dependence on petroleum and natural gas as the world's principal energy resource is a luxury we can no longer afford. Production

sponsor intercollegiate design-hardware fabrication competitions. The SCORE concept grew from the success of the 1970 Clean Air Car Race and the need for a project-oriented approach to engineering education. During its first three years, over 3,200 student engineers from 80 different colleges and universities participated in two national SCORE competitions. The first was in the

destructing in high winds. A built-in featuring device renders the blades inoperative at critical wind velocities and an automatic sensor uncouples the electrical system from the rotor to guard against the generator being burned out.

The windmill is attached to a D.C. generator whose power is stored in batteries. Through an inverter, the stored energy is converted to

NO. 22 CLEMSON UNIVERSITY

MODIFIED SEPTIC TANK TO PRODUCE ELECTRICITY

Clemson students are taking a farm's most plentiful resource, cow manure, and converting the waste into a valuable fuel.

In a large anaerobic digester (a modified septic tank), a bacterial process will change the waste into methane gas. The gas is piped into an intermediate expanding tank and then burned in a small internal combustion engine. The engine will turn a D.C. generator, which will produce electricity to be stored in 12 volt car batteries.

The stored energy is then converted to 110 volt alternating current and transmitted to the house through cables.

The digester's optimum temperature of 95 degrees Fahrenheit is maintained with the aid of two solar collector panels that heat the tank.

A bi-product of the waste conversion process is a diluted organic material called slurry. This excellent fertilizer is removed from the tank periodically and used to nurture crops. Since this fertilizer is higher in nitrogen content than untreated waste, it can replenish the nutrients in worn out soil much quicker than plain manure.

The potential dangers of the methane gas, explosions caused by exposure to air and careless sparks, are avoided by keeping the gas in an airtight enclosure. Because it remains contained, the methane gas is as safe as the gasoline in an automobile tank.

Clemson students have built their project as a full-

sized system designed for rural areas and small farms.

(Students: Bert Cornelius, Mike McHahan and Doug Seiler Advisor: Dr. Parviz R. Rad)

NO. 33 RENSSELAER POLYTECHNIC INSTITUTE

SOLAR POWERED STEAM ENGINE TO PROVIDE HOME NEEDS

The Rensselaer team has built a system designed to vaporize water via a flash boiler situated at the focus point of a concentrating solar collector.

The steam is used to drive a Rankine cycle turbine that powers an A.C. generator to provide electricity for both the household and the system. After the steam leaves the turbine, it condenses and is passed through heat exchangers for hot water and space heating. When sufficient heat has been supplied to the household, the excess heat is rejected into the atmosphere.

During hot months, a compressor attached to the steam turbine changes water to ice. Air, circulated around the ice, produces cool air that is blown through air ducts in the house for central air conditioning.

The project is also equipped with a back-up system to provide steam to the turbine when minimal solar energy is available. An insulated salt storage chamber, surrounding the flash boiler, absorbs any excess heat from the water vaporization cycle. Eventually the salt absorbs enough heat to liquefy. Because of the insulation, it remains in this liquefied state and can be

(Continued to Page 7)

SOLAR FOCUSING COLLECTOR—The student team from the University of Alabama in Huntsville placed first in the focussing collector division of the alternative energy competition sponsored by SCORE last August. [See story for team 36]

limitations and political interaction combined to severely limit the availability of petroleum products. Long lines at gasoline stations, the spectre of cold homes, and significantly higher fuel prices brought the message home to the public: the earth's petroleum reserves are being quickly depleted and a concerted effort must now be made to develop the technology for the utilization of alternative energy resources.

Student Competitions on Relevant Engineering (SCORE) announced on May 4, 1974 that its next program would deal with the energy problem. The Energy Resource Alternatives (ERA) competition was organized by SCORE to challenge the nation's top engineering college students to develop innovative energy conversion and power generating systems for homes and light industry using solar, synthetic gas, wind, and other non-conventional energy sources. Teams of undergraduate and graduate engineering students entering the competition had a year to design and build their projects in time for the Final Test Event held in August, 1975.

SCORE was established in 1971 by the academic engineering community to

1971-1972 Urban Vehicle Design Competition (UVDC) and the second was the 1973-74 Students Against Fires (SAF) competition.

Last summer ERA challenged its participants to develop the hardware which can help supply our energy requirements from non-petroleum sources.

The following are some examples of the projects developed by the 68 teams which entered the competition:

NO. 20; UNIVERSITY OF OAKLAND

"THE FLAPPER" IS A SELF-STARTING WINDMILL

Oakland students have built a three-bladed windmill, nicknamed "The Flapper". The sail-like blades rotate on a vertical axis and can operate under winds coming from any direction without changing orientation.

Since only three blades are used, the power output of the system is increased because resistance is minimized. (Also, three blades are the minimum number necessary to still make the windmill self-starting.)

The team project includes several safety controls to prevent the system from self-

alternating current for household use. By storing the energy in batteries, the A.C. output remains constant, despite erratic wind velocities powering the D.C. generator. (Group leaders: Stephen Rumancik, Mel Buss and Robert McFarland Advisor: Professor R. H. Edgerton)

SELF STARTING WIND MILL—Oakland University students used a computer to efficiently allocate output from solar and wind energy sources. [See story for team 20.]

Elsewhere students develop alternative energy

(Continued from Page 6)

used to vaporize the water when the flash boiler possesses insufficient heat. Photo-electric sensors

coal into the furnace as the oil supply shuts off. When the thermostat indicates sufficient heat has been supplied, the coal feed shuts off

back and enjoys the heat in comfort.

(Team captain: Ken Kriesel
Advisor: Professor A. Seireg)

AUTOMATIC COAL BURNING HOME FURNACE WITH EMISSION CONTROLS--University of Wisconsin students placed first in the coal utilization category. [See story for team 34]

perpetually signal an electric motor to angle the mirrors or the roof of the house to focus properly on the collectors, which maximizes solar absorption.

(Team captain: William Rogers
Advisor: Professor F. J. Bordt)

NO. 34 UNIVERSITY OF WISCONSIN AT MADISON MODIFIED OIL FURNACE TO BURN POWDERED COAL CONVENIENTLY

Madison students are converting a residential oil furnace to burn pulverized coal conveniently and automatically.

The problems with today's coal furnaces are that they are dirty, have to be manually stoked and leave an ash residue that must be collected and disposed of.

This team has built a coal burning unit with scrubbers to clean the exhaust and automatic feeding controls that dispense with these difficulties.

The unit supplements the oil furnace, being easily retrofitted into the heating unit. A special container, which the team has designed, can be delivered by the fuel supplier in the same manner as oil is delivered. Another specially designed container holds all the residue from the furnace and can be removed by the supplier upon each delivery of more coal.

When the thermostat sends a signal to the furnace that heat is needed, the oil burner and scrubbers begin to operate simultaneously. After about 40 seconds, the furnace is hot enough to support coal combustion. At this time an auger automatically feeds

and the oil burner turns on again for about 20 seconds. This prevents the formation of soot, caused by the incomplete combustion of coal remaining after the shut off signal. After the oil burner shuts off, the scrubbers also cease working.

The individual is not plagued by dirt, ash residue or the need to manually stoke the furnace. He merely sits

NO. 35 MICHIGAN STATE UNIVERSITY

COMPUTER ALLOCATES ENERGY REQUIREMENTS FOR THE HOME

When there are several solar panels and a windmill all producing energy at once, you need a computer to figure out how to allocate all the output efficiently.

So Michigan State students

have programmed a central computer to collect data on each component, compare the energy status of the storage system against the home needs and then allocate energy as required. The computer is programmed with certain priorities: space heating holds precedent over all other home needs.

Six different solar panels are monitored by the computer that controls the flow of water to and from the collectors. The water heated by collectors is routed a few ways: The hot water can be channelled to hot water storage where it is used for domestic hot water or hot water heating. Or the hot water can be piped through an insulated stearic acid chamber, where stearic acid crystals absorb heat from the water through heat exchangers and liquefy. In this liquefied state, the stearic acid can transfer heat back to the water when there is not enough energy in the solar panels.

The windmill can be attached to a generator whose energy is stored in batteries. Or the windmill can be attached to resistor heating coils to heat the water in the storage tank. The computer monitors the windmill to decide which output would best serve the needs of the home at that time.

Also under the computer's control is a hydrogen storage unit where hydrogen is used in cooking instead

of natural gas. Or it is burned under water for hot water heating.

(Team captain: Ben Foster
Advisor: Dr. H. R. Zapp)

NO. 36 UNIVERSITY OF ALABAMA AT HUNTSVILLE SOLAR ENERGY TO PRODUCE ELECTRICITY

Using parabolic solar collectors that track the sun, Alabama students have built a system that generates electricity for home use.

Water, piped through the collectors, absorbs heat and returns to a large thermal storage tank. Liquid freon is piped through a heat exchanger in the hot water tank where heat from the water is transferred to the freon until it vaporizes.

The vaporized freon drives a steam engine which runs an A.C. generator. The electricity generated is cabled into the home for domestic use. The vaporized freon condenses after passing through the turbine and is pumped back through the hot water tank to be re-vaporized.

In order to conserve the stored energy in the hot water tank, the pumps circulate freon only when there is a call for electricity.

On days with little solar energy available, the insulated hot water tank contains enough energy to operate the system efficiently.

(Team captain: John Fulda
Advisor: Professor Wallace)

DARRIUS ROTOR - Michigan State University students used a computer to efficiently allocate output from solar and wind energy sources. [See story for team 35].

Back to energy basics—scientifically

By Marcia Terry

The phrase, "Gentlemen, start your engines," could take on an entirely new meaning following the 1977 SCORE final test event held June 9-15 in Richland, Washington. SCORE, or Student Competitions on Relevant Engineering, is sponsoring ERA II, the second Energy Resource Alternative competition.

The object of the nationwide contest is to develop an engine that does not depend on fossil fuel and that can be used as a source of electricity for homes, farms, and light industry.

A group of UW engineering undergraduates had hoped to see their modified Rankine engine compete in the final testing, but the group's prototype still has not been built.

Mechanical engineering seniors Eric Stacy, Marc Schlosser, and Scott Dobrowolski were working at a disadvantage in the ERA II competition, as they only learned about the two year program a year after it had started. As of now, only a few parts of their machine have actually been manufactured.

Oddly, the group is undaunted by the fact that it might not win. SCORE has already accomplished what it set out to do—it has stimulated the interest of these engineering students into thinking about the engines that will have to be designed for the future.

Mechanical Engineering Professor John Bodoia, the group's faculty advisor, insists that the engine will be finished and built, whether it can be entered in the contest or not, simply because the project has proved so valuable a learning experience for the people involved.

The engine that the team has developed will look like an old radial airplane engine laid on its back, except that the internal combustion pistons will be replaced by piston-cylinder units containing freon gas. Freon, the coolant used in ordinary refrigerators, was chosen because it is inexpensive, non toxic, and its vapor pressure at low temperatures is sufficient to allow for efficiency loss due to friction.

The engine, which will measure five feet across and weigh between 300 and 500 pounds, might be described thermodynamically as a closed-system Rankine cycle. It will consist of four heat-exchanger-cylinder sets connected to a fixed pin that is situated off-center to provide displacement for the pistons.

It operates by rotating each heat-exchanger unit containing freon first past a stream of heated air exiting from a high-temperature reservoir (solar-heated rocks at about 180°F). Then the units complete the cycle by rotating through a low-temperature reservoir (ordinary air at about 70°F). The freon is caused alternately to boil and condense inside the pistons. The machine takes advantage of the fact that the vapor pressure of freon at 160°F (130 psi) is greater than its vapor pressure at 100°F (80 psi) when it condenses. The work done during the expansion process exceeds the work required to recompress the gas, and results in a net work output.

The work output is low (less than one horsepower) and the efficiency is low (6%), but the fact that the engine makes use of otherwise wasted heat to generate electricity is important. The blow-by heated air can even be used for space-heating in homes.

In putting together their ideas for the machine, the students encountered some typical design problems. The biggest problem was that the seal for the heat-exchanger unit had to be absolutely leak-free to prevent pollution and efficiency loss. No seals were commercially available that would fit the design, so

Marc Schlosser set to work developing his own roll-sock seals to fit the device. The project was substantial enough that he submitted the design for credit in an undergraduate research course. The other team members also received course credit for their part in the project. Stacy and Dobrowolski earned their credit for working out the design computations.

Clearly, the emphasis of SCORE is on this kind of innovation, encouraging students to make use of any materials and ideas that might solve specific engineering objectives.

From mold to finished seal in several not-too-easy steps. If you can't buy the part you need, you make it.

CHAPTER 10

Finances

ERA II Coordinating Committee

Competition Budget

November 1975 to July 1977

I. Office Expenses

	Contributors:	Washington State University
	<u>SCORE, Inc.</u>	
Typing Services		\$11,450.00
Office Supplies	\$1,781.06	
Photocopying	610.87	
Printing and Mailing	4,908.02	
Coordinating Committee Salaries (8,000 man hours)	11,418.20	10,823.30
Telephone	<u>3,929.42</u>	
Subtotal:	21,475.38	\$22,273.30
Total:	\$32,298.68	

II. Coordinating Committee Travel

	Contributors: <u>SCORE, Inc.</u>
<u>February 1976:</u> Meeting at SCORE, Inc. Boston, MA and First Advisory Board Meeting, Washington, DC (5 people, travel, one week food and lodging)	\$3,046.44
<u>March 1976:</u> First Symposium at University of Oklahoma (6 people, travel, 3 days food and lodging)	1,892.52
<u>October 1976:</u> Second Advisory Board Meeting, Washington, DC (6 people, travel, 3 days food and lodging)	3,076.60
<u>January 1977:</u> Second Symposium at University of Houston (Houston, TX) (6 people, travel, 3 days food and lodging)	1,928.83
<u>Spring 1977:</u> Assorted travel to Final Test Event Site (Richland, WA)	<u>638.96</u>
Total:	\$10,583.35

III. Travel of Others

Contributors: SCORE, Inc.

Five Speakers at First Symposium	\$1,310.86
Seven Speakers at Second Symposium	<u>1,347.17</u>
Total:	\$2,658.03

IV. First Symposium University of Oklahoma, Norman, OK

Contributors: SCORE, Inc. University of Oklahoma

Food and Lodging (150 people, 3 days)	\$4,000.00	\$4,000.00
Subtotal:	4,000.00	\$4,000.00
Total:	\$8,000.00	

V. Second Symposium University of Houston, Houston, TX

Contributors: SCORE, Inc. University of Houston

Food and Lodging (150 people, 3 days)	\$5,000.00	\$2,000.00
Subtotal:	5,000.00	\$2,000.00
Total:	\$7,000.00	

VI. Final Test Event Expenses Richland, WA June 9-16, 1977

Contributors: SCORE, Inc. City of Richland Local Industry

Food	\$3,536.85		\$3,500.00
Judges' Travel	2,228.10		
Judges' Food and Lodging	1,016.21		
Telephone, Printing, Photocopying, etc.	1,000.00		
Awards	2,035.20		
Coordinating Committee Travel	443.88		
Coordinating Committee Food and Lodging	2,490.17		
Site Preparation		<u>\$3,000.00</u>	
Subtotal:	12,750.41	\$3,000.00	\$3,500.00
Total:	\$19,250.41		

VII. Team Support

Contributors: SCORE, Inc.

From three team grants	<u>\$83,000.00</u>
Total:	\$83,000.00

VIII. Summary Expenses

SCORE, Inc.:	\$150,290.00
Washington State University:	22,273.00
Others:	<u>19,000.00</u>

GRAND TOTAL: \$191,563.00

CHAPTER 11

Conclusions

The organic teams concentrated on improving the conversion process from chemical energy to electrical. One team did extensive development work on a turbocharged air-motor burning pulverized coal. Another team was working on a solvent refined coal furnace driving a stirling engine built from an old V-8 car motor.

Factors contributing to the poor performance of the ERA II projects were the complexity and immense size of the teams' systems. By requiring that ERA II projects produce a useful amount of electrical energy, the size of the systems and their sophistication were greater than ERA I projects. Many teams who had competed at ERA I returned with projects designed from the same basic ideas but usually more complex and much larger than their ERA I projects. Oftentimes, the immediate goal of getting the energy collection system designed, constructed, and operating unknowingly took precedent in time over fully completing system details.

EDUCATIONAL CONTRIBUTIONS

No matter what ERA II contributes technologically in the short run, the real value and success of the program lies in its long run beneficial impact upon the student participants. The competition gave the team members an opportunity to apply their book-learned engineering knowledge to a "knuckle-busting" design and construction problem. Such an experience is useful in that the participants experienced the problems of design, materials, organization, and communications early in their careers. The lack of severe consequences allowed them the luxury of introspective hindsight to improve methods for the future. In addition, the interdisciplinary nature of the projects necessitated the cooperative contribution of many disciplines: physical sciences, journalism, business, public relations, etc. Those teams who successfully bridged the "discipline's communications gap" not only contributed to their project's success, but also learned an important social skill beneficial to later professional work.

TECHNOLOGICAL CONTRIBUTIONS

Technologically, ERA II provided the participating students an opportunity to contribute to the abatement of the energy crisis by developing alternate energy hardware. In evaluating the teams' successes, one concludes that alternate energy sources of electricity still remain quite expensive, and unreliable. The average cost of power from all ERA II systems designed for the 20 kW hour load was 48¢/kW hour; while only two systems produced more than 10 kW hours in a 24 hour testing period. While the implementation of alternate energy sources on a widespread scale as a viable source of electrical energy remains unproven, many teams demonstrated innovative thinking in several key areas.

The solar teams experimented with cost reducing materials for their collectors using, among other materials, glass tubes, fiberglass molds, black plastic ponds, etc. Extensive progress was exhibited in solar tracking systems.

The windmill teams concentrated on improving blade performance, weight reduction, and cost effectiveness. Extensive use of aluminium, plastics, fibreglassed honeycomb paper, and modified bicycle wheels helped to reduce rotating weight and cost. Blade systems capable of changing aerodynamics with windspeed to maximize performance were designed with movable blade tips and rotating airfoil assemblies as the blades turned in the wind.

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APPENDIX A

I. SPONSORS

The following organizations made major contributions to SCORE, Inc. for support of the Energy Resource Alternatives II Competition:

Government

U.S. Energy Research & Development
Administration
National Science Foundation

Corporations and Foundations

Allied Chemical Foundation
Carborundum Company
Cleveland-Cliffs Foundation
Exxon U. S. A. Foundation
General Electric Foundation
General Motors Corporation
International Business Machines
Corporation
International Paper Company
Foundation
International Telephone and Telegraph
Corporation
John Deere Foundation
Long Island Lighting Company
Mobil Research and Development
Corporation
Republic Steel Corporation
Rockwell International Corporation
Scott Paper Company Foundation
Shelby Mutual Insurance Company
Shell Oil Company
Sperry Rand Corporation
Texaco, Inc.
TRW Foundation
The Upjohn Company
Western Gear Corporation
Westinghouse Educational Foundation

II. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION - RICHLAND

We would like to express our public thanks to the Energy Research and Development Administration - Richland, and its employees, for their outstanding support of the Energy Resource Alternatives II Final Test Event. The great success of the final testing was ensured by ERDA - Richland's total commitment to the program and by all the ERDA - Richland personnel who helped above and beyond the call of duty.

III. MANY OTHERS WHO CONTRIBUTED

There were many other organizations and individuals who contributed to the overall success of the Energy Resource Alternatives II program. This includes those who took part in the two symposia and final test event; those who contributed funds, equipment, and supplies directly to the ERA II teams; and those who gave their time and assistance to the teams and SCORE. Without such help, there would not have been an ERA II Competition.

IV. THE ACADEMIC COMMUNITY

Finally, SCORE would like to thank the faculty and administration at the participating schools for their generous support of the ERA II program. The Massachusetts Institute of Technology and Tufts University deserve special thanks for their support of SCORE and the ERA II Coordinating Committee. The University of Oklahoma-Norman also helped greatly in coordinating the ERA II Symposium I. And, certainly, without the support of twenty-eight universities, the forty-three ERA II teams would not have had the opportunity for a tremendous learning experience.

V. FINAL TEST EVENT CONTRIBUTORS

Tremendous support for the SCORE/ERA II Final Test Event came from private organizations in the Tri-Cities. The list includes:

Joint Center for Graduate Study
Tri-City Nuclear Industry Council
Tri-City Technical Council
Battelle Pacific Northwest
Laboratories
J. A. Jones Construction Co.
Washington Public Power Supply
System
American Association of Cost
Engineers
City of Richland
Richland School District #400
Washington State University
Westinghouse Hanford Co.
Neil Lampson, Inc.
Coca Cola Distributors of Pasco
Tri-Cities Water Follies

APPENDIX B

THE ERA II ADVISORY BOARD

R. A. Coit
Senior Staff Engineer
Environmental Affairs
Shell Oil Company

Dr. Edward Creutz
Assistant Director of Research
National Science Foundation

Edward Gray
Office of Technology Utilization
National Aeronautics and Space
Administration

Dr. Wassily Leontief
New York University

Congressman Mike McCormack
U. S. House of Representatives

John W. Mitchell
College of Engineering
University of Wisconsin-Madison

Dr. Jack Snell
Chief of Energy Conservation in the
Center for Building Technology
U. S. Department of Commerce
National Bureau of Standards

Alex Squire
President
Westinghouse Hanford Company

David E. Stock
Chairman, Advisory Board
Department of Mechanical Engineering
Washington State University

APPENDIX C

ENERGY RESOURCE ALTERNATIVES II COMPETITION

ERA II RULES and GUIDELINES

DECEMBER 1975

SCORE
STUDENT COMPETITIONS ON RELEVANT ENGINEERING INC

For further information on the ERA II competition,
please contact:

ERA II Coordinating Committee

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ABSTRACT

This document presents a general outline and the specific rules for the 1976-1977 SCORE national intercollegiate engineering competition. The year-and-a-half program is directed toward the design and construction of innovative alternative energy hardware able to produce electric power for homes, farms and light industry. The emphasis in the design of this prototype hardware will be on utilizing such nonconventional energy sources as solar energy, synthetic fuels and wind. SCORE will provide seed money to help cover the cost of construction of the more innovative projects. All undergraduate and graduate students are encouraged to develop, with faculty guidance, their hardware solutions to the national energy problem and submit the system in competition with the ideas of other students from the United States and Canada.

ERA II SCHEDULE

September 1975	March 1976	April 30, 1976	May 15, 1976	October 1, 1976	November 1, 1976	February 1977	May/June 1977
ERA II Announced	1st ERA II Symposium	Design Proposals Due For May Grant Awards	First Round of SCORE Grants Awarded	Deadline For Late Entries	Progress Report Due	2nd ERA II Symposium	Final Test Event Final Reports Due Two Weeks Before Final Testing

-2-

OBJECTIVES OF THE ENERGY RESOURCE
ALTERNATIVES II COMPETITION

- A. To supplement engineering education with hardware design/fabrication projects which give students real-world type experience.
- B. To contribute to the solution of the world energy problem through student innovation in the field of alternative energy sources.
- C. To increase public awareness of the nature of the energy problem and the innovative concepts the student teams develop to help solve it.

SCORE

ERA II is the fourth intercollegiate engineering competition sponsored by SCORE, Student Competitions on Relevant Engineering. SCORE is a student-run, non-profit corporation established in 1971 by the academic engineering community to promote student inter-university programs. During the past four years, more than 4,000 students from 97 U.S. and Canadian universities have participated in SCORE's 1971-72 Urban Vehicle Design Competition; 1973-74 Students Against Fires competition, and 1974-75 Energy Resources Alternatives I competition.

The SCORE organization consists of the national SCORE office located at the Massachusetts Institute of Technology and Tufts University, and the ERA II Coordinating Committee at Washington State University. SCORE competitions focus on areas where a technological solution to a significant contemporary problem is possible. The challenge of developing new energy sources is certainly worthy of such an international student effort.

For the past three decades, man has relied mainly on petroleum and natural gas to supply his major energy needs. It is now clearly evident that the world demand for these fossil fuels is approaching the upper limits of supply and that our natural petroleum reserves are being rapidly depleted. We must develop alternative energy sources for the future.

The Energy Resource Alternatives II (ERA II) competition focuses on previously underutilized and potentially significant energy resources. Solar energy, biological wastes, wind and coal are prime examples of such resources.

The ERA I competition was recently concluded at Sandia Laboratories in Albuquerque, New Mexico, with a final testing program of 40 student-built alternative energy projects from 33 U.S. and Canadian universities. ERA I allowed a variety of energy outputs that would be of value to a home, farm or small industrial operation. ERA II concentrates on electric output because we at SCORE feel that this is now the real challenge for the alternative energy field.

ENERGY SYSTEMS

The energy systems developed for ERA II must be able to collect energy from an alternative energy source and deliver it in the form of electric power. The collection, storage and delivery components must be designed and built using sound engineering principles. Innovation is

the essence of the competition. The systems will be tested for their ability to produce electricity by trying to match a load curve based on average household power consumption. The loads have been set at a level reasonable for all anticipated energy source inputs.

In selecting an alternative energy source for conversion to electrical power, consideration should be given to potential for innovation, its availability, efficiency of the conversion process (both current and potential), economic implications, marketability, environmental impact, and safety. All of these considerations will vary according to the application and will be discussed by the team in its written reports to the committee and oral reports to the judges. Scoring of the competition will be based on four unequally weighted areas: innovation, system performance, economics and marketability.

Details of the energy system specifications are contained in the accompanying Rules.

THE COMPETITION

Teams entering the competition may be composed of any undergraduate and graduate students and must have at least one faculty advisor.

Two symposia will be held during the competition to help inform student teams of the current state of alternative energy technology and to aid in solving design and construction problems. The first symposium, scheduled for March 1976, will feature presentations by experts from a variety of fields, discussing the present status of nonconventional energy system. This should help provide basic knowledge for teams to aid in choosing and developing a project. The second symposium, planned for February 1977, will help provide answers to technical questions by giving team members the opportunity to discuss problems in workshop sessions with alternative energy experts and professional engineers.

Both symposia will include business meetings to discuss the competition's rules, timetable and final testing procedures.

If any changes in the basic rules are made, teams will be notified through newsletters which will be mailed regularly to keep teams informed of all competition news.

Team members will be required to make a progress presentation to members of the Coordinating Committee at the second symposium. Telephone reports also will be required at regular intervals during the competition.

SCORE grants will be awarded based on an evaluation of a team's Design Proposal, progress reports and requests for financial support for the actual construction of the project. These grants are "seed money" grants and in most cases will not pay for the entire project cost. SCORE will endeavor to assist teams in raising donations of equipment, materials and supplemental funds locally. SCORE funds do not cover student and faculty salaries or permanent equipment, and are not subject to overhead charges. A "Memorandum of Agreement" detailing the exact usage of SCORE funds accompanies each grant.

The Design Proposal and project budget should be submitted as soon as possible after the first ERA II Symposium and before April 30, 1976 for consideration in the May round of SCORE grants. The information required in the Design Proposal is detailed in the accompanying Rules.

The deadline for late entries in the ERA II competition is October 1, 1976. No new entries will be allowed after this date without the special permission of the Coordinating Committee.

Each team must submit a written progress report by November 1, 1976. This report, along with the regular telephone reports, will keep the Committee informed of team progress and problems encountered, and will be used to make supplemental SCORE funding decisions.

The culmination of the competition will be the Final Testing Event in late May or early June, 1977. All teams, with their completed projects, will meet at a single test site for four days of testing and evaluation. The student-built energy systems will be tested under real-world conditions to measure their performance accurately and allow their comparison.

The competing team members also will give oral presentations to judges. These simulate a marketing presentation in which the students try to "sell" their hardware design to the judges. Innovation, cost-effectiveness, marketability and environmental impact will be among the design features emphasized. The judges will be research and practicing engineers, policy makers from government and industry, and professionals in the energy field.

Each team is required to write a final report on its project, which will be due two weeks before the Final Testing Event. Reports will be read by the judges and used as part of the scoring procedure.

The winners of the ERA II competition will be announced at the Awards Banquet at the conclusion of the Final Testing Event. Awards will be given for overall standing, specific categories and special recognition.

COMPETITION RULES

1. TEAMS

1.1 All team members must be registered full- or part-time students currently enrolled in a degree program at an accredited educational institution. Participants may include:

- a. Undergraduates and graduate students.
- b. Co-op students who study full time (or equivalent) for at least one year of the two years June 30, 1975 to June 30, 1977 and work the remainder of the year.
- c. Students who graduate in June 1976 and anytime thereafter.

1.2 All teams must submit the attached entry form indicating affiliation with an accredited institution and signed by the President, Dean of Engineering or a department head of that institution. An initial entry form should be submitted as soon as possible. A final participation form will be required a month prior to the final testing.

1.3 All teams must have one or more faculty advisors whose name(s), telephone number(s), and address(es) must appear on the entry form.

- 1.4 The team captain must be either an undergraduate or graduate student. The major responsibilities of the team captain are:
- a. To organize and coordinate team member efforts during the design and fabrication stage of the ERA II competition.
 - b. To insure that the team Design Proposal, Progress Report and Final Report are written and sent to the appropriate parties by the deadline dates as indicated under "Reports."

The team captain will be the Coordinating Committee's team contact. All business between the Coordinating Committee and a team will be directed to the team captain; i.e., telephone conversations, reports, newsletters, etc.

2. SPONSOR GUIDELINES

Entrant teams may solicit financial technical, or other assistance from corporations, consultants, universities, governments and their agencies, other organizations, or individuals (referred to as "sponsors"), according to the following guidelines.

- 2.1 A "sponsor" will be defined as all divisions and subsidiaries of one parent organization. No exception to this interpretation will be permitted unless expressly approved in writing by the Committee.
- 2.2 Teams may accept from sponsors any part, system, component, design or idea (hereafter called "elements") to be used with their entry, subject to the following constraints:
 - a. No sponsor-supplied, commercially available or nonstudent design element will be eligible for an award given for innovative student design.
 - b. No sponsor-supplied element of a proprietary nature will be permitted in the competition.
 - c. Innovative combinations or modifications of existing elements will be eligible for design awards.
- 2.3 In order to determine the role of the sponsor, all teams must submit an analysis of sponsor participation. A "Sponsor Participation Form" will be issued.
- 2.4 The Committee and its representatives reserve the right to inspect all components, technical drawings and design work of an entry to evaluate the amount of sponsor participation. The decision of the Committee on this matter is final.
- 2.5 Except for items specified in Section 2.2, sponsors may act only in an advisory capacity in the design of any component or system of an entry.

- 2.6 Advertising of industrial sponsorship or the use of supplied components via any media must be reviewed and approved by the ERA II Coordinating Committee in writing prior to distribution or presentation.
- 2.7 Commercial advertising affixed to the project in the form of decals or lettered phrases shall be limited to a total size of 0.116 m².
- 2.8 No exceptions to these guidelines will be permitted, and violation of them is sufficient ground for disqualification from the competition.

3. DEFINITIONS

To clarify terminology in the sections which follow, these definitions have been adopted.

- 3.1 A system contains an energy source and conversion components resulting in electrical output.
- 3.2 All products less complete than an energy source and conversion component resulting in electrical output will be referred to as components.

4. REPORTS

All teams will be contacted by telephone by the Coordinating Committee at least once a month for "informal" progress reports during the duration of the one-and-a-half-year competition.

Four formal reports are required. All formal reports must be of professional quality. All reports will use SI units. These reports are:

- 4.1 The Team Entry Form (attached), due as soon as possible. No new entries will be allowed after October 1, 1976 except by special permission of the Coordinating Committee.

4.2 DESIGN PROPOSAL

Design Proposals are due as soon as possible after the first ERA II Symposium, no later than April 30, 1976 to qualify for the May round of grants. Each team is required to submit two copies of a Design Proposal and budget to the Coordinating Committee. This report will be used by the Committee as the basis for selecting projects to receive "seed money" grants from SCORE. It should include the following items in the order below:

- a. One-page, double-spaced abstract labeled: PROJECT ABSTRACT. The project abstract is a summary describing in words the proposed project.

- b. One page labeled: SYSTEM DIAGRAM. The system diagram illustrates the energy flow of the entire proposed system, indicating in block notation the identification and function of key components.
- c. One page, double-spaced, labeled: INNOVATION. The innovation page should describe the current "State of the Art" of existing systems which are at least similar in operating principle to a team's proposed project. It also should identify the areas of the team's proposed system where the team will be devoting the majority of its time to improvement upon existing technology.
- d. One page, labeled: BUDGET. The budget should be an itemized accounting of all anticipated costs of the team's project (attachment).
- e. A section labeled: INPUT SPECIFICATIONS. This section should provide a description of the energy availability in the geographic area for which the project is designed to operate. Include appropriate graphs and documentation as described in Section 5, "Project Specification."
- f. ECONOMIC PROSPECTS AND MARKETABILITY

With projects only in the proposal stage, it cannot be expected that all facets of a project's economics can be assessed completely. However, since ERA II is stressing the economic viability of alternative energy systems, it is important for a team to have a grasp of the economics of its proposed systems. Note that the results of the Design Proposal economic calculations will not affect a team's score at the end of the competition. Sections required in the Design Proposal will be:

- (1) An approximate identification of the market for which the system is proposed.
 - (2) A rough estimate of the proposed system's full-scale cost as installed in a residence and/or small business.
 - (3) A rough estimate of the cost to generate electrical power in dollars/kWh, based upon a full-scale installation. These calculations should follow the format as presented in "Design Proposal Economic Costs" (attached).
- g. A section labeled: SYSTEM INTEGRATION. To insure that teams formulate their proposed systems to maximize performance through a well integrated network of components, this section should be described technically:

(1) System Output Design Goals

This sub-section should describe how much electrical power, and in what form a team anticipates to produce this power from the system. Reasons for particular choices of output goals should be stated.

(2) Component Matching Criteria

This sub-section should justify why a particular component of a particular size has been chosen for the system, and how the network of components contributes to achieving the team's output goals.

(3) Optional Storage Component Criteria

This sub-section should identify the parameters used to calculate the energy available for storage in a system, the maximum amount of energy storable in the storage system and the reasons why a particular size storage system was chosen.

- h. Assorted material not required in the above categories, but felt to be of value in the Committee's assessment of a team entry.
- i. A complete TEAM MEMBER PARTICIPATION LOG (See attached). List all members including the faculty advisor(s).
- j. One page, labeled: ADDRESS. This should indicate the team's mailing address, telephone, faculty advisor's address and telephone number.

4.3 PROGRESS REPORT

Each team must submit two copies of a progress report postmarked no later than (tentatively) November 1, 1976. The progress report will assist the Coordinating Committee in planning the workshop sessions for the second ERA II Symposium. This report should be modeled after the "Design Proposal," with sections concerning the following:

- a. A one-page summary of the work completed to date.
- b. All modifications to the original design proposal supplemented with photographs and revised drawings. (Note: modifications must be approved in advance by the Coordinating Committee if the team is to continue using SCORE grant funds).
- c. A revised budget and list of expenses incurred to date.

- d. An updated "Team Member Participation Log."
- e. An enumeration and discussion of the problems the team has encountered with respect to its project and with respect to the coordination of the competition.

4.4 Final Report

Two weeks prior to the final testing event, the ERA coordinating Committee must have received three copies of each team's final project report. Reports will be read by the judges and used as part of the scoring procedure. These reports must be as accurate, detailed and complete as possible since they will be a basis for all future references to the projects by the sponsor groups and the Coordinating Committee. Final reports must include:

- a. A description of the final design in the following areas:
 - (1) A section labeled: INPUT SPECIFICATIONS. This section must state the input design criteria. Include daily input graphs and documentation.
 - (2) A section labeled: SYSTEM DIAGRAM. This section must contain the final energy flow diagram and a prose description of each major block function.
 - (3) A section labeled: INTEGRAL SYSTEM DESIGN. This section must describe the final component matching criteria as described in Section 5d and justify any deviations from this in the actual hardware.
 - (4) A section labeled: HARDWARE. This section must contain complete specifications, drawings and photographs of the project as actually constructed.
- b. A page labeled: FINAL BUDGET RECONCILIATION. This must include an itemization of income sources and amounts, and an accounting of total expenses associated with project construction. List travel expenses in a separate category.
- c. Sections describing the following:
 - (1) INNOVATION: Description of student-designed, -modified and -built components. Emphasize the advantages these new or innovative features have over other research prototypes or current market products.
 - (2) ECONOMICS: Future newsletters will indicate the exact format for reporting the calculations.
 - (a) Estimated mass production cost of project.

- (b) Exotic material requirements. An estimate of the effect upon the price elasticity of the materials based upon potential reserves.
 - (c) Energy accounting of system calculated over the projected life of system.
 - (d) Energy cost estimate. An estimated cost of the system to produce electrical energy in dollars/kWh for the life of the system.
 - (e) Internal rate of return and benefit cost ratio.
 - (f) Operating costs on yearly basis for life of machine.
 - (g) Maintenance costs on yearly basis for life of machine.
- (3) ENVIRONMENTAL IMPACT: This should include the environmental impact of the project in operation on site (more detail in future newsletters).
- (4) TEST RESULTS: Results of preliminary performance testing of the project. (Note: In the event of problems with environmental conditions, transportation problems, etc. during the final testing, the results of preliminary home testing of systems may be used, with permission from the Coordinating Committee, in lieu of final test results for scoring. As such, it is to every team's benefit to perform home testing of the system before disassembly and reassembly of the system at the final testing site.
- A specific format to follow in reporting the results of home testing will be given in later news bulletins.
- (5) MARKETABILITY: A report concerning market areas in which the project can be used and what changes are necessary to optimize for other areas; installation instructions, ease of retrofitting, maintenance schedule and safety considerations in use of project.
- (6) EDUCATIONAL IMPACT: Each team will receive a SCORE-ERA II Educational Impact questionnaire in April 1977. This questionnaire must be completed and included as a supplement to the project's final report.
- (7) OPERATING INSTRUCTIONS: A simplified set of instructions describing how to operate the project.

(8) A final "Team Participation Log."

(9) Critique of SCORE operations to date.

4.5 All documents required for entry as specified in Section 5 must be received by the ERA II Coordinating Committee before a project will be allowed at the final test event.

5. PROJECT SPECIFICATIONS

5.1 Input

Each team must research and develop its own input requirements.

To determine what type of unit to develop, the team should consider such items as the environment in which it is to be used, pollution, economics, retrofitting, etc.

Teams do not have to develop the system for their own region; i.e., a school in Michigan could construct a project for a desert in New Mexico.

All teams must have documentation of the region from which the input power source is derived. The documentation includes weather conditions, air temperature, relative humidity, availability of input energy source, etc., for an average day of both summer and winter.

Each team must provide graphs of these conditions for an average day in both summer and winter.

The sources used to research all specifications (documented) must be listed.

Documentation is necessary before beginning a project to determine regional specifications, restrictions and feasibility.

5.2 Output

Acceptable forms of electrical output will be:

- a. 115-volt, 60-Hz, sine wave
- b. 115-volt DC
- c. 24-volt DC

The system must be able to deliver a minimum of 20 kWh/24-hour period.

6. SCORING

Ethics of Scoring for ERA II

The ERA II scoring is designed to evaluate each team's performance in researching, designing and building an alternative energy system. The emphasis will be on the innovation displayed in approaching the problem of producing electric power from these non-conventional energy sources. The scoring system employed in ERA II will penalize team entries which exhibit little or no attempt to extend current state-of-the-art technology by student-applied innovation.

(Note: Awards will be presented for innovation and excellence of design and fabrication for individual components of a system despite the overall rating of the system.)

The actual scoring schedule will consist of four unequally weighted categories, with internal subdivisions of unequal weight contributing to the category total points.

The four general categories and anticipated subdivisions are:

(1) Innovation (30% total points)

Points will be assigned to the following subgroups:

- (a) Student-designed and -built hardware. Points will be awarded based on the degree of design innovation and student fabrication.
- (b) Student Innovation of Concept. Points will be awarded based upon the degree of concept innovation exhibited in the system. This is independent of Sec. (a). This section is designed to award points to a system that may be poorly designed and fabricated, yet exhibits real innovation in its basic concept of operation.
- (c) Modification. Points also will be given for innovative modification of commercially available parts or components.
- (d) Storage Innovation. Points will awarded based upon the degree of innovation exhibited by the students in their system's optional energy storage system.

The performance section of the scoring system and this section are intended to encourage team entries that will be operated as peaking systems.

(2) Performance (25% total points)

Performance points will be based upon the technical tests of the project at the final test event. In the event that a project fails to perform satisfactorily at final testing, the team may request (subject to the committee's approval) that validated preliminary test results be considered by the judges.

Performance points will be awarded in two categories:

(a) Total Output (50%)

Each system will be required to output 20 kWh in a 24-hour period.

(b) Peaking Output (50%)

Systems will receive points for meeting the load requirements under the peaks in the load curve.

The distribution of peaking points will be determined by the percent of the total area under the peaks in the load curve relieved by a system (load curve attached).

(3) Economics (25% total points)

Unequal weights as indicated will be assigned to the following subgroups. Specifics of calculations will be presented in later newsletters.

- 30% a. Energy cost: how much it costs for a system to produce electrical energy in dollars/kWh for the life of the system.
- 15% b. Energy accounting of system.
- 20% c. Exotic material requirements (as described in report section).
- 20% d. Internal rate of return and benefit cost ratio.

(4) Marketability (20% total points)

Equal weights will be assigned to the following subgroups:

- a) Statement of existing potential market
- b) Durability of system
- c) Simplicity of system
- d) Safety of system
- e) Maintenance schedule
- f) Environmental impact
- g) All other sections contained in the final report section 5.4 (c) from a team entry, but not yet specifically mentioned.

DESIGN PROPOSAL ECONOMIC COSTS.

As part of the Design Proposal, a rough estimate of the cost to produce electrical power is required. The following calculation format should be used:

- (1) Full-Scale Production Cost = P dollars.

(a) Estimated labor cost.

(b) Estimated materials cost.

(c) Estimated full-scale fabrication cost.

- (2) Installation Cost = I dollars.

Therefore, Installed Capital Costs = P+I.

- (3) Equal-Payment Series Capital Recovery Calculation.

Given the installed capital cost of the system, the series of equal payments to be made each year to pay off the capital investment over the life of the system (either the cost of borrowed money or the opportunity cost of income foregone) is given by:

$$A = (P+I)\{i(1+i)^n / [(1+i)^n - 1]\} \text{ \$/year.}$$

- (4) Depreciation Costs.

Using a straight-line depreciation scheme, the annual depreciation cost (assuming zero salvage value at the end of the system's life) is given by:

$$B = (P+I)/n \text{ \$/year.}$$

- (5) Equal-Payment Series Sinking Fund Calculation.

Given the installed capital costs of the system, the equal payments to be made each year to re-purchase the system at the end of system life is given by (assuming constant prices):

$$C = (P+I)\{i / [(1+i)^n - 1]\} \text{ \$/year.}$$

- (6) Yearly estimated maintenance costs = D, \\$/year.

- (7) Yearly estimated operation costs = E, \\$/year.

- (8) Yearly estimated energy output = F, kWh/year.

$$\text{Finally, Yearly Electric Energy Cost} = \frac{(A+B+C+D+E)}{F} \frac{\text{\$/year}}{\text{kWh/year}}$$

$$\text{Therefore, Electric Energy Cost} = \frac{(A+B+C+D+E)}{F} \frac{\text{Dollars}}{\text{kWh}}$$

These calculations should be performed three separate times using first the 5% interest rate, next the 10% interest rate and finally the 15% interest rate:

- (a) $i=0.05$, 5%
- (b) $i=0.10$, 10%
- (c) $i=0.15$, 15%

The life of the system should be considered to be fifteen years.

- (a) $n=15$

In addition to the fifteen-year calculations, if a team believes the expected life of its system to differ from 15 years, with proper documentation a team may perform additional calculations using its own expected system life.

BUDGET

As stated in the guidelines, an itemized accounting of all anticipated expenditures is required as part of the Design Proposal (Section 5.2). The following format should be used in preparing the budget.

1. Equipment

This section should contain an itemized accounting of all equipment necessary to build the system. This may not include permanent equipment such as is ordinarily bought by the college or university.

2. Materials

An itemized listing of materials to be purchased for fabrication or use in a system.

3. Telephone

Teams probably will need to make phone calls to the Coordinating Committee in Pullman, Washington (approximately one per month), to have questions answered and clear up any problems which may arise. The estimated cost of these communications should be included so that they may be considered in determining SCORE grants.

4. Other

This section may include any necessary expenditure in the design and fabrication of the team project which cannot be included in the above categories.

There will be two symposia and a final testing, which at least the team captain should attend. At present, locations for these events have not been selected; therefore, estimates of travel expenses cannot be made and will not be considered in the first round of SCORE grants. Updated budgets will be requested as the competition proceeds, and travel expenditures then can be added.

ENERGY RESOURCE ALTERNATIVES II

TEAM ENTRY FORM

SECTION I Affiliation
Name of Institution _____
Name of Authorizing Official _____
(President, Dean of Engr., Dept. Head)
Signature of Authorizing Official _____ Date _____

SECTION II Faculty Advisor(s)
Name(s) _____
Position(s) _____
Address(s) _____

SECTION III Team Roster

<u>Name of Student</u>	<u>Year in School</u>	<u>Major</u>	<u>Area(s) of Project Participation</u>	<u>Home Town and Newspaper</u>
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SECTION IV Project Idea

TEAM MEMBER PARTICIPATION LOG

University _____

Team Number _____

[illegible]

Energy Resource Alternatives II

*** Saturday, March 13 ***

Morning: BREAKFAST at the Commons
Restaurant

SESSION CHAIRMAN DALE WARK

- 9:00 Welcome
Roland Haden
Chairman Electrical Engr.
University of Oklahoma
- 9:15 Introduction to SCORE
Mark Radtke
President of SCORE
- 9:30 The ERA II Competition
Joe Eschbach, Chairman
Coordinating Committee
- 9:45 Keynote Speaker
John H. Sununu, Chairman
of the Board, SCORE, Inc.
- 10:30 BREAK
- 10:45 Innovation
F. Burton Sellers
Texaco Develop. Corp.
- 11:30 Rules & Guidelines
Joe Eschbach, Chairman
Coordinating Committee
- 12:30 LUNCH
- SESSION CHAIRMAN KURT BERGMANN
- 1:30 Alternative Energy Resources
Part 1, Dean Eckhoff
Kansas State University

UNIVERSITY OF OKLAHOMA

- 2:15 Alternative Energy Resources
Part 2, James Greene
University of Pittsburgh

DESIGN WORKSHOPS

- 3:00 Solar Systems
Jerald Parker
Oklahoma State University
- Faculty Advisor Meeting
Dave Stock
Washington State University
- 3:30 Wind Systems
Herman Dreves
Pinson Energy Corporation
- 4:00 Coal and Synthetic Gas Systems
James Greene
University of Pittsburgh
- Design Proposal Discussion
Jon Anson & Kurt Bergmann
Coordinating Committee
- 6:30 BUFFET

Evening Beer Bust

*** Sunday, March 14 ***

SESSION CHAIRMAN JON ANSON

BREAKFAST

- 9:00 Conversion to Electrical Power
William Eaton
Independent Consultant
- 10:00 Engineering Economics & Mrktg.
John Crowley
United Engineers
- 11:00 BREAK
- 11:15 Systems Integration
Roy Kaplow
Professor at M.I.T.
- 12:00 LUNCH
- DESIGN WORKSHOPS
- SESSION CHAIRMAN DAN MASON
- 1:00 Thermionics and Solar Cells
William Eaton
Independent Consultant
- Design Proposal Discussion
Jon Anson & Kurt Bergmann
Coordinating Committee
- 1:30 Heat Engines
William R. Martini
Research Professor
University of Washington
- 2:30 Energy Storage Systems
Philip Jarvinen
Lincoln Laboratories

APPENDIX D

Energy Resource Alternatives II

*** Friday, February 4 ***

BREAKFAST

SESSION CHAIRMAN DALE WARK

- 9:00 Welcome
Dean Honeywell
College of Engineering
University of Houston
- 9:20 Introduction to SCORE
Rich Aseltine
President of SCORE
- 9:40 Keynote Speaker
Delbert Fowler
Regional Administrator
Region VI
Federal Energy Admstrtn.
- 10:30 BREAK
- 10:50 ERA II Objectives
Dave Stock
Advisor, Coordinating Com.
Washington State Univ.
- 11:15 LUNCH
Team Captain Meeting

UNIVERSITY OF HOUSTON

SESSION CHAIRMAN KIRK ROSENER

- 12:30 Project Management
Dr. Robert Beals
Dept. of Industrial Engrg.
Texas A & M
- 1:30 Innovation
Hank M. Wales
Value Management Specialist
General Electric Co.
- WORKSHOPS
- 2:15 Solar
Dr. James Colthart
Shell Development Corporation
- Coal
Dr. Paul Scott
Asst. Director, Univ. Programs
U.S. E.R.D.A.-Fossil Energy

Wind
Robert Dodge
Automatic Power Division
Penwalt Corporation

6:00 Faculty Advisor
No host cocktail hour

7:00 DINNER

*** Saturday, February 5 ***

BREAKFAST

SESSION CHAIRMAN DAN MASON

- 9:00 Generators
R. D. Chenoweth
Dept. of Electrical Engrg.
Texas A & M
- 9:45 Final Test Event-Socring
Joe Eschbach & Kurt Bergmann
Coordinating Committee
- 10:45 BREAK
- 11:00 Final Test Event-Logistics
Bill Cawley, U.S. E.R.D.A.
Richland, Washington
J. Anson, Coordinating Com.
- 12:00 LUNCH
- WORKSHOPS
- 1:00 Methane
Dr. Jack Matson
University of Houston
- Storage
Bill Smith
Mgr. Battery Storage Plnng.
ESB Incorporated

APPENDIX E

SCORE

STUDENT COMPETITIONS ON RELEVANT ENGINEERING INC

ERA II NEWSLETTER

Feb. 1976 Volume 4 Letter 1

Another Student Competition on Relevant Engineering (SCORE) is on the move. More than 4,000 students have participated in the first three SCORE competitions. This year's competition looks to be the most promising yet.

This year's Energy Resource Alternatives II (ERA II) competition will focus on the design and fabrication of systems which will use energy sources other than natural gas or petroleum to produce electrical power. Hopefully universities, colleges and individuals interested in the possibility of participating in the ERA II competition have received a set of the Rules and Guidelines. If you have not and are interested, please phone or write us at the location indicated at the end of this newsletter.

The ERA II COORDINATING COMMITTEE

Washington State University has been chosen as the location for the ERA II student coordinating committee. Members of the committee are Joe Eschbach, Kurt Bergmann, Jon Anson, Dale Wark, and our faithful accountant Dan Mason. Dave Stock is the faculty advisor to our group.

Joe Eschbach is the chairman of our committee. We look up to him as our leader because he is taller than any of us. Joe has received a degree in economics this semester and will begin graduate work in Thermal Sciences for his M.S. in M.E. Joe also has a special interest in Hi-Fi equipment.

From left to right: Jon Anson, Kurt Bergmann, Joe Eschbach, Dan Mason, and Dale Wark. Standing is Dr. David Stock.

Kurt Bergmann is in charge of communications. He will be responsible for making sure everybody receives the right information. He will also be responsible for phone contact with the schools in the Pacific and Mountain time zones. Kurt is a junior in Mechanical Engineering and gets into skiing as well as our hair.

Jon Anson has primary responsibility for the final testing event. He will be the individual making phone contacts with the people in the Central time zone. Jon spent a summer and a semester working at Tektronix and another summer at Weyerhaeuser as part of the Industrial Participation Program (IPP) at WSU. The IPP allows engineering students (Jon is a mechanical engineering student) to gain work

experience in the field of engineering prior to graduation. Jon has a private pilot's license and enjoys flying and skiing.

Dale Wark is our symposium coordinator and will be making phone contacts in the Eastern time zone. To get hold of people at 9:00 a.m. he will have to be on the phone at 6:00 a.m. PST. Dale has also participated in the IPP, working at the Puget Sound Naval Shipyard. He enjoys just about anything other than classes.

Originally there were four members on the committee but we have acquired a fifth wheel named Dan Mason (accountant), who has worked his way into our hearts, our office and our finances. Dan is a sophomore in B.A. and has a bowling average of 180.

Dr. Stock is the committee's advisor and has been an advisor in the past two SCORE competitions. His familiarity with SCORE competitions will be of great value to the ERA II Coordinating Committee. He enjoys horseback riding, but it appears that his horses aren't as fond of him as he is of them, as one of them ran him over and broke his hip last summer.

WASHINGTON STATE UNIVERSITY

Washington State University, a member of the all-powerful PAC-8, is located in Pullman, Washington, one of the richest wheat-growing areas in the world. WSU is noted for its contributions to agricultural education, research and engineering.

Degree programs are offered by the Colleges of Agriculture, Veterinary Medicine, Economics and Business, Sciences and Arts, Home Economics, Education, Pharmacy and Engineering.

The College of Engineering, showing steady growth over the past few years, has a current enrollment of 1,300. Instruction and research share equally important roles in the College's program.

There are slightly more than 21,000 people in Pullman, while the University enrollment is more than

Washington State University

16,000 this year. Students at WSU are a close-knit group (nearly all living within walking distance of the campus. We're one of the top five residence universities west of the Mississippi. Working together, we have earned the distinct honor of being the second highest per capita drinking university in the U.S. (recently slipping from the number 1 spot).

COMPETITIONS AND MAILING STATISTICS

Past competitors say that the competition will give the students practical engineering experience which you often don't learn from the textbooks. You also learn how to work with other people as a team. Colleges and universities from forty-nine states, nine foreign countries, nine Canadian provinces and one U.S. territory have indicated interest in the 1976-77 SCORE, ERA II competition. We have sent out about 1,000 copies of the Rules and Guidelines for the competition to individuals at the various institutions. More than 65 percent of the four-year colleges and universities with engineering programs in the United States have responded.

We are very enthused about the prospects for this year's ERA II

competition. Teams are required to submit a design proposal to the committee before April 30, 1976 for consideration in the May round of SCORE grants. The required information for the design proposal is detailed in the Rules and Guidelines. Don't be left out--enter a team now.

SYMPOSIUMS

The first of two planned symposiums of the ERA II competition has been scheduled for March 13 and 14, 1976, at the University of Oklahoma at Norman, Oklahoma. The two-day program will present energy resource experts discussing energy resource alternatives. A better understanding of the ERA II competition and the philosophy of SCORE will be explained. Additional details about the ERA II symposium will be given in the next newsletter.

SCORE PRESIDENT

The President of SCORE is Mark Radtke, a recent graduate of M.I.T. This will be the third SCORE competition that Mark has been involved in. If you have any questions, please give the Coordinating Committee a call or write us at the address shown below. If we don't have an answer to your question, Mark will.

PERSONS TO CONTACT FOR QUESTIONS

SCORE, ERA II Coordinating Committee
Department of Mechanical Engineering
Washington State University
Pullman, WA 99163
(509) 335-7070

Mark Radtke, President
National SCORE Office
Room 5-336
Massachusetts Institute of Technology
Cambridge, MA 02139
(617) 253-6833

SCORE, ERA II Coordinating Committee
Department of Mechanical Engineering
Washington State University
Pullman, Washington 99163

SCORE

STUDENT COMPETITIONS ON RELEVANT ENGINEERING INC

ERA II NEWSLETTER

Volume 4, Letter 2, February 20, 1976

MARCH 13 & 14

FIRST SYMPOSIUM TO BE HELD IN OKLAHOMA

As was indicated in our first newsletter, the first ERA II Symposium will be held on March 13 and 14, 1976 at the University of Oklahoma in Norman, Oklahoma. The two-day program will present energy resource experts discussing energy resource alterna-

During the Coordinating Committee's trip to M.I.T., Dale Wark, ERA II Symposia Director, worked at the M.I.T. SCORE office on preparations for the first ERA II Symposia.

tives. And a more complete understanding of the ERA II competition and the philosophy of SCORE will be presented.

Since the initial announcement of the symposium, the ERA II Coordinating Committee has been feverishly working with the Symposium Committee at the University of Oklahoma to pull the event together.

Dale Wark, the Symposium Director for the ERA II Coordinating Committee, just last week visited with the Symposia Committee at the University of Oklahoma, headed by Laurie Morgan, to check on preparations and facilities. Dale's response to the question of how things look at the University of Oklahoma was: "Fantastic." The University of Oklahoma has the Oklahoma Center for Continuing Education located right on campus. The Center is composed of approximately one-half dozen buildings that are solely directed to convention and symposium operations. The very excellent facilities at the University of Oklahoma and in Norman should make the ERA II First Symposium tremendously successful. Dale has already suggested that he would gladly give up his apartment in Pullman for living space like that at the U of O; few accommodations are as nice as those that all ERA II First Symposium participants will be staying in.

FUNDING

Turning to the ever-popular topic of money: how to get it, and how much is needed for participants at the First Symposium. SCORE will be paying for the room and board of all Symposium participants during the duration of the two-day event. This means that Symposium participants need only provide for the cost of transportation to and from Oklahoma City, Oklahoma. There will be free transportation from

the airport to the University. The ERA II Coordinating Committee strongly suggests that ERA II teams contact their appropriate department heads and deans for the transportation funds.

PROPOSAL WRITING SEMINAR

The first ERA II Symposium will feature two new topics that have never been included in any of the past Symposia: (1) a Design Proposal Writing Seminar will cover the ethics and structure of design proposal writing in general. This portion will be useful to all participants in writing design proposals both for the ERA II competition, and any endeavors in one's later professional career that require proposal writing. In addition, the design proposal writing seminar will focus on how the ERA II design proposals should be written for maximum clarity and relevant information content. We are looking forward to this seminar being an important addition to the Symposia that should inform all participants.

FACULTY ADVISOR MEETING

The Faculty Advisor Meeting will be held during the workshop periods on the first day of the Symposium. The meeting will be chaired by executives of SCORE, and the ERA II Coordinating Committee. The thrust of the Faculty Advisor Meeting will be to explain in greater detail the ethics and objectives of SCORE competition. In addition, the position of Faculty Advisor and the role he should assume in SCORE competition will be discussed.

Overall, the Symposium should be attended by all team members who can make it. The absolute minimum should be the Team Captain and Faculty Advisor if possible. Laurie Morgan, Chairman of the University of Oklahoma Symposia Committee, is inviting many of her friends to the beer party on Saturday evening. So how can you all resist?

REGISTRATION INFORMATION

The attached Symposium schedule gives more detail on the specifics of the topics and time schedule, and a registration blank to fill out.

In consulting the airlines, there are many flights into and out of Oklahoma City throughout the weekend. It should be no problem for Symposium participants to stay the duration of the two-day event, and still be able to make connecting flights into and out of Oklahoma City.

Remember, the place is the University of Oklahoma on March 13 and 14 at the ERA II Symposium. Symposia participants should plan to arrive in Norman, Oklahoma on Friday, March 12 for registration. This promises to be the best Symposium yet offered. Don't be left out--mail your Symposium registration today!!

COORDINATING COMMITTEE MEETS WITH SCORE OFFICERS & ADVISORY BOARD

The ERA II Coordinating Committee, Joe, Dale, John, Kurt and Dave Stock, have just returned from meetings with SCORE at M.I.T., and with the Advisory Board in Washington, D.C.

At M.I.T., the Coordinating Committee met with Mark Radtke, President of SCORE, Charles Barringer, Executive Secretary of SCORE, and John Sununu, Chairman of the Board of Directors. Primarily, the meeting served to coordinate the final efforts on the First Symposium between the SCORE and Coordinating Committee offices. In addition, a preliminary budget for the respective offices and competition was organized and approved.

While in Boston, Mark devoted a lot of time seeing to the room and board necessities of the Coordinating Committee. It wasn't only words that flowed while we were there.

Dale received the hardest workout in these meetings, discussing plans to make the first ERA II Symposium the

Left to right: John Sununu, Chairman of the SCORE Board of Directors, Mark Radtke, President of SCORE, Charles Barringer, Executive Secretary of SCORE, David Stock, ERA II Coordinating Committee Faculty Advisor.

best SCORE Symposium yet. Jon slept, suffering from jet lag, and Kurt flashed film for an immortal record of the encounter, excerpts of which are printed here in the Newsletter.

Directly after Boston, the Coordinating Committee proceeded to Washington, D.C. for a one-afternoon meeting with the Advisory Board. The Advisory Board, as listed below, is a body of industrial, government and educational

representatives who aid the Coordinating Committee in technical suggestions, choosing speakers for the Symposium, etc. At the first Advisory Board meeting, Edward Creutz, Jack Snell, Ed Gray, Bill Porter (representing Austin Heller) were able to attend. The Advisory Board gave extensive suggestions that will make the competition and symposia run more smoothly. In addition to the Advisory Board members present and the Coordinating Committee, Charles Barringer, the Executive Secretary of SCORE, and Mark Radtke, President of SCORE, were also present. All parties came away from the meeting feeling that important suggestions and points had been made by the Advisory Board.

ADVISORY BOARD MEMBERS LISTED

Listed below are the names and addresses of the members of the ERA II Advisory Board.

David E. Stock, Assistant Professor
Department of Mechanical Engineering
Washington State University

R. A. Coit
Senior Staff Engineer
Shell Oil Company

U of H is first

TEAM ENTRIES BEGIN TO ARRIVE

Be sure to fill out the Team Entry forms attached to the ERA II Rules and Guidelines. The University of Houston is the first school to send in not one but three Team Entry forms. Congratulations, and welcome to the new ERA II team members:

Brett Babbitt
Charles Redding
Dave Bilberry
Don Dickey
Donald Laird
Mark O'Neill

Anthony Richard
Osagiede Macaulay
Tom Shaddox
Gerald Shoults
Gary Somberg
John English

Donald Sands
Mark Ownby
Bryan Chambers
Robert Pollard
Susan Jackson
Ted Bowers
Henry Keller
Gal Medora
Doug JaLuaz
Jim Davis
Bill Adams
A. Youssefi
Forrest Gibbs
Barry Wind

Steven Larson
Ray Payne
Ernie Kacher
Tony Finnegan
Hugh Harrington
Thomas DeRouen
David Allen
Antoinette Boone
John McGarity
Vernon Wade
Brad Linder
Stanley Hopfe
Paul Ortiz
Robin Ramirez

Advisory Board List (Continued)

Edward Creutz
Assistant Director of Research
National Science Foundation

S. William Gouse
Deputy Assistant Administrator -
Fossil Energy
U.S. Energy and Research Develop-
ment Agency

Edward Gray
Office of Technology Utilization
NASA

Austin Heller
Assistant Administrator for Conserva-
tion
U.S. Energy Research and Develop-
ment Agency

Wassily Leontiff
Professor of Economics
New York University

Congressman Mike McCormack
U.S. House of Representatives

John W. Mitchell
Professor of Mechanical Engineering
University of Wisconsin - Madison

Jack Snell
Chief of Energy Conservation in the
Center for Building Technology
National Bureau of Standards

SCORE, ERA II Coordinating Committee
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Pullman, Washington 99163

SCORE

STUDENT COMPETITIONS ON RELEVANT ENGINEERING INC

ERA II NEWSLETTER

Vol. 4, Letter 3 - April 1976

SYMPOSIUM - At the first ERA II Symposium, students and faculty members had the opportunity to find out more about new energy sources (or new uses for old ones).

ERA II SYMPOSIUM

The ERA II competition was officially kicked off with the SCORE sponsorship of the competition's first Symposium held at the University of Oklahoma, March 12-14. The attendance at the Symposium broke all previous SCORE records--approximately 100 students and a handful of faculty advisors registered by Saturday morning.

Innovation, which will be heavily stressed in the competition, was even apparent in the methods by which competition members descended upon the University of Oklahoma. Team members from the University of West Virginia drove for approximately three days from Morgantown to Oklahoma City, while students from the University of Illinois at Urbana drove continuously and swiftly throughout Friday night to reach Norman by the morning. Two fellows from the University of Wisconsin at Madison arrived late

Friday night at the Oklahoma City Airport--in talking to them it appeared that even they were not sure how they got to Oklahoma. Finally, a team member from the University of Halifax flew his own plane from Nova Scotia to Boston to catch a commer-

SYMPOSIUM REGISTRATION - Students and faculty members sign up for the first ERA II Symposium.

cial flight to Oklahoma City. Although some members arrived a little bedraggled, all in all everyone was very excited about the Symposium.

Each morning of the two-day Symposium presented speakers addressing the general topics of alternative energy sources: wind, solar, fossil, synthetic gas--highlighting key aspects of a topic that may particularly suit or disable it as an alternative energy source.

In addition, general talks were presented on energy conversion, energy costing, innovation and systems integration.

Each afternoon was broken into specific design workshops. Key areas of each general energy source, conversion process and energy storage method were concentrated on, led by a person who has had practical design experience in each area.

After the intense proceedings of the first day, everyone was able to relax over a beer and good conversation at the local University of Oklahoma hot spot, the Jockey Strap Tavern.

For those ERA II competition members who were not able to attend the Symposium, a transcription of the proceeding is being compiled by the Coordinating Committee. The transcription will also include the ERA II Design Proposal Writing Seminar presented by the Coordinating Committee at the Symposium. A copy of the Proceedings and also a Fundraising Guide will be available upon the Coordinating Committee's receipt of a Team Entry Form from ERA II teams.

DESIGN PROPOSALS DUE APRIL 30

In order to be considered for the first round of grants to be issued before June 1, 1976, the Project Design Proposal must be sent to the Coordinating Committee by April 30, 1976.

WIND WORKSHOP - Herman Drees of Pinson Energy Corporation discusses some specifics of wind-powered systems at a design workshop.

TEAM ENTRY FORMS

Have you completed your team entry form yet? If not, do it today. Remember, you cannot receive the special attention of the Coordinating Committee unless we have you registered as a team. There is a special team mailing list, and in order to be on it we need a team entry form.

TELEPHONE NUMBER MISTAKE

With our last newsletter, we sent out the ERA II Symposium I schedule and preregistration sheet (yellow paper) with the wrong area code for the Coordinating Committee. It reads (206) 335-7070 where it should be (509) 335-7070.

Jon, Administration Director for the Coordinating Committee, made the mistake. If you think that three-digit numbers are a problem for him, you should see what he does with tough three-letter words like cat, dog, etc.

In any event, don't make the mistake of dialing the wrong area code. If you do, your call will end up on the Pacific Ocean side of Washington State.

POSTER COMPETITION

As announced at the Symposium, the Coordinating Committee is sponsoring an ERA II poster competition. Interested persons should design a poster that thematically describes the competition: alternative energy electrical production, student-designed and -built, education, etc. These are only ideas of what one may wish to focus upon.

The idea is to develop a poster that is both eye-catching and yet tells people about the thrust of the ERA II competition.

The only restrictions are that the design must be on an 8½ x 11 sheet of paper, and the design must include the name SCORE and ERA II Competition.

The awards are irresistible: 1) a credit to the designers on the poster

face when it is nationally distributed, 2) a case of the designer's favorite beverage at the next Symposium, and 3) the eternal gratitude of the Coordinating Committee.

COORDINATING COMMITTEE MESSAGE

As we told those team members at the Symposium, the Coordinating Committee should be viewed by all teams as an aid, not as a judge. Realistically, the Coordinating Committee never judges the teams' design proposals, final reports or final project hardware. All judging in the competition is performed by impartial com-

(Cont. on p. 4)

T-SHIRTS

The Coordinating Committee has two styles of competition-related T-shirts for sale at \$3.50 apiece. One style has SCORE emblazoned across the front, while the other has Energy Resource Alternatives II delicately stenciled across the breast. These shirts are first-rate quality, all done by a commercial shirt factory.

If you would like some, just write and tell us how many you want, what style and what sizes (S, M, L and XL). The shirts are made of 100% cotton.

Those who bought the shirts last year have expressed extreme satisfaction with their purchases. Both male and female team members have reported wild occurrences while wearing their shirts, especially when going on a date with a SCORE T-shirt.

RULES & GUIDELINES ERATA SHEET

Small typo and duplication mistakes have been noted in the Rules and Guidelines. Please make the appropriate corrections and deletions:

1. Reference Mistakes

- a) On page 10 in 4.4, Final Report, part (a) (3), a reference is made to section 5d. The reference should read "4.2 (g)."
- b) On page 14 in (4) Marketability, part (g), a reference is made to section 5.4 (c). The reference should read "4.4 (c)."
- c) On page 16, right under Budget, a reference is made to Design Proposal (section 5.2). The reference should read "Design Proposal (section 4.2)."

2. Percentage Mistake

On page 14 in (3) Economics, part (a), it reads 30% where it should read 45%.

Also, some revisions have been made to the Rules and Guidelines:

1. Design Proposal Economic Costs Revision

- a) On page 15, (5) Equal-Payment Series Sinking Fund Calculation is being dropped. Sinking Fund Calculations are used in large businesses and usually not in small businesses or households. We feel you should not be made

to worry about the Sinking Funds, so disregard them.

- b) Drop section 1 (c), relating to "Full-Scale Fabrication Costs." For our costing, labor and materials are adequate.

2. Forms of Power Output

220 volts, 60-Hz sine wave, and D.C. can be added to the list of acceptable outputs already contained in the Rules and Guidelines (which are 115 and 24 volts).

UNIVERSITY OF HOUSTON TEAM ENTRY

An apology to Kirk Rosener of the University of Houston. We inadvertently left his name off the second newsletter under the University of Houston team entry roster.

(Cont. from p. 3)

mittees composed of appropriate representatives from industry and education. The Coordinating Committee exists to define and lubricate the competition structure. We can only help teams by being taken into their confidence. So, if problems arise, feel free to contact us for help. It can only help your project, not hurt it.

SCORE, ERA II Coordinating Committee
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SCORE

STUDENT COMPETITIONS ON RELEVANT ENGINEERING INC

ERA II NEWSLETTER

Vol. 4, Letter 4, May 1976

TEAM ENTRY FORMS

If you have a SCORE/ERA II Team Entry Form, be sure to fill out the form in the back of the Rules and Guidelines and send it to us.

We are developing a team mailing list so that we can send pertinent team-related information directly to the teams. This will enable us to speed the distribution of team information, as well as cut costs.

So send us your team entry form as soon as possible. Be sure to include the team and team captain's name, address, and phone number.

DESIGN PROPOSAL EVALUATION

We will be evaluating the group of design proposals that we have received by mid-May to determine the size of grants to be distributed to each of the teams that already have sent design proposals in.

Incidentally, Rutgers University was the first university to send us a design proposal.

We wish to emphasize that if you did not get your design proposal in by April 30, it does not mean you will receive a smaller grant. What it means is that you won't receive it as soon.

The disbursement of SCORE grants to each team will be split into more than one allotment over the year and a half of the competition. We wish to receive further input from teams as to their progress in order to make a better determination of need.

SCORE grants, although substantial, are not generally enough to finance an entire project. They are intended as "seed money" grants. It is likely teams will want to seek additional funds from their school or local industry. A fund-raising guide will be mailed to all teams which have sent us team entry forms.

PERFORMANCE SCORING

Questions have been raised as to how points will be awarded in the Performance section of the Rules and Guidelines.

Of the total scoring points, 12.5% will be awarded for "Peaking Output", and 12.5% will be awarded for "Total Output" (see Rules and Guidelines). Measurements will be made at the Final Test Event to determine your system's ability to produce total output and peaking output.

"Total Output" will be scored on a linear scale. For 20 kWh in a 24-hr period, the system will receive 100% of the 12.5% scoring points allocated to the "Total Output" section. Additional points will not be given for Total Output that exceeds 20 kWh in a 24-hr period. For 0 kWh in a 24-hr period, the system will receive 0% of the "Total Output" points. Similarly, for 10 kWh in a 24-hr period, the system will receive 50% of the 12.5% scoring points allocated to the "Total Output" section.

Peaking points will be awarded on a system's ability to meet the peaking area under the load curve. The peak-

ing area is defined as the of the load curve above the 0.75 kW level. The peaking area contains 16 kWh in a 24-hr period.

There is the obvious implied trade-off between "Peaking Output" versus "Continuous Output". A team may not wish to include a storage system as such; they may produce the 20 kWh/day by continuous power output--but with none of the peaks in the load curve relieved. This team would receive 100% of the "Total Output" points, but 0% "Peaking Points". Alternatively, a team using a storage system might produce 16 kWh of output in the peaks with a 4 kWh elsewhere would receive 100% of the "Peaking Output" points and 100% of the "Total Output" points. In its design, each team must consider the possible tradeoff in "Peaking Output" versus "Total Output" versus the additional cost and complexity of a storage system.

The Load curve contained in the Rules and Guidelines is shown below:

Below is a sample output curve from a hypothetical team showing how it would be scored:

$$\text{Points awarded} = \left(\frac{\text{Peak output kWh}}{16 \text{ kWh}} \right) \cdot$$

12.5% of total points +

$$\left(\frac{\text{Total output kWh}}{20 \text{ kWh}} \right) \cdot 12.5\% \text{ total points}$$

$$\text{Points awarded} = \left(\frac{10}{16} \right) \cdot 12.5\% + \left(\frac{20}{20} \right) \cdot 12.5\%$$

Points awarded = 7.8% + 12.5% of total scoring points.

Points awarded = 20.3% of total scoring points.

If questions still persist, please give the Coordinating Committee a call (509) 335-7070.

OTHER TEAMS' PROGRESS

The Coordinating Committee has talked to several schools to get a report on their progress and problems. Christian Brothers College of Memphis, Tennessee is going through an evolutionary process in its design. They started with wind-augmented solar cells and are now working on a Minto Wheel powered by solar heat. When the Coordinating Committee talked to them, they were redoing some calculations, as somebody apparently dropped a decimal point (remember, calculators are not perfect).

Amarillo College at Amarillo, Texas is pushing ahead with three one-hour meetings a week, plus nights and weekends. The team members are working hard, as they are starting from the basics and working up, and this includes learning aerodynamics from the beginning.

Three teams from the University of Houston are attacking three different fronts. Proposed are wind-, wave-, and solar-powered projects. The wind team is working on special blade tips that will serve as speed brakes if the windmill rotates too fast. They've also actively scrounged \$1,000 worth

of material to build a 35-foot tower. The Coordinating Committee hopes that other teams will search out and ask for such donations. A microcomputer is planned for the control system for the heliostatic set of tracking mirrors for their solar project, and possibly a storage component will be added. Waves don't look like they contain a lot of hydrostatic head, but with Houston's wave-amplification system, their wave team will demonstrate whether wave power will be practical in the near future for electrical power generation.

All the teams that we talked to plan to have their design proposals in almost on time. The Coordinating Committee hopes that many more will arrive in the next few weeks. Good luck to all the hard-working teams.

Hopefully, we will be able to talk to you soon to find out what you've been doing.

KEEPING UP WITH THE COMPETITION

In future Newsletters, we would like to include information as to the progress of different teams throughout the nation. We therefore are asking that you send black-and-white photographs and information on your progress to us for publication in the Newsletter.

So, if you want free publicity for yourself and your project to be distributed internationally to other colleges and universities, send us your information.

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SCORE

STUDENT COMPETITIONS ON RELEVANT ENGINEERING INC

ERA II NEWSLETTER

Volume 4, Letter 5, August 1976

STAY ON IT, GUYS!

It's less than a year now until the ERA II Final Test Event. Time is really flying by. There are currently 47 teams entered in the ERA II Competition, with two months left for teams to enter.

Team Progress

Most teams are working right through the summer. The photograph below indicates that the University of Houston's Wind team is quite far along in the development of their project.

Left to right: Dave Bilberry, Anthony Richard, Prof. Art Paul, and Don Laird assembling air-brakes on Houston's windmill.

Mike Bergey from the University of Oklahoma tells us that his team will have their project built by December. The rest of the time prior to the Final Test Event will be spent working out the bugs. Knowing Mike, he will need all the time he can get.

Hugo Kruesi, team captain for Rutgers, says his team will have some hardware early in the fall. At Rutgers they are also working hard on a fund-raising campaign.

If you are considering entering the ERA II competition do it, the deadline is approaching fast.

SCORE GRANTS ISSUED; FUNDING EXPLAINED

As many of you know, the initial round of SCORE grants has been issued. The proposals were evaluated by a group of highly competent engineers from the Richland, Washington area. A brief summary of the comments made by the evaluators was sent to teams, along with a monetary determination. The initial grants averaged just under \$1,000 per team. The next round will probably take place in the fall.

In addition to proposal evaluations, each team was sent a fund-raising guide. SCORE expects all teams to procure as much in the way of equipment and funds from other sources as possible. In general, SCORE will not provide full funding for projects. In the near future we will provide teams with a fund-raising update which will provide useful information to aid in gaining equipment and funds. Also it is important that you allow plenty of

time for a response from potential contributors. Lag time, especially for monetary contributions, can be very long.

For those receiving grants from SCORE, it is very important that an accurate accounting be kept of where the money was spent. Also, you must sign and return the agreement sent out with the grant. Future grants are entirely dependent on performance of these responsibilities. If you have any questions on either of these points, please contact the Coordinating Committee or Mark Radtke.

STILL ON SALE: T-SHIRTS!

We announced in Newsletter No. 3 that ERA II and SCORE T-shirts are being sold through the Coordinating Committee at Washington State University. We can't imagine the possibility of anyone passing up the opportunity of getting a T-shirt that says SCORE on it. They make excellent gifts--to your girlfriend, for instance. They can say so much that can't (or shouldn't) be put into words. Send us type, size, quantity, and \$3.50 for each shirt ordered. Please make the payment in the form of a money order.

In addition to the T-shirts, we now have for sale ERA I Final Reports. The Final Report is a 227-page, 8- by 11-inch booklet which gives a detailed accounting of the ERA I Competition. So, if you participated in last year's ERA I Competition or are interested in alternative energy resource systems, or just feel like spending some cash, send \$5.00 to the return address on this newsletter and ask for an ERA I Final Report. We'll be pleased to send you a copy.

SYMPOSIUM LOCATION SOUGHT

The Coordinating Committee is looking for a location to hold the next Symposium. A few universities have already indicated an interest in holding this event on or near their campuses. If there are any other universities interested in reaping the benefits of such an event, please contact the Coordinating Committee at Washington State University. Use the return address on this newsletter or phone (509) 335-7070.

RICH ASELTINE NAMED NEW SCORE VICE PRESIDENT

Also in SCORE news, SCORE has a new Vice President. He is Rich Aseltine. Rich will be working with Mark Radtke in Cambridge, Massachusetts. He recently received a B.S. in Electrical Engineering from the University of Tennessee. Rich gets off on scuba diving, laser beams and ripping off piñatas.

DO YOU HAVE A CHANGE OF ADDRESS?

With a new fall session beginning soon, many will have new addresses. We are making an effort to send mail to two addresses for each team. One set of information is being sent to the faculty advisor and one set to the team captain. If team captains are not receiving information directly or if they have a change of address at any time, please let us know. Along with the team captain's address we need a phone number.

Faculty advisors are sometimes hard to run down. Team members are even harder. For that reason teams should get a Departmental mail box to insure communication between their Advisor and themselves.

COORDINATING COMMITTEE KEEPING BUSY THIS SUMMER

During the summer the Coordinating Committee has dwindled down to just

two people, Joe Eschbach and Dale Wark. We are both keeping quite busy. Our goal is to accomplish enough to diminish the workload during fall and spring class sessions.

As for other members of the Committee, Jon Anson is in Bolivia suffering from Montezuma's Revenge. He should return in September if he doesn't become a political prisoner. Dan Mason is working in Olympia, Washington at a supermarket, where he is running over little old ladies with shopping carts. Kurt Bergmann is a blue-collar worker (where the money is these days) at a power plant on the west side of the state. And Dr. Stock, our advisor, will be suffering through two weeks in the Virgin Islands soon, poor devil.

ACKNOWLEDGEMENTS

Finally, we would like to thank the Washington State University Word Processing Center for the job they do in making the material we send them look so fine. We would truly be dead in the water without them.

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SCORE

STUDENT COMPETITIONS ON RELEVANT ENGINEERING INC

ERA II NEWSLETTER

Vol. 4, Letter 6, November 1976

SECOND ERA II SYMPOSIUM

SITE ANNOUNCED

The Second SCORE/ERA II Symposium will be held at the University of Houston in Houston, Texas, on Friday and Saturday, February 4 and 5, 1977. The team captains chose Texas as the most preferred location for the Symposium in their responses to our questionnaire.

We hope to see at least one member of each team at the Symposium. This will be an excellent time to meet people from other teams, to discuss techniques of fundraising, ideas and types of projects, problems encountered and how these problems have been dealt with. This will also give you a chance to meet the Coordinating Committee in person which will make later discussions on the phone easier for both groups.

The February Symposium will cover a wide variety of topics having to do with the development of alternative energy resource projects. There will also be discussions about problems teams are encountering in the development of their projects, the Final Test Event and scoring of projects... so be there!

Near the end of December, preregistration forms including the program will be sent to all who receive our newsletter. Although the Symposium will be orientated toward the ERA II Competition, we welcome everyone who has an interest in alternative energy resources.

FINAL TEST EVENT

For those teams waiting to travel to Cape Cod for the Final Test Event (FTE) -- sorry to disappoint you. Maybe you can detour enroute and visit Yellowstone. For now, start mapping your course to the Pacific Northwest and the city of desert sun and water fun -- Richland, Washington. Don't stay at the Tetons too long; you need to arrive by June 9 and plan on staying through June 16, 1977 (tentative FTE dates). After June 16th you might want to work off some steam by climbing Mt. Ranier before starting to drive home.

Richland, probably best known as a national center for the development of nuclear energy, is one of the largest engineering-based communities in the nation. It is the home of such corporations as Exxon Nuclear, Westinghouse Hanford, the Battelle Memorial Institute Northwest Labs, Washington Public Power Supply System, United Nuclear Industries, and the Joint Center for Graduate Study (operated by Washington State University, the University of Washington, and Oregon State University). These groups are conducting extensive research and development in the areas of solar-heated and cooled commercial buildings, wind, geothermal, fossil fuels, nuclear breeder reactors, commercial fission reactors, and other energy-related fields.

The FTE is being hosted by the Energy Research and Development Administration Richland office (ERDA--RL),

and is supported by all the corporations in the area, including the Tri-Cities Engineering Council. Be sure to bring some copies of your resumes, as the area corporations will be operating a job recruitment center near the test site.

The test site provides all the space you will need and equipment such as small cranes and fork lifts are available to help unload and set up your projects. A liaison engineer will be provided for each team to give assistance in case any emergencies or problems should crop up. If you have a special problem or requirement, please let us know as soon as possible.

Since weather is a prime concern for the FTE -- team captains should receive in the near future detailed climatological data covering the last several years. For now -- the wind averages sixteen kph (10 mph) and the average solar incidence is 310 watts/m² (640 Langleys per day).

Keep up the hard work -- see you in Richland.

TEAM TRAVEL MONEY

Twenty-five percent of SCORE seed money grants can now be used for team travel to the Second ERA II Symposium and Final Test Event. Each team is free to decide if it wants to use up to 25% of its grant to cover travel costs. However, all team travel paid for by a portion of the team grant must be strictly accounted for.

The Coordinating Committee suggests that each team assay its sources of local funds very carefully. If it is easy to get travel money, then save your team grant for materials; however, if travel money is difficult to come by, then use up to 25% of the grant for travel, second, canvass local sources for cash and material donations. In early spring, a special team travel grant will be issued to partially cover the cost of travel to the Final Test Event. If you feel

your team needs special consideration, please give the Coordinating Committee a call.

FUND RAISING

If you haven't started a fund raising campaign, you had better start now. You should have a well-organized fund raising proposal which describes all aspects of your efforts and budget. There are many teams which have done an excellent job on their fund raising effort, such as University of Houston, California State University at Long Beach, and West Seneca East Senior High School at West Seneca, New York.

Rutgers University has pictures of their team working, business cards, pamphlets and a very detailed report which they use during their fund-raising. Their report consists of eight sections: 1. Abstract; 2. Introduction; 3. Objectives; 4. Experimental Program; 5. Design Description; 6. Budget; 7. Funding and Grant Information; and 8. Appendix.

West Seneca has pictures and an excellent proposal. Their proposal consists of a description of SCORE, Project Abstract, System Diagram, Innovation, Budget, Input Specifications, Economic Costs, System Integration, Proposal Evaluation Results, and a Grant Request. They have already been given the free use of a rental truck, donated for transport of their project to the Final Test site.

You must go out into the community and contact potential contributors. Present your material to them in a well-organized form and ask for their help and support. You not only want to find money, but also materials and technical advice. Show them you're serious, enthusiastic, and determined to make your project a success. Use your Fund Raising Guide to help you prepare a good proposal.

There are companies which have funds which are used for supporting

local programs like your ERA II project. Don't pass them up!

We are pleased with the fund raising activities of some of the teams and hope that the other teams will follow their lead. Good luck in the future and let us know how your efforts are paying off.

TEAM PROGRESS

Team #058, Ocean Power team for Stevens Institute of Technology, is developing a method for the extraction of energy from the waves on the New England coast. Bob Schwalbenberg, team captain, says that they are presently modifying the design of a contouring raft. The team is testing a 3 ft by 3 ft scale model to determine the optimum dimensions for the raft. Bob's team is also developing a mathematical model to predict the motion of the raft.

Milton Michailidis, team captain of California State University at Long Beach, Solar Team #067, says that their progress to date is excellent. They have launched a strong publicity campaign producing a small working model of their system for media and public display. They have received two large donations, one of aluminum for their mirror bank structure, and the other of fiberglass cloth for their parabolic trough mirrors. Milton says that the team is using an intricate technique in constructing the troughs from molds and that the actual mold work will begin soon. They have also constructed the first of the ten units of the mirror bank support structure and expect to have the total structure completed soon. Milton projects that their solar system will be 80% completed by mid-January, 1977.

Reginald Moore, team captain of the Kansas State University, Wind Team #106, says that progress on their wind collection system is proceeding very well. They have designed the tower

for their Savonius rotors and had the design checked by a local engineering firm with only a minor change in a cross member length. They have planted, harvested, crushed, and are now fermenting and distilling sorghum to produce the raw ethanol fuel for their internal combustion engine.

Teams seem to be progressing very well; keep up the good work. The Coordinating Committee will be in contact with you shortly for the monthly reports.

SECOND ERA II ADVISORY

BOARD MEETING

The Second ERA II Advisory Board meeting was held on October 22, 1976 at the American Society of Engineering Headquarters in Washington, D.C. The Board met with:

Mark Radtke, Outgoing President of SCORE;

Rich Aseltine, Incoming President of SCORE;

John Sununu, Chairman of the SCORE; Board of Directors;

and the Coordinating Committee.

Dr. David Stock, Chairman of the Advisory Board, conducted the meeting. Dan Mason, Accountant for the Committee, presented a short financial report on the average monthly expenses incurred by the Committee. Dale Wark, Symposia Coordinator for the Committee, announced that the Second ERA II Symposium will be held at the University of Houston (Texas) on Friday and Saturday, February 4 and 5, 1977. Dale briefly outlined plans for the two-day event. In addition, Dale solicited suggestions from the Advisory Board for speakers at the Symposium. Jon Anson, Final Test Event Coordinator for the Committee, led a discussion to choose the Final Test

Event site for the ERA II Competition. The group decided that the best location would be the ERDA-Hanford laboratories at Richland, WA. At the conclusion of the meeting, Rich Aseltine assumed the Presidency of SCORE, since Mark Radtke is retiring from SCORE to find fame and fortune in the real world of business.

Overall, the Second Advisory Board meeting was very successful. The Committee sought and received the help that will be needed to insure the continued efficient and successful operation of the ERA II competition.

MEMORANDUM AND PATENT AGREEMENTS

It is very important that each team send in its Memorandum and Patent Agreement (M & P) in order to receive seed money grants from SCORE. The SCORE corporate offices at MIT cannot send seed money to a team until SCORE has received the completed agreements. Although the first round of seed money grants were issued at the same time as the agreements, the SCORE office has changed this policy. The SCORE/MIT office will now send the seed money grant check to a team only after it has received the M & P Agreement form. If a team already has its first check, and has not sent in the agreements, no further checks will be issued until these agreements are sent to SCORE/MIT. The following teams will not be receiving additional money until the agreements are sent to SCORE/MIT:

- # 10-University of Houston
- # 16-University of Houston
- # 22-Rensselaer Polytechnic Institute
- # 28-University of Wisconsin @ Green Bay
- # 34-University of West Virginia

- # 37-Oklahoma State Technical Institute
- # 52-University of Illinois @ Urbana
- # 55-Los Angeles Pierce College
- #103-University of Ohio @ Athens
- #109-University of Indiana @ Evansville
- #130-University of Florida @ Gainesville
- #139-Syracuse University
- #157-University of Florida @ Gainesville
- #160-University of Florida @ Gainesville

Get these agreements in now to reduce your waiting time for money. If there are any questions or problems, please give the Coordinating Committee a call at (509) 335-7070.

SPECIAL NOTE:

The mailing address of SCORE/MIT has changed, please direct all mail concerning grants and agreements to:

Rich Aseltine, President
SCORE
Room 9-220, MIT
Cambridge, MA 02139

ERRATA

For those who have received our report on the First ERA II Symposium, there is an error on page 25, 12 lines from the bottom of the page. By "Thermal Storage" it reads "Highly efficient"; it should read "Not highly efficient".

SCORE
STUDENT COMPETITIONS ON RELEVANT ENGINEERING INC

ERA II NEWSLETTER

Vol. 4, Letter 7—April 1977

Dr. R.D. Chenoweth explaining how to match a generator to a system

Houston Symposium

Over 110 student and faculty from universities across the United States attended the second ERA II symposium at the University of Houston at Houston, Texas, according to Symposia Coordinator Dale Wark.

Dale says the symposium of Feb. 4-5 accomplished three major objectives: 1) reiterating ERA II objectives, 2) assisting teams in solving technical problems and 3) explaining the ERA II Final Test Event.

Symposium participants enjoy Friday dinner of ribs and beer

Presentations at the symposium included talks on project management, innovation, generators and the Final Test Event. In addition, problem solving workshops on solar energy, coal, wind energy, methane producers and energy storage were held.

On Friday evening, in relaxed atmosphere complete with barbecued ribs and beer, participants exchanged a great amount of information with the other teams, the speakers and the Coordinating Committee.

The symposium report is being written and will be in print by late March. Each team and those associated with the symposium will receive a copy of the report. Dale added that anyone who does not fall into those groups, but would like a copy, should request it in writing to the return address on this newsletter, and one will be sent free of charge.

Jon Anson of the Coordinating Committee and Gerry Kins, Team Captain for Illinois Institute of Technology, hash over a problem

Dale also wanted to say, "On behalf of the ERA II Coordinating Committee, I wish to thank the University of Houston for the use of their fine facilities and the hard work of persons associated with the university in conjunction with the symposium. We also sincerely appreciated the time and knowledge shared by our fine speakers."

Final Test Event Schedule of Events

The following is a tentative schedule for the Final Test Event (FTE) at Richland, WA:

Thursday, June 9—Check-in, project set-up
Friday, June 10—Check-in, project set-up, kick-off barbecue
Saturday, June 11—Project set-up, judge orientation
Sunday, June 12—24 hr. testing, judging
Monday, June 13—Rework projects, judging, tours
Tuesday, June 14—24 hr. testing (optional), judging, tours
Wednesday, June 15—Public open house, awards banquet
Thursday, June 16—Pack-up and go home

—Teams were told at the Feb. 4-5 symposium that no telephone poles would be available for wind projects at the Final Test Site. The Coordinating Committee is checking into this matter again and a definite answer will be released later.

—Tours of the many different energy and environmental facilities plus research projects will be conducted for interested teams on June 13 and 14 at the FTE.

The Richland office of U.S.-ERDA is hosting the FTE in cooperation with the following industrial and educational institutions Battelle-Northwest, Westinghouse Hanford, United Nuclear Industries, Joint Center for Graduate Study, City of Richland, Washington Public Power Supply System and U.S.-ERDA. These organizations in addition to others will be interviewing at the FTE site. (This will be an excellent opportunity for those seeking future employment.)

—In fulfilling team requests, the Coordinating Committee is planning to have a cherry picker, a forklift, power and water at each site where needed, computer analysis of projects, a weather station and drinking water at the FTE site.

—The ground at the FTE site is a closely cropped grass in a sandy soil. Holes may be dug to anchor projects, but they must be filled in before leaving. Sorry, no permanent concrete can be installed.

Final Test Event Information

"Great things are happening in the planning of the Final Test Event at Richland, Wa.," says Coordinating Committee member Jon Anson.

"The local companies, schools, government organizations and ERDA (Energy Research and Development Administration) are giving us strong support."

Jon says arrangements for computer testing and scoring of the projects is underway and "the judges and equipment are starting to line-up."

The Tri-Cities Technical Council, a consortium of over 20 professional societies, has invited the teams to stay in private homes near the Final Test Site (FTS). "Hopefully," Jon says, "this homestay family will be the same person as your liaison engineer."

Each team's liaison engineer, will be "a person who knows the local area, what to do for entertainment and, more importantly, can give you technical help and find technical services for a team's project if emergencies arise."

Jon says the home will be chosen as close to the FTS as possible so that teams will not be spread out any more than necessary.

Team members should bring their sleeping bags, for some will be sleeping on the floor or on the cots, etc., that members bring.

"The homes," Jon says, "are not required to provide meals." He says "simple" breakfasts and "hearty" lunches will be provided at the FTS as well as the Kick-off barbecue and the Awards Banquet. "All other dinners will be the team's responsibility."

Families and friends of the team members are invited to attend the Final Test Event but homestays will not be provided for the non-participants unless special arrangements are made ahead of time with the Coordinating Committee.

Campgrounds, he says, are available and a block of motel rooms have been reserved at reduced rates for non-participants and teams who wish them but that they are at the person's own expense.

Team 79 from MIT with its 200 square foot test pond. Members are, left to right, Mike Anciqux, Pat Brown, Tom Davidson, Vivek Ranadive, Bille Battye, Tony Pelham

A questionnaire will be mailed out soon to each team in an effort to provide the services and equipment a team may require. Jon asks that teams fill it out in as much detail as possible and return it as soon as possible to the Coordinating Committee.

"If these questionnaires are not returned to us fast," Jon says, "we may not have what you need or the quantity of what you want at the FTE."

Money

REMINDER TO ALL TEAMS: Additional funding is available for those teams that need it. Teams who want this money will have to send the information requested below to The ERA II Coordinating Committee before March 11, 1977. Based on that information, the additional money will be sent to the teams with the most need.

Also, this information from the teams will update the Committee's files so they can keep within the standards of SCORE. This information is required from all teams.

The Committee would like an itemized budget of the following:

1. Materials obtained to date:
 - a. Obtained with SCORE money
 - b. Obtained with donated money
 - c. Materials donated
2. Materials to be obtained
3. Cash donations not including travel funds
4. Travel donations:
 - a. Cash
 - b. Vehicles

Additional travel money will be sent to all teams before the Final Test Event only if all SCORE requirements have been met.

Projects Progressing

Teams in the ERA II Competition are now in the home stretch after many months of hard work. The following describes how a few of the teams are dealing with their present problems, modifying their project designs and generally making progress towards the completion of their projects:

The team at Midwestern State University says the success of its solar energy project depends upon publicity and fund-raising, coupled with technical development.

David Gierke, Faculty Advisor for WASP team and team member Jim Capece, with the solar portion of their project.

To accomplish the task of publicity and fund-raising, the M.S.U. team says two of its members, Helen Burt and David Parker, have made several radio and television interviews and a series of public appearances before service organizations. David discusses the SCORE competition, while Helen talks about the technical aspects of their project.

As a result of their efforts, the M.S.U. team says it has received cash donations totaling \$300 and several hardware contributions.

In order to solve some of the technical difficulties of their project, the M.S.U. team says it is first building a scale model of their modified Minto Wheel before building the full-size model. They also take the scale model along when explaining their project to a group and say it has turned out to be a good fund-raiser. The team plans to have the full design ready in May.

The team at West Seneca East Senior High School with State University College at Buffalo, N.Y., is designing and constructing an "integrated system of wind and solar components." They call their team WASP (Wind and Solar Power).

In the wind powered portion of their project, the WASP team says it has designed a spoked-wheel wind turbine which will be light weight, portable and an efficient system component. Recently, the team changed from an 8 ft. to a 12 ft. diameter wind turbine in the hopes of obtaining 2 KW at 20 mph with the 12 ft. turbine rather than the lower output of the 8 ft. turbine.

Another team, this one at Illinois Institute of Technology (IIT), is developing a solar-powered/jet-generator.

After submitting their design proposal, the IIT team says it split up into four subgroups: Solar Collectors, Heat Transfer, Heat Engine, and Electrical Generation and Storage. Each group is responsible for completing the design of its assigned subsystem.

In order to coordinate the groups, the IIT team has created a management group consisting of the project leaders from each of the subgroups. The project leaders assume the responsibility for system integration, budget determination, fund-raising, environmental impact assessment and communications with the Coordinating Committee.

IIT says its management group has not eliminated all coordinating problems for the 16 member team but added that as a result of bringing in new members, their solar powered/jet-generator system has undergone a series of "evolutionary steps."

SCORING

Joe Eschbach, chairman of the Coordinating Committee, gave a brief talk at the symposium on the scoring of team projects at the Final Test Event. Joe reiterated the philosophy of the Rules and Guidelines under each of the scoring topics: Innovation, Performance, Economics and Marketability.

Innovation, Joe says, will be broken into two categories: 1. Innovation of Concept—how innovative a team's idea is for a component's operation or design (This category, is not influenced by the success of component fabrication) and 2. Innovation of design/fabrication or modification—how clever a team is in getting a component constructed from scratch or modified from commercial parts. In Storage Innovation, Joe says, a team that uses electrical batteries commercially available will not receive innovation points whereas a team using any other means of storage will be awarded innovation in storage points.

Performance scoring was reviewed by Joe. It remains essentially unchanged as outlined in Newsletter No. 4, May 1976.

Joe says to make sure that all teams are using the same cost of materials data to insure fair scoring of all projects, the Coordinating Committee is requiring that teams use: *R.S. MEANS Building Construction Cost Data 1976*, as the standard of cost data. He says if your engineering school does not have one available, the book can be purchased at the educational cost of \$5 per copy (regularly \$15) from:

R.S. Means Company
100 Construction Plaza
Duxbury, MA 02332

In addition, Joe says the Coordinating Committee is writing a computer program, ERACC, which will calculate all economics costs of a project for a team. He says this should relieve some of the burden from the team, and insure uniform cost calculations. A cost questionnaire will be issued to every team in two months which will solicit cost data about each project. Teams should return the cost data to the Committee, which in turn will run through ERACC and calculate all cost data for the teams, and return the results to the team.

Joe also reviewed the marketability topics in the Rules and Guidelines at the symposium. Most important, he says, will be that each team will discuss each topic of marketability with ERA II judges in a presentation/discussion session at the FTE. The presentation will also be the team's chance to explain and emphasize details of its project which would otherwise be overlooked by the judges in the scoring of projects. He says teams will be free to use whatever visual aids and format it desires.

Complete details on ERA II SCORING will be forthcoming in the SCORING REPORT issued on April 1, 1977. Along with this report, he says, will be the cost questionnaire for each team to fill out and return to the Committee.

SCORE, ERA II Coordinating Committee
Department of Mechanical Engineering
Washington State University
Pullman, Washington 99163

SCORE
STUDENT COMPETITIONS ON RELEVANT ENGINEERING INC

ERA II NEWSLETTER

Vol. 4, Letter 8—June 1977

Final Test Event

The Final Test Event (FTE) for the ERA II Competition, scheduled for June 9-16, is rapidly approaching. There is where the efforts of a year-and-a-half will be put to test.

The FTE will take place at Richland, Washington, sun city of the Pacific Northwest and a major energy research center for the United States. The people of Richland have gone all out in their efforts to insure the success of the FTE, including opening their homes to lodge teams.

The schedule for the event is shown below.

Thursday	June 9:	project set-up
Friday	June 10:	project set-up, Welcoming Barbecue 6 p.m.
Saturday	June 11:	project set-up
Sunday	June 12:	24 hour testing of the electricity producing performance of the projects running off the environmental conditions at Richland, plus cost and innovation judging
Monday	June 13:	project rework, cost and innovation judging
Tuesday	June 14:	optional 24 hour testing, cost, marketability and environmental judging
Wednesday	June 15:	public open house 9 a.m. to 5:30 p.m., Awards Banquet 7 p.m. at the Hanford House
Thursday	June 16:	teams pack and leave for home

Final Test Event Site in Richland, Washington.

Teams will have three days to set-up and two opportunities to test their projects. On June 15 there will be a public open house, tours of energy development facilities for the teams and the Awards Banquet.

The Coordinating Committee office at Washington State University has been a bee-hive of activity in the weeks prior to the FTE. A bald spot on the Final Test Event Coordinator, Jon Anson's, head grows day by day. The scoring document, including a computer program to assist in the economic evaluation of the projects, has been written and sent to judges and teams.

The SCORE Headquarters at the FTE will be in Room 120 of the Joint Center for Graduate Study, 100 Sprout Road, Richland, Washington 99352, (509) 943-0128.

The SCORE Office at MIT has been busy arranging press coverage for the FTE. Articles in several major news sources have been arranged.

Grants

The final round of grants for the ERA II Competition has been distributed. Need was the most important factor in this round and, in all but a few cases, team needs were met.

Symposium Report

The first printing of the ERA II Symposium Report, which lacks one presentation, was sent out several weeks ago to teams. When the last presentation is received a second printing will be sent to those who requested a copy, the Board of Directors, team Faculty Advisors, and the Advisory Board. Others who would like a copy should send their requests to the return address on this newsletter.

The ERA II Final Report

A Final Report will be prepared on the Energy Resource Alternatives II competition for distribution this coming fall. Requests for the report should be made to SCORE, Room 9-220, MIT, Cambridge, MA 02139.

Final Newsletter

A final newsletter for the ERA II Competition will be issued in July with a report on the Final Test Event and information on the next SCORE competition.

SCORE, ERA II Coordinating Committee
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SCORE
STUDENT COMPETITIONS ON RELEVANT ENGINEERING INC

ERA II NEWSLETTER

Vol. 4, Letter 9—July 1977

Second place Grand Award went to University of Oklahoma's Modified Darrius Wind Turbine.

Final Test Event

The week long challenge of setting up and testing projects developed during the two year ERA II competition is over. Thirty teams from 22 universities and over 225 participants were present at the Joint Center for Graduate Study in Richland, Washington to test their projects. The wind projects were mounted on home built towers or telephone poles, many of which were over 40 feet in the air. Unfortunately, the wind did not cooperate as planned during the two 24 hour performance testing periods. Two large gusts of nearly 50 mph blew down two wind projects, while during the 24 hour test periods the wind hardly blew at all. Nevertheless, the sun was out in full force helping the solar projects show off. During the 24 hour testing, often the only sounds heard were coal, ethanol, and methane projects chugging away.

The Final Test Event, hosted by the ERDA Richland Operations Office was such a success because of the tremendous support from the firms and people of the Tri-Cities (Richland, Kennewick, and Pasco). The teams stayed in local engineers own homes during the week long event, and many of these engineers doubled as the team's

Liason Engineers, providing them with technical advice if needed and materials from company shops on short notice.

At the Award's Banquet on June 15, 1977, the excitement was high from the anticipation of the awards to be handed out, plus the knowledge that the week of steady work and little sleep was over.

Below is a list of Awards given out:

First Place Grand Award: Kansas State University
Second Place Grand Award: University of Oklahoma
Third Place Grand Award: West Virginia University
Grand Innovation Award: University of Texas at Austin
First Place Wind Division: University of Florida at Gainesville
Second Place Wind Division: Southern Methodist University
Third Place Wind Division: Washington State University
Third Place Wind Division: University of Wisconsin at Stout
First Place Wind Innovation: University of Oklahoma
Second Place Wind Innovation: University of Florida at Gainesville
Third Place Wind Innovation: Washington State University
First Place Solar Division: Georgia Institute of Technology
Second Place Solar Division: Midwestern State University
Third Place Solar Division: Oregon State University
Second Place Solar Innovation: Georgia Institute of Technology
Third Place Solar Innovation: Midwestern State University
First Place Organic Division: Georgia Institute of Technology
Second Place Organic Division: Washington State University
Third Place Organic Division: University of Wisconsin at Madison
First Place Organic Innovation: University of Wisconsin at Madison
Second Place Organic Innovation: Washington State University
Third Place Organic Innovation: University of Wisconsin at Green Bay
First Place Combined Systems Division: West Seneca High School-Buffalo State University
Second Place Combined Systems Division: Oregon State University
Third Place Combined Systems Division: University of Wisconsin at Milwaukee

The Next Competition

The next SCORE competition has the title of "Energy Efficient Vehicles."

There is no limitation to the source of energy. Alternate sources of power such as electricity, coal, wood and ethanol will be highly rewarded. The details of the next competition can be obtained, when available, by contacting John Sununu.

Members of Oregon State University Concentrating Solar Collector team wiping down their reflecting surface.

Volunteers For The Next Coordinating Committee

The next competition should be exciting. While the preliminary organization has been done, the Coordinating Committee for the Competition has not yet been chosen. The Coordinating Committee can be located at any university or college in the United States. They will be responsible for the day to day affairs of the competition. Their principle duties will include: writing the Rules and Guidelines, recruiting teams, and running the Final Test Event.

It is an exciting job with lots of opportunities. Universities and Colleges who are interested should contact:

John Sununu, Room 105 Anderson Hall
Tufts University, Medford, MA 02155
(617) 628-5000 Ext. 268

Apologies

The SCORE national office at MIT appologizes to the University of Florida at Gainesville for their mistake in national newsrelease.

Florida was not listed as the first place winner in the Wind Division Category. We extend congratulations to the University of Florida for their First Place Award.

New President of SCORE

Richard Aseltine, the President of SCORE, has resigned and will be leaving the office on July 15, 1977. The SCORE president helps set overall policy and is responsible for national publicity and fund raising. A technical background is helpful. Anyone interested in applying for the position should contact John Sununu, address above.

ERA II Final Report

The Final Report for the ERA II competition is being compiled and written right now. The complete report documenting all activities of the two year competition and the team projects should be available from the national SCORE office in the Fall of 1977. For more information on the availability of the Final Report, contact John Sununu.

SCORE, ERA II Coordinating Committee
Department of Mechanical Engineering
Washington State University
Pullman, Washington 99164
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APPENDIX F

SCORE TEAM GRANTS

SCORE, Inc. made the grants listed on the following page to teams participating in the Energy Resource Alternatives II Competition. This list reflects grants awarded prior to the Final Test Event and includes unused funds that were returned at the completion of the competition. SCORE grant funds were used to help pay for the project construction

costs and travel expenses associated with the Final Test Event held in Richland, Washington. These SCORE grants were seed-money awards and were not expected to cover the team's entire project costs. Contributions of cash, materials, and equipment from their university and local sponsors provided the balance of each team's support.

<u>Team #</u>	<u>Name of School</u>	<u>Total Grant</u>
10	University of Houston	\$2,088
13	University of Houston	900
16	University of Houston	1,944
19	Washington State University	1,625
22	Rensselaer Polytechnic Institute	3,047
25	Amarillo College	1,672
28	University of Wisconsin @ Green Bay	1,919
31	Rutgers University	3,057
34	West Virginia University	2,601
37	Oklahoma State University Technic	1,920
40	Christian Brothers College	1,753
43	Southern Methodist University	2,321
49	University of Pittsburgh @ Johnstown	1,808
58	Stevens Institute of Technology	2,010
64	University of Texas @ Austin	3,223
67	California State U. @ Long Beach	2,156
70	Washington State University	1,125
76	West Seneca High School	2,543
79	Massachusetts Institute of Technology	2,052
81	Georgia Institute of Technology	1,990
84	Georgia Institute of Technology	2,030
90	Georgia Institute of Technology	1,845
93	Georgia Institute of Technology	1,885
97	Midwestern State University	3,712
100	University of California @ Berkeley	2,694
106	Kansas State University	2,084
109	University of Evansville	2,847
112	University of Wisconsin @ Madison	2,802
115	Illinois Institute of Technology	2,925
121	University of Maryland	1,834
124	University of Oklahoma	2,321
127	University of Oklahoma	1,387
130	University of Florida @ Gainesville	3,256
133	University of Wisconsin @ Milwaukee	1,414
136	University of Wisconsin @ Stout	1,470
142	Oregon State University	2,333
145	Clemson University	2,310
151	Oregon State University	3,113
154	University of Alabama @ Huntsville	1,579
157	University of Florida @ Gainesville	1,920
160	University of Florida @ Gainesville	1,920
163	University of Alabama @ Tuscaloosa	2,194
		<u>\$91,629</u>

APPENDIX G

INNOVATION SCORING

Objective

The objective of evaluating all ERA II entries on innovation is to reward those projects exhibiting innovative engineering. The history of alternative energy availability is extensive, and current technology can produce electricity from these sources. However, for alternate sources to become cost effective, breakthroughs by innovative engineering must occur to reduce system costs and boost energy output.

Innovation Judges

ERA II innovation judges will be selected from the federal government, industry, and education.

Innovation Abstract

A short abstract of a team's innovations must be available at the team site of the Final Test Event. The abstract should identify the team's innovations by: (1) describing the current state-of-the-art for similar commercially-available counterpart components; (2) describing the team's goal for the innovative designs, i.e., smaller size, less weight, optimal performance, reduced costs, etc.; and (3) describing how successful the team feels their designs met the innovation goals. Twenty copies of the abstract should be available upon arrival at the site to be bound by the Committee for disbursement to judges prior to project review.

Student Innovation of Concept

It is intended that this section will reward teams who exhibit innovative ideas in component concept. An innovative idea is constituted by a new means of achieving a component's operation when that means is unknown by current technology. The idea's success of execution as a finished component, or performance, will not be considered. Cognizant of the team's innovation abstract, the judges' responses will range from 0 to 13 points.

Fabrication and Modification

It is intended that this section will reward teams for excellence in the execution of innovative ideas by the student fabrication of student-designated parts, and the student modification of commercially-available components. Excellence in fabrication and modification is the successful transformation

of an innovative idea into operating hardware by clever design and fabrication, or the modification of commercial components. Cognizant of a team's innovation goal and innovative ideas, the judges' responses will range from 0 to 12 points. If a team exhibits only original design and fabrication, or only the modification of commercial parts, the judges will evaluate the appropriate sub-category for a possible 12-point maximum. If a team's project exhibits a portion of each sub-category, the judges will award a possible maximum of 12 points in view of how well both sub-categories contribute to the innovation goal.

Storage Innovation

If a team's optional energy storage system uses any means of storage other than that used in the current technology existing for electrical storage which is commercially available (batteries, for example), the system will receive innovation storage points. The judges' responses will range from 0 to 5 points.

PERFORMANCE SCORING

Objective

Since the ERA II Competition is an engineering design competition, it is imperative that the team's hardware performs to achieve the design objective. The design objective is to produce single-phase AC or DC electricity at 110, 220, or 24 volts in a variable range from 0 to 2.5 kw power by closely following the ERA II load curve. The performance scoring contributes up to 25% of a team's final score. The performance section is broken into two main parts: (1) total output for 12.5% of a final score; and (2) peaking output for the final 12.5% of the final score.

Load Curve

The ERA II load curve was constructed from an actual average of residential power consumption in the U. S. The approximate area underneath the load curve totals 34 kw hours. The purpose of using the realistically derived load curve is to correctly locate the time and magnitude of user demand.

Total Output Scoring

For 20 kw hours in a 24-hour period, a system will receive 100% of the 12.5 points allocated to total output scoring. Additional points will not be awarded for output in excess of 20 kw hours for the 24-hour period. 20 kw hours was chosen as the upper limit in power for maximum points because a current challenge to using alternate energy is to develop a system which supplements the utility power supply. Hence, less than the full load curve is required to demonstrate a system's achievement of design criteria for maximum total output points. Total output

will be scored on a linear scale. For 10 kw hours in a 24-hour period, the system will receive 50% of total output points, while for 0 kw hours in a 24-hour period, the system will receive 0 points.

Peaking Output Scoring

One of the very real benefits of an alternative energy system is its usage as a peaking power source which will relieve much of the peaking burden from the utilities. Hence, ERA II projects will be tested for peak power capabilities. The basis for peaking points is a system's ability to meet the peaks in the ERA II load curve. The peaking area of the load curve is defined as the area of the load curve bounded by the times 6:30 to 22:30 hours, and above the 0.75 kw line. The peaking area contains 16 kw hours for a 24-hour period. Peaking power will be scored on a linear scale. Similar to the Total Output Section, a team that produces 16 kw hours in the peaking region will receive 100% of the peaking points. If a team produces 8 kw hours in the peaking region, they will receive 50% of peaking points, while a team that produces 0 kw hours in the peaking region will receive no points for peaking output.

Environmental Scaling Factor

The Coordinating Committee realizes that the input conditions for which a team is designing a project may not exactly occur on the Final Test Event test day or that damage may occur during transit. At the Second Symposium, the Committee indicated that an "environmental scaling factor" was being considered. The scaling factor would scale the environmental conditions present at the Final Test Event to the team's design conditions allowing a direct comparison of power outputs. After extensive research and consultation with alternate energy experts, it is apparent that an accurate scaling factor is not possible. Wind turbines are designed to operate in a narrow band of wind speeds with changing efficiency at the different speeds, and solar system efficiency changes with solar incidence as the possible temperature difference changes. The result is that for 50 different alternative energy systems, there is no scaling factor which can be applied fairly and accurately to all.

If the environmental conditions at the Final Test Event do not meet a team's design environmental conditions, a team may petition the Coordinating Committee to use the team's certified home-site test results as performance data. The petitioning process will require that a team submit its home-site test data and original design criteria environmental input data, as sent to the Coordinating Committee in the Design Proposal, to a special panel of judges who are familiar with environmental conditions throughout the U. S. and the power capabilities of alternative energy hardware. It will be the judges' duty to decide whether the home-site power output is realistic, given the environmental input. If a team designed its project for a

region different than that used in the home-site test, it is the Team's responsibility to also provide the judges with a certified performance curve (input-vs-power output) for their project. The performance curve should show, given the home-site results and the environmental conditions at the design site, that the team's claimed power output is feasible at the design site. If the judges agree that the design output could be achieved from the design input, the design output will be substituted for the performance test results. If the judges do not accept the home-site or design results, the performance scoring will be based upon results taken at the Final Test Event.

Testing Procedure

The performance testing will be conducted over a 24-hour period. The electrical loading of systems during the 24-hour period will follow the ERA II load curve. The quantities that will be measured and recorded into the Final Test Event computer are:

- (1) load voltage;
- (2) load current;
- (3) storage system voltage;
- (4) storage system current; and
- (5) auxiliary power input.

These quantities will be recorded throughout the 24-hour test period at relatively short time intervals. The Coordinating Committee will measure these quantities by reading the instrumentation installed on the project by the team, except for the auxiliary power, whose instrumentation will be provided at the Final Test Event.

Auxiliary Power

The electrical output of a system shall be set up in such a way that no power input to the system from an outside electrical source may be used to contribute to the electrical output of the alternative energy system directly. Auxiliary energy input to power fans, etc., will be recorded on a watt-hour meter provided by the city of Richland. At each reading during the 24 hour test, the auxiliary power used will be deducted from the team's power produced during that interval of the test.

Overload

If, during the test period, the system is overloaded (where the deviation in voltage is greater than +10% of the ERA II accepted values given in the Rules and Guidelines, the load on the system will be reduced until acceptable voltage can be maintained.

What the Teams Need to Bring to the Final Test Event

All teams must bring the following to the Final Test Event:

- (1) voltmeter to measure load voltage;
- (2) ammeter to measure load current;
- (3) voltmeter to measure storage system voltage;
- (4) ammeter to measure storage system current;
- (5) resistance loading device;
- (6) hard hat for every team member;
- (7) one clip-board to display test results; and
- (8) completed "Team Statistics" portion of Home-site Testing Document.

If a team's storage system is different than electrical storage in batteries, the team must come equipped with adequate instrumentation to measure the energy dissipation of their storage system, i.e., thermometers, flowmeters, pressure gages, etc. The team should bring the necessary auxiliary equipment to calibrate their instrumentation at the Final Test Event.

Since there are no industry standards to judge the quality of AC or DC power by frequency, ripple, etc., no measurement of output quality will be made.

Storage Systems

The storage system will be charged up to its normal fully charged capacity prior to the test. Additional storage facilities or components other than those incorporated in the system will not be used to store energy or to supply energy during the course of the test. The total power delivered by the storage system to the load will be deducted from the total output of the system at the end of the 24-hour test.

Instrumentation Calibration

All instrumentation should be calibrated before use at the Final Test Event. The Coordinating Committee will be spot-checking instrument accuracy at the Final Test Event.

Resistive Loading Device

All teams will bring a resistive loading device to the Final Test Event which can simulate the ERA II load curve for power demand and duration. The most probable supply for the load devices will be a school's electrical engineering department. If one cannot acquire a resistive device at school, one can be built from common light bulbs. The reactance in a household light bulb at low frequencies is minimal. A light bulb bank with a set of switches allows one to vary the load in small increments from 0 to 2.5 kw for fine tuning of the project loading. Wiring diagrams for suggested loading devices for 110 and 220 volts are shown in Figures A through E. For a 24-volt system, the number of light bulbs to handle the large currents is prohibitive. Rather, one would want to use a loading device from an electrical engineering department or a loading device from a commercial battery maker. Reactive motor/generator loads are not acceptable.

MARKETABILITY SCORING

Objective

The final evaluation of team projects occurs in the marketability presentation. The marketability score is 20% of a team's final score. The goal of the marketability presentation is to allow each team to demonstrate to the judges how thoroughly the team has considered the very important marketability and environmental aspects of a project and how the project has been designed to meet those considerations.

Marketability Judges

The marketability judges will represent a cross section of professionals from industry and government who are familiar with component reliability, repair, environmental impact, and the retailing of commercial products.

Procedure

Each team will have one hour to make their verbal presentation to a panel of marketability judges. The presentation should demonstrate how thoroughly the teams considered and designed for the six marketability topics. The format of presentation is unrestricted. A team may use any audio-visual material which they deem desirable and effective to make their points. A team should expect to field judges' questions and should plan their time accordingly. The six marketability topics and the information which the judges will be looking for are:

- (1) Potential Market: How many of the team's units can be sold per year in their market and market location?
- (2) Maintenance Schedule: Is the schedule desirable in complexity and frequency to insure predictability of the system's operation?
- (3) Durability: Will the project operate with scheduled maintenance for the 20-year economic life of the system?
- (4) Simplicity: Does the system's design allow malfunctions to be traced and repaired?
- (5) Safety: Have adequate precautions been taken to prevent the system from "run-away" operation in severe environmental conditions? Have safety precautions been taken to protect the owner of the system from mishap during operation?
- (6) Environmental Impact: Have the effluents of system operation been satisfactorily taken care of?

Scoring Responses

All six marketability categories are equally weighed. After the team's presentation, the judges will assign a single score out of a maximum of 20 possible points.

ECONOMICS SCORING

Objective

The intent of the economics scoring section is to evaluate the economic feasibility of all ERA II alternate energy systems by a standardized method. The acceptance of alternate energy systems in the marketplace will depend upon its socio-economic costs. The Coordinating Committee has developed a computer code, ERACC, to evaluate all of the ERA II project economics. The Exotic Materials Report, Project Job Costs Report, and the Net Energy Report must all be completed and returned to the Coordinating Committee by May 28, 1977 for uniform evaluation. The economics scoring will evaluate all ERA II projects in three important socio-economic categories: (1) Busbar Electricity Cost; (2) Net Energy Accounting; and (3) Exotic Materials Requirements. The distribution of points among the categories are divided as follows: 12.5 points allocated to Busbar Electricity Costs, 7.5 points to Net Energy Accounting, and 5 points to Exotic Material Requirements.

I. Exotic Materials Requirements

Objective: "Since energy is fundamental, energy production must have first call on materials" (2). The intent of this section is to identify those mass-produced alternate energy systems whose material requirements will seriously strain the U. S. production of key exotic materials.

Procedure: Using several references -- (1), (2), and (3) -- a list of exotic materials used in alternate energy systems was compiled. Each team will fill out the Exotic Materials Report for their project. The report must indicate how much, if any, of each material is used in the project. The units of the report are in kg of material per project. The potential annual commercial market for the project should also be recorded (the same as in the Marketability "Potential Market" topic). Since energy independence is the nation's goal, the total demand for the energy-related materials must be judged in terms of domestic production. From the annual market prediction and materials usage per project based on a project that produces 20 kw hr/24 hours, an annual total use of the key materials can be calculated. The annual total usage will then be compared to the U. S. 1976 annual production of each material. If no material use is larger than 2% of the annual U.S. production, then the project will receive 5 points (4). If any material use is larger than 2% of the annual U. S. production, then the project will receive 0 points for the Exotic Materials section of the Economic Scoring.

Exotic Materials Annual Production (3)

Aluminum	3.811×10^9	kg
Steel	1.162×10^{11}	kg
Copper	1.388×10^9	kg
Cement/Concrete	6.679×10^{10}	kg
Silicon	4.90×10^8	kg
Cadmium	1.996×10^6	kg
Gallium	2000	kg
Arsenic	5.445×10^6	kg
Tellurium	5.942×10^4	kg
Selenium	1.842×10^5	kg
Fiberglass-Resin (1)	2.632×10^8	kg

Scoring Responses:

(1) If an annual demand for any material exceeds 2% of the annual U. S. production, the project will receive 0 points for the Exotic Materials section of the Economics Scoring.

(2) If a project's material requirements never exceed 2% of any of the listed materials, then 5 points will be recorded for the Exotic Materials section of the Economics Scoring.

II. Net Energy Analysis

Objective: By mandate from the federal government, all alternate energy projects must be evaluated for net energy production.

Federal Non-Nuclear Energy Research and Development Act, 1974, Section 5 (a) 5 states: "The potential for production of net energy by the proposed technology at the stage of commercial application shall be analyzed and considered in evaluating proposals."

The intent of this section is to evaluate the net energy-producing capabilities of the ERA II alternate energy systems. This section counts for 7.5 points of a team's total score.

Procedure: For every material, component, etc., used on an alternate energy system, special coefficients have been devised which indicate the energy content embodied in each portion of the project. For example, the steel coefficient shows how much coal, petroleum, gas, and electrical energy was used in the mining, refining, transporting, and fabricating of one dollar of finished steel ready for consumption. If every material and commodity used on a project are multiplied by the energy coefficients and then summed, a total energy cost of the project is calculated.

The annual energy production of a system is taken as energy revenue. One can then solve for the years that will be required of energy production for the system to pay back the

energy required to build the system. At this point, the net energy balance is zero: Cost = Revenue.

Considering energy consumed now to produce an alternate energy system, as an investment, one expects a favorable return on that investment in the future. Using a modest interest rate of 6%, the doubling time of an investment is about 12 years or an investment of one energy unit now should pay back two energy units in 12 years.

For ERA II, each team must complete the Net Energy Report indicating how many 1976 dollars of each material or component are contained in their system. The Net Energy Report lists 45 materials and components commonly found in alternate energy systems. The Net Energy Report must then be returned to the Coordinating Committee by May 28, 1977 for standardized evaluation in ERACC. ERACC uses energy coefficients calculated by Bullard et al (5), for the 45 categories which indicate how many watts of oil, coal, natural gas, and electricity are embodied in each 1976 dollar of the commodity. The coal, oil, and natural gas coefficients were converted to an electrical equivalent using thermal efficiency of 35%. A total amount of electrical energy per dollar per category is then calculated. Using the team's indicated use of the materials and commodities, an energy cost per project can be calculated.

Given the annual energy production of the system, the time period required to double energy revenue compared to energy cost for a 6% interest rate is then calculated. Based on this time period, different scoring responses will be made.

Scoring Responses:

- (1) If energy payback doubling time is .LE. 12 years:
7.5 points.
- (2) If energy payback doubling time is .LT.18.but.GT.12:
1.9 points.
- (3) If energy payback doubling time is .GT. 20 years:
0 points.

III. Busbar Cost of Electricity

Objective: The role of alternate energy in the marketplace will be determined by the relative cost of power generated by the alternate energy system. The intent of this section is to estimate the mass-produced system's Busbar Cost of Electricity to the consumer from an ERA II project.

Procedure: Using the computer code, ERACC, the construction of any system is broken down into a line of sequential jobs. At each job, the material and labor costs for that job are entered into the cash flow. As the system proceeds down the assembly line, the material and labor costs are automatically added (see figure 1). At the end of the assembly line, the sub-totals of material and labor costs for a system are available from the continuously added sums.

By learning curve analysis, the labor costs of a mass-produced system are 0.25 of the prototype labor costs (6). Therefore, ERACC will reduce the subtotal labor costs of a project by 0.75 to calculate the project's total labor costs. The material and total labor costs are then summed at the end of the assembly line for the total system cost.

To estimate the purchase cost of an alternate energy system to the consumer, ERACC adds a manufacturer's overhead cost, a working capital cost, and a profit cost to the previously calculated assembly line cost.

ERACC calculates the manufacturing overhead costs as a 125% surcharge applied to the total labor hours expended on the project.

For a manufacturing process, materials and labor tied up in partially-completed products represent real costs to the producer. Money that could have been put in interest-bearing investments is instead invested in non-interest bearing products. Hence, the income forgone by the investment, or the cost of money to fund the manufacturing process in materials and payroll must be added to the cost of the final product. Given an annual working capital interest rate (i), and the fraction of a year that the time to complete one unit is (n), the cost of working capital is calculated by multiplying the assembly line cost of the system by the standard single payment future value factor.

Cost of working capital = (Assembly line capital cost) * (i)ⁿ

ERACC uses a working capital rate of 10% which is representative of the interest rate for a small manufacturer (2).

Since ERACC transforms the prototype cost of a project into a likely mass-produced cost, for an estimation of the profit rate, the routine assumes that equilibrium mass production runs have been accomplished. This voids the complexities of determining a gross profit rate in view of start-up costs, marketing costs, quality control costs, etc. For ERA II, a gross profit rate of 10% was chosen from current literature (6).

Given a per unit profit rate based on the final assembly line cost of the product, a simple profit multiplier is applied to the assembly line cost to appropriately boost the cost of the final product.

$$\text{Profit cost} = (\text{Assembly line cost}) * (\text{Profit rate per unit})$$

Then, the estimated purchase price of an alternate energy system is:

$$\text{Purchase price} = \text{Assembly line cost} + \text{Overhead cost} + \text{Working capital cost} + \text{Profit cost}.$$

ERACC estimates the annual Busbar Cost of Electricity to the system owner by amortizing the purchase cost of the system and by adding the additional cost of insurance, taxes, operation, and maintenance.

By the standard application of the equal payment series capital recovery factor, the capital recovery factor indicates to the owner the amount of money that must be paid to purchase the total system:

$$\text{Capital recovery factor} = (1. + i)^n (i / [(1. + i)^n - 1])$$

where i = interest rate, and n = payback years, and the annual amortized costs are then calculated as:

$$\text{Annual amortized system cost} = (\text{System purchase cost}) * (\text{Capital Recovery Factor})$$

For ERA II, an interest rate and payback period were chosen to represent the median between the two extremes of automobile versus household product financing. An interest rate of 10% and the payback period of 10 years are used. At the moment, this is the best estimate of the eventual amortization conditions which will apply to an alternate energy system in the near future.

Estimating the annual cost of insurance for the protection of the total system as a small percentage (r) of the system purchase cost, the annual cost of insurance:

$$\text{Annual insurance costs} = r * (\text{Purchase price of system} + \text{Battery Cost})$$

The annual insurance rate (r) is entered as input data. For ERA II, the annual insurance rate of 0.1% is taken from current literature (6).

As an approximation to a system's annual operation and maintenance cost, it is accepted that a small percentage multiplying factor of the capital cost adequately models these important costs (6, 8, 9). Estimating the annual cost of operating and maintaining the total system as a small per-

tage (p) of the system purchase cost, the annual cost of operation, and maintenance is:

Annual operation and maintenance cost = (p)*(Purchase cost)

For ERA II, the annual operation and maintenance cost rate is 2% and is entered as input data (13).

Since an alternate energy system represents an addition to the value of a household, one can anticipate a higher tax assessment. Even though the tax structure is complex, one can estimate the annual cost of taxes for the total system as a small percentage (q) of the system price plus battery cost (13). The annual cost of taxes is then:

Annual tax cost = (q)*(Purchase price + Battery cost)

For ERA II, the tax rate is 1.5% of the total system cost (6),

Electric Energy Cost: Summing up the individual cost components -- annual amortized system cost, insurance costs, operation and maintenance cost -- the result is a total annual cost to the consumer of owning the complete energy system. By entering the annual power output of the system in kw hours, and the load factor for the system (LF) as input data, the total annual cost of power to the consumer is calculated by:

Annual Busbar Cost of Electricity = $\frac{\text{Total system annual cost (\$)}}{\text{Annual power (kw hrs.)} * \text{LF}}$

The load factor (LF) indicates the amount of overlap between the alternate energy source and the residential electrical load. The load factor is the fraction of energy delivered to the load compared to the upper limit of energy that the system could produce at a given location.

Load factor = $\frac{\text{Average power output}}{\text{Rated power output}}$

Each team must complete the Project Job Costs Report. The report is broken down into 30 individual jobs. Thus, a team can consider the construction of their project as composed of 30 individual jobs. Examples of possible jobs may be: machining of cylinders for stirling engine, cutting of lumber for supports, bending of tubing, assembly of collectors from component parts, etc. These only serve as examples. The possible list of jobs for an individual project goes on. Some aggregation of jobs may be necessary to reduce the total description of the project to 30 individual jobs. At each job, the cost of materials used in the job should be indicated in dollars and cents. The prices for the materials must come from the R. S. Means Construction Cost Data Book, 1976 to insure uniform costs throughout all the projects. (Remember that this was stipulated in the #7 NEWSLETTER and at the Second Symposium.) These materials are like steel plate, 2 x 4 lumber, copper tub-

ing, etc. Tools are not included. If a cost for a component cannot be found in the R. S. Means book, then by permission from the Coordinating Committee, a team may use another representative commercial price. In addition to materials, each job should indicate how many hours of labor are involved to accomplish that job. Consulting the labor key at the bottom of the project costs report, the team should also indicate what type of labor was used by placing the number of the labor title in the appropriate column. The recording of material cost, labor time, and labor type should be done for each of 30 job steps.

The completed Project Job Cost Report should be mailed back to the Coordinating Committee along with the Exotic Materials and Net Energy Report by May 28, 1977 for computation and scoring. A partial example of a completed job cost sheet is shown below.

<u>Step</u>	<u>Description</u>	<u>Material Cost</u>	<u>Labor Type</u>	<u>Labor Time</u>
.	.	.	.	.
14	Machine Collectors	\$ 50.00	1.	2 hours
15	Drill Plate Holes	.00	1.	.5 "
16	Install Pump	100.00	4.	2 "
17	Control Wiring	50.00	2.	8 "
.	etc.	etc.	etc.	etc.

Scoring: Once all the team Project Job Costs Reports are returned to the Coordinating Committee, the scoring of all points will range from 0 to 12.5 points based on the natural breaks in the distribution of team Busbar Electricity Costs.

Amendments and Additions to Scoring Document

(1) When completing the Project Job Costs Report, a team should cost their project as it appears at the final test site, not as one might think the project would appear when mass produced. The ERACC costing scheme already includes factors to account for the cost reduction from the team's prototype to a mass-produced product. In estimating the labor time for each component, the team should report the time necessary to only fabricate and assemble the components. Do not include the development time.

(2) At the Final Test Event, each project will undergo a cost judging review. Professional cost estimators from industry will check each project's job cost information to verify its accuracy. The cost judges will have the authority to change any cost information that they feel is incorrect. If so, the economic calculations will be re-done and the project

re-scored using the corrected figures. The cost judges will review the projects at the team's site at the final test site, with free exchange between team members and judges.

(3) In evaluating the project's "Durability" (see the Marketability section of the Scoring Document), the marketability judges may change the expected economic life of a project. Initially, all projects are assumed to have a 20-year economic life. If the judges adjust the figure based on project design, construction, etc., the new adjusted figure will be used in re-calculation of project economics along with the appropriate re-scoring.

(4) To insure that all projects are evaluated for Exotic Material Requirements as systems producing the design criteria output of 20 kw hours in a 24-hour period, the material inputs of a project will be scaled to represent a system producing 20 kw hours in a 24-hour period.

(5) Estimating the operation and maintenance costs of a system by a small percentage of a capital cost is not fine enough to judge the many ERA II projects. Instead, each team must submit an individual figure indicating the annual cost of the project's operation and maintenance. This should include the costs of fuel, auxiliary power to drive fans, and maintenance costs, etc.

(6) To calculate the load factor, the rated power output should be the annual power demanded by the portion of the ERA II load curve used in scoring (20 kw hrs./24-hrs. or 7300 kw hrs. per year). The average power output is the annual average power output of a team's project at its design location.

Therefore,

$$\text{Load factor} = \frac{\text{Average power output}}{7300 \text{ kw-hrs.}}$$

The maximum load factor can only be 1.0. A load factor greater than 1.0 indicates that the design criteria has not been met for power production since the system is oversized. If a team's load factor is greater than 1.0, for the purpose of calculations, the load factor will be truncated to 1.0.

(7) There was an error in the original Scoring Document. The expression for the annual Busbar Electrical Costs should have been:

$$\text{Annual Busbar Cost of Electricity} = \frac{\text{Total system annual cost (\$)}}{\text{LF} \times \text{annual power output (kw-hrs)}}$$

REFERENCES

- (1) Federal Energy Administration, "Project Independence-Solar Energy Task Force Report," November 1974, National Science Foundation, Washington, D.C.
- (2) "Demand and Supply of Non-fuel Minerals and Materials for the United States Energy Industry, 1975-90--A Preliminary Report," Geological Survey Professional Paper 1006A,B, United States Department of the Interior.
- (3) Commodity Data Summaries 1977, Bureau of Mines, United States Department of the Interior, Washington, D. C.
- (4) Conversation with R. L. Watts, April 20, 1977, Battelle Northwest Laboratories, Richland, Washington.
- (5) Bullard, W. Clark; Penner, Peter S.; Pilati, David A., "Energy Use Handbook," CAC Technical Memo No. 214, October. 1976, Center for Advanced Computation-University of Illinois at Urbana-Champaign, Urbana, Illinois.
- (6) Coty, Ugo and Vaugh, Lou, "Effects of Initial Production Quantity and Incentives on the Cost of Wind Energy," Lockheed California Co., January 3, 1977, Burbank, California.
- (7) Conversation with loan officer, December 12, 1976, Seattle First National Bank, Pullman Branch.
- (8) LeBoff, J. Peter, "Wind Power Feasibility," Energy Sources, Volume 2, Number 4, Crane & Russak Co., Inc.
- (9) Obermeir, John Lee, "Wind - Electric Power Generation in Montana," M.S. Thesis, March 1976, Montana State University, Bozeman, Montana.

Project Job Costs Report

Team name: _____

Team number: _____

I. Job Costs Sheet

STEP	DESCRIPTION Limit description to 20 characters maximum.	MATERIAL COSTS	LABOR TYPE	LABOR TIME
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				

STEP	DESCRIPTION	MATERIAL COSTS	LABOR TYPE	LABOR TIME
20.				
21.				
22.				
23.				
24.				
25.				
26.				
27.				
28.				
29.				
30.				

Labor type key

1. Carpenter
2. Electrician
3. Machinist
4. Motorized equipment mechanic
5. Painter
6. Plumber/Steamfitter/Pipefitter
7. Heating/refrigeration mechanic
8. Sheet metal mechanic
9. Welder
10. Assembly line labor

S C H E M A T I C A.

SYSTEM TESTING DIAGRAM

S C H E M A T I C B.

(110 Volt Light Bulb Loading Bank)

S C H E M A T I C C.

110 Volt Light Bulb Loading Bank

S C H E M A T I C D.

(220 Volt Light Bulb Loading Bank)

S C H E M A T I C E .

220 Volt Light Bulb Loading Bank

NET ENERGY REPORT

Team Name: _____

Team Number: _____

I. Please indicate the amount, in 1976 dollars, of each material or component used in your team's ERA II project.

1. Textile goods: _____	23. Zinc: _____
2. Veneer and plywood: _____	24. Aluminium: _____
3. Other assorted wood products: _____	25. Non-ferrous metal products: _____
4. Miscellaneous chemical products: _____	26. Heating/air conditioning system hardware: _____
5. Plastics: _____	27. Other hardware: _____
6. Paint products: _____	28. Pipe: _____
7. Tires: _____	29. Fabricated metal products: _____
8. Leather: _____	30. Steam engine: _____
9. Glass containers: _____	31. IC engine: _____
10. Cement: _____	32. Pump-compressor: _____
11. Bricks: _____	33. Bearings: _____
12. Ceramic tile: _____	34. Blowers: _____
13. Clay refractory: _____	35. Power transmission equipment: _____
14. Plumbing fixtures: _____	36. Refrigeration equipment: _____
15. Concrete products: _____	37. Electrical system instrumentation: _____
16. Stone products: _____	38. Transformers: _____
17. Asbestos: _____	39. Switchgear: _____
18. Gaskets: _____	40. Motors/generators: _____
19. Non-clay refractory: _____	41. Electrical hardware: _____
20. Steel products: _____	42. Computers: _____
21. Copper: _____	43. Batteries: _____
22. Lead: _____	44. Scientific instrumentation: _____
	45. Optical instrumentation: _____

II. What is the annual power output of the system in the project's market: _____ kwhrs.

II. Load Factor

The definition of the load factor is the fraction of energy delivered to the load compared to the upper limit of energy that the system could produce at the project's market.

$$\text{Load Factor} = \frac{\text{Average power output}}{\text{Rated power output}}$$

III. Annual Power Output

The annual power output of our system at its market place is:

_____ kwhrs.

EXOTIC MATERIALS REPORT

Team Name: _____

Team Number: _____

- I. Please indicate, in kg, the amount of each material used in the teams project:

Aluminium	_____	kg
Steel	_____	kg
Copper	_____	kg
Cement/Concrete	_____	kg
Silicon	_____	kg
Cadmium	_____	kg
Gallium	_____	kg
Arsenic	_____	kg
Tellurium	_____	kg
Selenium	_____	kg
Fiberglass & Resin	_____	kg

- II. How many units per year of the project do you estimate can be sold in the project's market? _____
- III. What is the annual power output of the system in the project's market? _____ kw hrs.

APPENDIX H

HOME-SITE TESTING DOCUMENT

May 1, 1977

I. Objective

This document provides all teams with a procedure to record their project's performance during home-site testing. In the event of project damage during transportation to the final test event, or inclement weather during the final test event, this performance data may be submitted as performance data eligible for scoring in lieu of the data actually taken at the final test event. For more complete details on this process, please consult the scoring document, "Environmental Scaling Factor."

II. Testing Procedure

The test must be over one continuous 24-hour period. The requested data must be recorded at successive 15-minute intervals.

If more than one alternate energy input is used (such as wind and solar), each input must be separately recorded.

The load voltage, the current, and the product (watts) must be recorded as shown. If, during the test, the system is overloaded where the deviation in voltage is greater than $\pm 10\%$ of the acceptable output voltages given in the Rules and Guidelines, the load on the system must be reduced until the acceptable voltage is maintained.

The resistive load used in the test must be variable so as to duplicate the load curve of power demand as shown in the Rules and Guidelines.

If a system uses an alternate energy source which cannot be tabulated under the categories given on the data chart, the team must record similar data which shows the Committee how much energy is produced from the alternate energy source.

All auxiliary power used to drive pumps, blowers, etc., whose origin is not from the team's project must be recorded as shown.

The test may begin with the storage system fully charged up. During the test, storage system voltage and current (+ for charge; - for discharge) must be recorded as shown. If elec-

trical storage by batteries is not used, the team must record similar data which will tell the Committee how much energy is delivered to and from the storage system to the main system.

Vital project statistics and system diagram must be recorded under the "Team Statistics" section. All test results must be certified by the team captain's and faculty advisor's signature.

A professional engineer not directly connected with the project must verify by his signature that the system producing the submitted results is the same as the one diagrammed in "Team Statistics" and that correct instrumentation was used to obtain the results.

All readings must be accurate to within ± 0.1 of the unit recorded.

TEAM STATISTICS

School Name and Number: _____

Date: _____

I. General Characteristics

- a. Type of alternate energy source: _____
(If different than solar and wind, give details on composition, energy content, etc.)
- b. Average % efficiency of energy conversion from alternate source to electricity: _____
- c. If system has multiple alternate energy inputs (i.e. wind and solar), indicate average % of each source's contribution to total output:

Wind	_____	%
Solar	_____	%
Methane	_____	%
Other (specify)	_____	%

- d. On a separate sheet of 8.5" x 11" paper, draw a schematic of the operating system. The system components should be clearly marked with approximate sizes of each indicated. The schematic should also show the type and placement of test instrumentation on the system.

Type of power output (AC or DC) voltage	_____
Phase	_____
Frequency	_____

II. General Characteristics

Type (model, manufacturer)

Type of power generated (AC or DC) voltage	_____	@	_____	pf.
Phase	_____	@	_____	pf.
Frequency	_____			
Kilovolt-amperes at power factor	_____			
Kilowatts at power factor	_____			
Voltage	_____			
Current	_____			
Frequency	_____			
Speed Rating	_____			
Number of phases	_____			
Field amperes	_____			
Field volts	_____			

III. Converter Characteristics

Type (model, manufacturer) _____

Direct or inverted _____
Single or polyphase _____

Type of input (AC or DC) Volts _____
 Phase _____
 Frequency _____

Type of output (AC or DC) Volts _____
 Phase _____
 Frequency _____

IV. Storage Characteristics

Type (model, manufacturer) _____

Average % efficiency for conversion from alternate energy
source to storage energy: _____%

Average % efficiency for conversion from storage energy
to electrical energy: _____%

Battery type (lead-acid, nickel-iron, Ni-cad, etc.):

 Voltage _____
 Rating (amp-hrs) _____
 Number used _____

V. Voltage Regulator Characteristics

Type (model, manufacturer, rating) _____

Team Captain's signature: _____

Faculty Advisor's signature: _____

Professional Engineer's signature and seal: _____

HOMESITE DATA CHART

TEAM: _____
 DATE OF TEST: _____
 PLACE OF TEST: _____

TIME HRS	WIND M/SEC.	SOLAR WATT/MT	LIQUID KG/SEC	GAS KG/SEC.	LOAD VOLTAGE VOLTS RMS	LOAD CURRENT AMPS	POWER WATTS	AUXILLARY POWER WATTS	STORAGE SYSTEM VOLTAGE VOLTS RMS	STORAGE SYSTEM CURRENT AMPS (1)
0.00										
0.25										
0.50										
0.75										
1.00										
1.25										
1.50										
1.75										
2.00										
2.25										
2.50										
2.75										
3.00										
3.25										
3.50										
3.75										
4.00										
4.25										
4.50										
4.75										
5.00										

(1) Please note a (+) for charging of the system;
 (-) for discharging of the system.

page 2

TIME HRS	WIND M/SEC.	SOLAR WATT/MT	LIQUID KG/SEC	GAS KG/SEC.	LOAD VOLTAGE VOLTS RMS	LOAD CURRENT AMPS	POWER WATTS	AUXILLARY POWER WATTS	STORAGE SYSTEM VOLTAGE VOLTS RMS	STORAGE SYSTEM CURRENT AMPS (1)
5.25										
5.50										
5.75										
6.00										
6.25										
6.50										
6.75										
7.00										
7.25										
7.50										
7.75										
8.00										
8.25										
8.50										
8.75										
9.00										
9.25										
9.50										
9.75										
10.00										
10.25										
10.50										
10.75										
11.00										
11.25										
11.50										
11.75										
12.00										

page 3

[illegible]

Page 4

TIME HRS	WIND M/SEC.	SOLAR WATT/MT	LIQUID KG/SEC	GAS KG/SEC.	LOAD VOLTAGE VOLTS RMS	LOAD CURRENT AMPS	POWER WATTS	AUXILLARY POWER WATTS	STORAGE SYSTEM VOLTAGE VOLTS RMS	STORAGE SYSTEM CURRENT AMPS (1)
19.25										
19.50										
19.75										
20.00										
20.25										
20.50										
20.75										
21.00										
21.25										
21.50										
21.75										
22.00										
22.25										
22.50										
22.75										
23.00										
23.25										
23.50										
23.75										
24.00										

APPENDIX I

Final Test Event Judges

Members of the Energy Resource Alternatives II Coordinating Committee and SCORE would like to thank the following persons for being judges at the ERA II Final Test Event.

James Allen
Washington Public Power Supply System
Richland, Washington

Donald Anderson
VITRO Engineering, Inc.
Richland, Washington

Larry Bowls
Washington Public Power Supply System
Richland, Washington

Donald Cockeram
Atomics International, Inc.
Richland, Washington

Jack Davis
Burns and Roe, Inc.
Richland, Washington

John DeSteeze
Battelle Northwest Laboratories
Richland, Washington

Om Dhiman
Burns and Roe, Inc.
Richland, Washington

Herman Drees
Pinson Energy Corp.
Marstons Mills, Massachusetts

Erich Farber
University of Florida
Gainesville, Florida

John Fox
Battelle Northwest Laboratories
Richland, Washington

Farley George
VITRO Engineering, Inc.
Richland, Washington

Fred Goldsberry
ERDA
Richland Operations Office

Scott Kelly
Battelle Northwest Laboratories
Richland, Washington

Harold Lage
Burns and Roe, Inc.
Richland, Washington

Milton Lewis
Columbia Engineers Services, Inc.
Richland, Washington

Lonn Liffick
ERDA
Richland Operations Office

Jack Matson
University of Houston
Houston, Texas

Jack Parks
Helion, Inc.
Brownsville, California

Dick Perault
Weyerhaeuser, Inc.
Tacoma, Washington

Jim Phoenix
ERDA
Richland Operations Office

Lou Prues
VITRO Engineering, Inc.
Richland, Washington

William Reed
Bechtal Corporation
Richland, Washington

Charles Ripely
Olympic Engineering, Inc.
Richland, Washington

Burton Sellers
Texaco Development Corp.
New York, New York

Dave Squires
ERDA
Richland Operations Office

Bernard Stiefeld
Sandia Laboratories
Albuquerque, New Mexico

Daniel Uman
Washington Public Power Supply System
Richland, Washington

Donald Vargo
NASA
Washington, D.C.

Robert Wilson
Oregon State University
Corvallis, Oregon

Smokey Yunick
Smokey Yunick, Inc.
Daytona Beach, Florida

APPENDIX J

Final Test Event Schedule

- June 9: Project set-up.
- June 10: Project set-up; Welcoming Barbeque, 6 p.m.
- June 11: Project set-up.
- June 12: 24-hour testing of the electricity-producing performance of the projects running off the environmental conditions at Richland; cost, marketability and innovation judging; PUBLIC OPEN HOUSE, 12 to 5 p.m.
- June 13: Project rework; cost, innovation and marketability judging.
- June 14: Optional 24-hour testing; marketability and environmental judging.
- June 15: PUBLIC OPEN HOUSE, 9 a.m. to 4 p.m.; Awards Banquet, 6:30 p.m. at the Hanford House.
- June 16: Teams pack and leave for home.

APPENDIX K

STUDENT COMPETITIONS ON RELEVANT ENGINEERING, INC.

DIRECTORS OF THE CORPORATION

Dr. John H. Sununu Chairman of the Board	College of Engineering Tufts University
Dr. Leroy S. Fletcher	Chairman, Mechanical Engineering University of Virginia
Dr. S. William Gouse	Deputy Assistant Administrator- Fossil Energy U.S. Energy Research & Develop- ment Administration
Dr. Wallace Honeywell	Associate Dean Cullen College of Engineering University of Houston
Dr. Richard Howe	Manager of Public Relations Exxon Company, U. S. A.
Dr. Alfred H. Keil	Dean, School of Engineering Massachusetts Institute of Technology
Dr. Ron Larson	School of Electrical Engineering Georgia Institute of Technology
Dr. W. Robert Marshall	Dean, College of Engineering University of Wisconsin
Dr. Leonard Reiffel	Chairman of the Board Instructional Dynamics, Inc.
Dr. Thomas E. Stelson	Vice President for Research Georgia Institute of Technology
Dr. William R. Upthegrove	Dean, School of Engineering University of Oklahoma
Mr. Ron Weaver	Environmental Activities Staff General Motors Technical Center
Mr. James F. Young	Vice President-Technical Resources General Electric Company

APPENDIX L

ERA II Team Fundraising Guide

To get your ERA II project from the design stage to the hardware stage is going to require money. Possibly lots of money. SCORE expects to be able to help by providing a "seed-money" grant, but in most cases the SCORE funds won't cover your entire project cost. This means that you'll have to raise the remaining funds from local sources. What follows are some suggestions for project fund raising that have proved successful in past SCORE competitions.

Team Organization

A well-organized team effort will pay off in the design and construction of your project, and in your fund raising. Specific tasks assigned to specific people usually get done. It therefore might be a good idea to have one person in charge of the fund raising effort. One of the educational aspects of participating in SCORE competitions is learning how to ask people for money for an R & D project. Knowing how to do this is a valuable asset for a practicing engineer as well as an engineer in a managerial position. You might also consider getting a student from your business school to organize and run your fund raising. In any event, you're going to need money to build your project so approach your fund raising effort with the same seriousness you give to its design and construction.

The SCORE Grant

By submitting a Design Proposal to the SCORE ERA II Coordinating Committee, your team will be considered for a SCORE grant. As we mentioned, these are "seed money" awards which mean they are initial grants for your project expected to attract additional

funding from other sources. The first major grant is usually the hardest to get. Once you've received it, credibility is added to your project and other potential sponsors are more willing to provide support.

SCORE, Inc. was established to solve a related problem that arose during the 1970 Clean Air Car Race (CACR). In addition to finding local sponsors, all the CACR teams were approaching the same federal agencies, national corporations and foundations for grants. Many of the national organizations were interested in funding teams, but their granting systems weren't designed to make numerous small awards. They suggested that the national fund raising for future competitions be centralized so that they could make a single, large grant to the competition's organizer, and it in turn could make the individual team grants.

SCORE was formed the following year to be this centralized national fund raising organization. During our first five years, SCORE has sponsored and conducted the 1971-72 Urban Vehicle Design Competition, the 1973-74 Students Against Fire Competition, and the 1974-75 Energy Resource Alternatives Competition, granting was over \$240,000 to competing teams.

The SCORE team grants for ERA II will be awarded based on an evaluation of your team's Design Proposal and progress reports. A description of the information required in these documents is contained in the ERA II Rules and Guidelines. The construction grants will support the purchase of expendable materials and supplies needed to construct your project. The travel grants will help defray the cost of travel to the second symposium and the final test event. SCORE funds do not cover student or faculty salaries or capital (permanent) equipment, and are awarded with the stipulation that they will not be subject to overhead charges. A "Memorandum of Agreement" detailing the use and restrictions of SCORE funds accompanies each grant. Further, depending upon the original source of the funds, i.e., an NSF grant, an ERDA contract, industrial support, etc., appropriate copyright and patent agreements will be included which must be adhered to.

Design Proposals received by April 30, 1976 will be eligible for the first round of SCORE grants to be announced following May 15, 1976. A second round of grants will be made in the early fall.

Other Sponsors

The overall average of the estimated cost of projects entered in last year's ERA competition was \$5,482. SCORE provided an average of \$2,642 to the teams for construction expenses. This indicates that you should plan to raise a major portion of your ERA II funding from local sources.

You should draw up a list of all potential sponsors in your area, including businesses, foundations, and state agencies. Organizations involved with energy, such as the electric utilities and energy resource development agencies, are good prospects. Many companies have funds earmarked for the support of local programs and activities of the nature of your ERA effort. Don't forget your own school, either. It probably has funds you can get, and you're certainly going to want to ask for lab space, equipment, secretarial help, and other services it can provide.

Money, Equipment, Supplies, etc.

In some cases you should not be asking for cash contributions. Your ERA project will be composed of nuts, bolts, sheet metal, electronics, chemicals, etc., and you'll probably need some testing equipment and machine shop work you can't get from your school. Instead of asking for money from everyone, go to the manufacturers and distributors of the equipment and supplies you need and ask them to give their products to you as a grant. They still get their tax write-off, and your needs are met too. You should therefore make a detailed list of all the hardware and services you're going to need and include in your potential sponsors list the companies that can supply them.

The Proposal

If people are going to give you money, they have to know what they're giving it for. You should therefore put together a fund

raising proposal which describes your ERA II effort and includes a project budget. To help you explain about SCORE and our competitions, we've appended to this Funding Guide a SCORE description. Your proposal should put your ERA efforts in the perspective of a national collegiate competition to design and build innovative devices to help ease the energy crisis. Include: a grant request; a description of what your project is, how it works, and the specific problem it's designed to solve; drawings, diagrams, and schematics; a list of team members with short biographies; a detailed project budget (more about the budget below). Play up the fact that you're students at the local university and that your school is behind your efforts. You'll find companies receptive when you approach them for help as university students who are working on a program to help solve a real world problem that they can relate to. Have your proposal offset printed instead of Xeroxed. It will look better and cost you less.

Project Budget

Make your budget as detailed and itemized as you can. It will show you've done some hard thinking and planning on your project. Below are some budget categories you should think of including:

Project equipment and supplies - we've already discussed this.

Travel - you'll need some money to help pay for travel to two ERA symposia and the Final Testing event.

Wages - in addition to getting academic credit for your ERA work, you might want to get paid. This is especially true over the summer. Be sure your rates are consistent with school policy.

Publication and Xerox - your team may want to send a newsletter to sponsors, make copies of documents, and publish a final report. Your funding proposal will have to be printed.

Telephone - hopefully your school can pick up this item, but then again, it may not be able to do so.

Accounting

You should talk to the accounting officer of your department or school about setting up a special grant account for your use. When you receive grants, the money should be deposited in this account and all expenditures for your project charged to this account. Potential sponsors will be much more willing to give you funds if they know your school is handling the administration of the grant. They then know that proper records will be maintained, and it helps with your credibility.

Hello, I'm calling from . . .

Now that you know who you're going to ask for help and have a good proposal, call them up. Tell them who you are, what you're doing and how they can help. Don't say too much, but try to set up an appointment so you can meet with them personally and sell them on your ERA project. You might think of putting together a brief slide show to take. At any rate, bring copies of your proposal to discuss and leave with them. If they are too far away or want to see a letter from you first, send a proposal with a cover letter. Most of all, don't get discouraged if it seems like you aren't having much luck. One of the marks of a good fund raiser is persistence.

In approaching these potential sponsors, it might help to have a letter of introduction from the dean of engineering or some other official from your school. If SCORE can help in this way, let us know. We also have publications describing our past competitions which we can provide as background material.

Remember to emphasize that your project is being run by students with a faculty advisor and administrative support from your school. Also impress your sponsor with your intention to keep strict accounting control of their grant money, and send them occasional reports on your project's progress.

Publicity

An indirect, but very effective way to boost your fund raising effort is to conduct a publicity campaign. It's much easier to sell a potential sponsor on your project if they've already read or heard about you through the media. A booklet of news clippings displayed at a presentation can also be very influential.

The fact that your team is entered in an international competition to develop alternative energy sources is considered very newsworthy. The place to start your publicity campaign is at your school's News Office (which may also be called the Public Information Office, Office of News Services, etc.). The News Office's job is to get your school's name in the news, so they should be eager to help you. Its staff should be able to prepare press releases and arrange interviews with reporters for newspapers, wire services, and radio and television stations.

If for any reason your News Office doesn't take the initiative in your publicity effort, at least ask them to help you write a press release and provide you with a list of their media contacts with mailing addresses. You might also consider recruiting a journalism student to help with publicity.

Don't underestimate the value of good publicity. We had an ERA team last year that was on the verge of dropping out of the competition because of lack of funds. They prepared a highly "visual" (a term used by the media to describe anything kinetic and eye-catching which lends itself well to still and motion photography) presentation of the uses of solar energy and mounted a publicity campaign. The media coverage that resulted was so good that they ended up raising more money than they could use.

Here's wishing we all have this same problem!

APPENDIX

STUDENT COMPETITIONS ON RELEVANT ENGINEERING

SCORE was established in 1971 by the academic engineering community to sponsor national intercollegiate engineering design/hardware fabrication competitions. The SCORE concept grew from the success of the 1970 Clean Air Car Race and the need for a project-oriented approach to engineering education. During its first four years, over 4,000 student engineers from 97 different colleges and universities have participated in SCORE's 1971-72 Urban Vehicle Design Competition (UVDC), 1973-74 Students Against Fires (SAF) competition, and the 1974-75 Energy Resource Alternatives (ERA) competition. SCORE's current program is the 1976-77 Energy Resource Alternatives II (ERA II) competition.

SCORE competitions focus on a significant contemporary problem area where technological solutions are possible. Environmental quality, fire safety, and the utilization of alternative energy resources are three of the many appropriate topics. Each theme selected must promote the achievement of SCORE's three principal objectives: first, to stimulate a project-oriented approach to engineering education; second, to promote new approaches to solving relevant engineering problems; and third, to increase national awareness of the problem the competition addresses.

A student-staffed coordinating committee is formed to organize each competition. The committee may be located at any participating university in the United States or Canada. The UVDC committee was at the Massachusetts Institute of Technology, Students Against Fires at the Georgia Institute of Technology, ERA at the University of Wisconsin - Madison, and the ERA II Coordinating Committee is located at Washington State University.

The goal of the competing SCORE teams is to produce innovative hardware solutions to the problem defined by the competition. The goal in UVDC was to design and build a small, low polluting,

safety oriented car suited to an urban environment. In SAF the student efforts were aimed at developing new prototype hardware for fire prevention, detection and control. ERA challenged its participants to produce space heating and cooling, hot water, and electricity for a home or light industry using non-conventional energy sources, while ERA II focuses on electric power production from alternative energy sources. SCORE teams may be composed of both undergraduate and graduate engineering students.

The Competition

SCORE competitions have two phases: a design phase and a hardware construction and testing phase. In the first, the student teams study the problem and the design objectives of the competition and develop a design for their hardware solution. The team next submits its design proposal to the coordinating committee. On the basis of the quality of the proposal, the committee will recommend that SCORE grant funds to the team to help finance the actual construction of the project.

It is in the hardware construction and testing phase that many students get their first intensive exposure to hands-on engineering. In translating a design from paper to hardware, the student must cope with the various trade-offs (such as cost, materials, and simplicity) that the practicing engineer faces daily. This is a fundamental aspect of engineering often ignored in today's classroom.

Final Testing

The culmination of the competition is the Final Testing Event. All the teams and their projects meet at a single test site for four days of testing and evaluation. Not only does the team's hardware have to be innovative, it has to work. As part of the evaluation procedure, the hardware is tested under rigorous experimental conditions. The final testing of the Urban Vehicle Design Competition was held at the General Motors Proving

Grounds in Milford, Michigan. The 66 UVDC vehicles, representing 61 United States and Canadian colleges and universities, were subjected to a wide range of emissions, performance, handling, and safety tests. The Students Against Fires final testing took place at the Ansul Company's Fire Technology Center in Marinette, Wisconsin. The Ansul Fire Technology Center is a unique test facility where fires of all description were generated to evaluate the performance of the SAF projects. ERA concluded with the final testing of 40 student-built alternative energy projects at the Sandia Laboratories in Albuquerque, New Mexico. Sandia provided a comprehensive testing facility to evaluate the solar, wind, methane, coal and wave-powered projects entered in the competition.

During final testing, the SCORE team members also give oral presentations before panels of judges. The orals are a simulated marketing presentation where the students try to "sell" their hardware design to the panel members. Innovation, relevance, cost-effectiveness, and marketability are among the design features discussed. The judging panels are comprised of research and practicing engineers, policy makers from government and industry, and professionals in the field.

The teams' scores are computed on the basis of the objective hardware test and the subjective oral presentations.

Symposia

Each of the two phases of the competition includes a SCORE sponsored symposium. At the first, leading experts speak on the topic of the competition to discuss various aspects of the problem and to acquaint the students with state of the art technology. Teams have found the first symposium very helpful in choosing a project for the competition. The second symposium gives team members the opportunity to discuss their projects with experts in workshop sessions. Both symposia include business meetings to discuss such matters as the competition's rules and timetable and preparations for final testing.

At the end of each competition SCORE publishes a final summary report which includes technical data on all the entries.

Organization

SCORE is a non-profit corporation whose members are U. S. and Canadian engineering colleges. SCORE's organization consists of a Board of Directors, executive officers, staff, and the member schools. The Board of Directors currently consists of eight Deans of Engineering and faculty members and three representatives from government and industry. The executive officers and staff members are students and recent graduates. Each SCORE member school has a faculty SCORE representative. It is not required that a school be a SCORE member to participate in SCORE competitions. The Annual meeting for the Board of Directors and members is held during the fall of each year.

SCORE raises its funds from industry, government, and private foundations. Membership in SCORE is open to any university or college offering the baccalaureate degree. The annual membership fee is \$100 per one thousand enrolled engineering undergraduates.

For further information contact:

SCORE, Inc.
Room 105, Anderson Hall
Tufts University
Medford, Mass. 02155
(617) 253-6833

ERA II Coordinating Committee
Dept. of Mechanical Engineering
Washington State University
Pullman, WA 99163
(509) 335-7070

APPENDIX M

ENERGY RESOURCE ALTERNATIVES COST CODE
(ERACC)

User Instructions for ERACC

The use of ERACC is very easy if one follows the following instructions.

All of the assembly line cost variables (LINCST) are dimensioned for a maximum of 30 jobs per system. If the project considered is composed of more than 30 jobs, then the DIMENSION statements in the main program must be changed; the dimensioning of variables in the subroutines is done automatically.

INPUT STATEMENTS

(1) Read the title of the case being computed. FORMAT (20A4)

(2) Read the number of jobs in the system assembly line; the annual energy output of the system; and the annual load factor of system and load.
FORMAT (I2, 8X, 2F10.3)

(3) The values for interest rate, tax rate, insurance, overhead rate, etc., are entered by simple statements of the form (A=B). The variables are: OMRT, XINFR, SLIFE, BLIFE, DRATE, XINRT, TRATE, UNIT, FACCST, SHFT, EQPLF, WCRATE, OHFCL, OHFCSP, SPCST, PRFT. The definition for each can be found by consulting the list of variables.

(4) The hourly labor rates for the different assembly line labor types are entered by simple statements of the form (A=B). Even though the array for labor types is dimensioned to handle 30 different types, in ERA II, only 10 different labor types were used. The last labor type, index value=22, signifies a job with no labor input, i.e., materials acquisition only. In reading each job's cost data, if a null value for labor type is specified, then the routine will try to use the null value as the index for the array. Hence, one must specify a non-null value for the index, i.e. 22, which will be properly indexed and read to set LABRT(j)=0 for that index value.

(5) Read each job's cost data: DM,LABOR,J,SCRFC,SPCE,EQPR.
FORMAT (2F10.2,I5,2F5.1,2F10.2)

- (6) Read system costs: OM,BCST. FORMAT (2F10.5)
- (7) Read the exotic materials inputs: AL,ST,CU,CE,SE,CD,GA,AR,TE, SE,FG; and the estimated annual market for the system (MRKT); and the annual energy output (POWER). FORMAT (F10.2)
- (8) Read the dollar values of the 45 selected materials and components comprising the system for net energy calculations. FORMAT (F10.5)
- (9) Read the annual energy production of the system. FORMAT (F10.3)

This is all the input required to load and run ERACC.

SPECIAL ASPECTS OF ERACC USED FOR ERA II

(1) In calculating exotic material requirements, all systems' materials requirements were scaled (FAC) to those required to produce 20 kwhrs of energy per day for one year (7300 kwhrs). This might be changed or deleted for other purposes.

(2) The energy coefficients, identifying the BTU's of energy consumed in the production of one 1967 dollar of the 45 selected commodities and materials were taken from the publication: "Energy Analysis Handbook," Center for Advanced Computation, University of Illinois. CAC Document No. 214.

(3) The price indices to change the 1976 prices for a system's commodities and materials to 1967 prices for the net energy calculations were approximated by price indices from the Bureau of Labor Statistics.

These instructions should be sufficient to use the program, ERACC. If after reading this information and the scoring document, the reader desires additional information on the specifics of the ERACC program and its calculations, write for a copy of the Masters Degree Project by Joseph E. Eschbach: "ERACC (Energy Resource Alternatives Cost Code)." The address is:

Dr. David E. Stock
Department of Mechanical Engineering
Washington State University
Pullman, WA 99164

Selected Commodities and Materials for
Net Energy Analysis

Textile Goods
Veneer, Plywood
Wood Products
Misc. Chemical Products
Plastics
Paint Products
Tires
Industrial Leather
Glass Containers
Cement
Bricks
Ceramic Tile
Clay Refractory
Plumbing Fixtures
Concrete Products
Stone Products
Asbestos
Gaskets
Non-clay Refractory
Steel Products
Copper
Lead
Zinc
Aluminium
Non-ferrous Metals
Heating Hardware
Pipe
Fabricated Metal Products
Steam Engine
IC Engine
Pump-Compressors
Bearings
Blowers
Power Transmission Equipment
Refrigeration Equipment
Electrical Instrumentation
Transformers
Switchgear
Motors-Generators
Electrical Hardware
Computers
Batteries
Scientific Instrumentation
Optical Instrumentation

Variables List

I. Subroutine LINCST (Line Cost)

SCRFC: Scrap factor for each job (I)
REFC: Recycle factor for each job (I)
DM: Direct materials cost for each job (I)
LABRTR: Labor rates of employees (J)
LABOR: Labor time for each job (I)
UNIT: Number of units of production that costs calculated on
SCFAC: Scale factor for job input
JBCOST: Job Cost for each job (I)
MTCST: Material costs for each job (I)
LABCST: Labor cost for each job (I)
TJBCST: Total of all job costs
TMTCST: Total of all material costs
TLBCST: Total of all labor costs
NJOB: Number of jobs in assembly line
TTIME: Total labor time in assembly line

II. Subroutine MNFCST (Manufacturing Cost)

SPCE: Space required for each job (I)
TSPCE: Total space required for all jobs
SPCST: Space cost rate (\$/area)
TSPCST: Total space costs for all jobs
SHFT: Number of shifts per working day
RANPRD: Real annual production total
EQPLF: Equipment economic life
EQPR: Equipment price per job (I)
TEQPR: Total equipment price for all jobs
DEPC: Depreciation factor for equipment
TEQCST: Annual equipment cost assessed per unit production
OHFCL: Overhead cost rate on direct labor (\$/hr.)
OHCL: Overhead costs on direct labor per unit production
OHFCSP: Overhead cost rate on floorspace (\$/area)
OHC2: Overhead costs on floorspace per unit production

TOHC: Total of all overhead costs per unit production
 CPRD: Number of capital payment periods that assembly time is
 WCRATE: Working capital interest annual rate (%/system capital cost)
 WCCST: Working capital costs per unit production
 FACST: Total fixed manufacturing costs
 FCST: Annual distribution of fixed costs per unit production
 PRFT: Percentage profit rate (%/system capital cost)
 TCST: Total cost assembly line plus manufacturing cost adders

III. Subroutine CANCEST (Consumer Annual Cost)

DRATE: Annual amortization discount rate
 EPSCRF: Equal payment series capital recovery factor
 SLIFE: System amortized economic life (years)
 ANCOST1: Annual amortized system cost (\$/year)
 BCST: Battery capital cost
 XINRT: Annual insurance rate (%/capital cost)
 INCST: Total annual system tax cost
 TRATE: Annual tax rate (%/capital cost)
 TXCST: Total annual system tax cost
 OMRT: Annual operation and maintenance cost rate (%/capital cost)
 OMCST: Total annual operation and maintenance cost
 XINFR: Annual inflation rate
 INFCST: Inflated system cost
 EPSSF: Equal payment series sinking fund factor
 RECAP1: Annual recapitalization cost of system
 RECAP2: Annual recapitalization cost of batteries
 BLIFE: Battery economic life (Years)
 BICST: Battery inflated cost
 TACST: Total annual cost of system to consumer (\$/year)
 POWER: Annual power output of system
 ACST: Annual busbar cost of electricity to owner of system (\$/kwhr.)

IV. Subroutine EXMT (Exotic Materials)

ALS: Aluminum annual 1976 production
 STS: Steel annual 1976 production
 CUS: Copper annual 1976 production
 CES: Cement annual 1976 production

SIS: Silicon annual 1976 production
 CDS: Cadmium annual 1976 production
 GAS: Gallium annual 1976 production
 ARS: Arsenic annual 1976 production
 TES: Telleurium annual 1976 production
 SES: Selenium annual 1976 production
 FGS: Fiberglass annual 1976 estimated production
 FAC: Scaling factor of material demand for common system size
 MRKT: Annual estimated market for system
 ALD: Aluminum demand
 STD: Steel demand
 CUD: Copper demand
 CED: Cement demand
 SID: Silicon demand
 CDD: Cadmium demand
 GAD: Gallium demand
 ARD: Arsenic demand
 TED: Telleurium demand
 SED: Selenium demand
 FGD: Fiberglass demand
 K: Counter
 EMS: Exotic material score

V. Subroutine NEA (Net Energy Analysis)

C: Energy coefficients (I,J) (Btus/\$)
 PI: Price indices from 1967 to current period (I)
 AMT: Amount of commodity used in system (I) (\$)
 ESUM: Total energy cost of system (Btus)
 AEPM: Annual energy production (kwhrs.)
 AEP: Annual energy production (Btus)
 DYRS: Number of years to payback twice energy cost
 NEAS: Net energy analysis score

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1.                                     ENERGY RESOURCE ALTERNATIVES
2.                                     COST CODE
3.                                     (ERACC)
4.
5.     REAL LABRTR,LABOR,LF,LABRT,JBCOST,MTCSST,LABCST,NEAS
6.     C   SET UP VARIABLES FOR ROUTINE LINCST
7.     C
7.1    DIMENSION CASE(20)
8.     DIMENSION SCRFC(30),REFC(30),DM(30),LABRTR(30),LABOR(30),LABRT(30)
9.     C
10.    C   SET UP VARIABLES FOR ROUTINE MNFCST
11.    C
12.    DIMENSION SPCE(30),EQPR(30),MTCSST(30),SCFAC(30),LABSCT(30)
12.1   DIMENSION JBCOST(30)
13.    COMMON /CDE/ SHFT,EQPLF,OHFCL,OHFCSP,WCRATE,UNIT,SPCST,TJBCST
14.    COMMON /CDF/ FACCST,PRFT,TLBCST
15.    C
16.    C   SET UP VARIABLES FOR ROUTINE CANCST
17.    C
18.    COMMON /EFG/ DRATE,SLIFE,BCST,XINRT,TRATE,OMRT,XINFR,BLIFE,POWER
18.1   COMMON /EFH/ OM
19.    C
19.1   C   READ CASE LABEL
19.2   C
19.3     READ(5,51) CASE
19.4     WRITE(6,60) CASE
19.41    51  FORMAT(20A4)
19.5    60  FORMAT (//,'$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$',20A4//)
19.6    C
20.    C   READ VARIABLE VALUES FOR ROUTINE CANCST
21.    C
22.    READ(5,100) NJOB,POWER,LF
23.    100  FORMAT (12,8X,2F10.3)
25.    C
26.    C   READ VARIABLE VALUES FOR ROUTINE MNFCST
27.    C
27.01   OMRT=2.0
27.02   XINFR=0.
27.1    SLIFE=20.0
27.2    BLIFE=1.0
27.3    DRATE=10.0
27.4    XINRT=0.1
27.5    TRATE=1.5
27.6    UNIT=1.0
27.61   FACCST=0.

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27.7      SHFT=3.0
27.8      EQPLF=0.
27.9      WCRATE=10.0
28.       OHFCI=125.0
28.1      OHFCSP=0.0
28.2      SPCST=0.0
28.3      PRET=10.0
30.       C
32.       C   SET UP LABOR COSTS
33.       C
34.       LABRT(1)=8.80
35.       LABRT(2)=10.80
36.       LABRT(3)=9.60
37.       LABRT(4)=9.60
38.       LABRT(5)=9.0
38.1      LABRT(6)=12.80
38.2      LABRT(7)=11.60
38.3      LABRT(8)=11.20
38.4      LABRT(9)=11.20
38.5      LABRT(10)=7.70
38.6      LABRT(22)=0.
39.       C
40.       C   READ VARIABLE VALUES FOR ROUTINE LINCST
41.       C
42.       DO 50 I=1,NJOB
43.       READ(5,300) DM(I),LABOR(I),J,SCRFC(I),REFC(I),SPCE(I),EQPR(I)
44.       300  FORMAT(2F10.2,15,2F5.1,2F10.2)
45.       LABRTR(I)=LABRT(J)
46.       50  CONTINUE
46.1      READ(5,52) OM,BCST
46.2      52  FORMAT(2F10.5)
47.       CALL LINCST(NJOB,UNIT,TJBCST,TTIME,SCRFC,REFC,DM,LABRTR,LABOR,
48.       1MTCST,LABCST,SCFAC,JBCOST,TLBCST)
49.       CALL MNFCST(NJOB,TCST,TTIME,SPCE,EQPR)
50.       CALL CANCST(ACST,TACST,LF,TCST)
50.1      CALL EXMT(EMS)
50.2      CALL NEA(ESUM,AEP,DYRS,NEAS)
51.       STOP
52.       END
53.       SUBROUTINE LINCST(NJOB,UNIT,TJBCST,TTIME,SCRFC,REFC,DM,
54.       1LABRTR,LABOR,MTCSST,LABCST,SCFAC,JBCOST,TLBCST)
55.       DIMENSION SCRFC(NJOB),REFC(NJOB),DM(NJOB),LABRTR(NJOB),LABOR(NJOB)
56.       DIMENSION SCFAC(NJOB),MTCST(NJOB),LABCST(NJOB),JBCOST(NJOB)
57.       REAL JBCOST,MTCST,LABCST,LABRTR,LABOR
58.       TJBCST=0.
59.       TMTCSST=0.
60.       TLBCST=0.
61.       TTIME=0.
62.       DO 10 J=1,NJOB
63.       IF(SCRFC(J)+REFC(J).LT.1.) GO TO 2

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64.          SCFAC(J)=UNIT/(1.-SCRFC(J))
65.          SCFAC(J)=UNIT/(1.-REFC(J)) + SCFAC(J)
66.          GO TO 5
67.      2    SCFAC(J)-UNIT/(1.-SCRFC(J)-REFC(J))
68.      5    CONTINUE
69.          MTCST(J)=DM(J)*SCFAC(J)
70.          LABCST(J)=LABRTR(J)*LABOR(J)*SCFAC(J)*0.25
71.          JBCOST(J)=MTCST(J)+LABCST(J)
72.          TJBCST=JBCOST(J)+TJBCST
73.          TMTCSST=TMTCSST+MTCST(J)
74.          TLBCST=TLBCST+LABCST(J)
75.          TTIME=TTIME+LABOR(J)
76.      10   CONTINUE
76.1         TTIME=TTIME*0.25
77.          WRITE(6,100)
78.      100  FORMAT('1',10X,'JOB NO',4X,'JBCST $',4X,'MTCST $',4X,
79. 1'LABCST $',3X,'LABRT $/HR',2X,'LABOR HRS',4X,'SCFAC',/)
80.          DO 20 J=1,NJOB
81.          WRITE(6,200) J,JBCOST(J),MTCST(J),LABCST(J),LABRTR(J),
82. 1LABOR(J),SCFAC(J)
83.      200  FORMAT(12X,12,4X,F8.2,3X,F8.2,4X,F8.2,3X,F6.2,5X,F6.2,5X,
84. 1F8.3)
85.      20   CONTINUE
86.          WRITE(6,300) TJBCST,TMTCSST
87.          WRITE(6,400) TLBCST,TTIME
88.      300  FORMAT(10X,'TOTAL LINE COST=',F8.2,' $/UNIT',
89. 15X,'TOTAL MAT COST=',F8.2,' $/UNIT')
90.      400  FORMAT(10X,'TOTAL LAB COST=',F8.2,' $/UNIT',
91. 15X,'TOTAL LINE LABOR TIME=',F8.2,'HRS/UNIT',///)
92.          RETURN
93.          END
94.          SUBROUTINE MNFCST(NJOB,TCST,TTIME,SPCE,EQPR)
95.          DIMENSION SPCE(NJOB),EQPR(NJOB)
96.          COMMON /CDE/ SHFT,EQPLF,OHFCL,OHFCSP,WCRATE,UNIT,SPCST,TJPCST
97.          COMMON /CDF/ FACCST,PRFT,TLBCST
98.      C
99.      C  CALCULATE FLOOR SPACE REQUIREMENTS
100.         TSPCE=0.
101.         TEQPR=0.
102.         DO 10 J=1,NJOB
103.         TSPCE=TSPCE+SPCE(J)
104.      10   CONTINUE
105.      C
106.      C  WORKING TIME
107.         RANPRD=SHFT*6240/TTIME
108.      C
109.      C  CALCULATE FLOORSPACE COSTS
110.         TSPCST=SPCST*TSPCE*TTIME*3./(SHFT*RANPRD)
111.      C

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112.      C   FIXED COSTS OR FACILITIES
113.          FCST=FACCST/RANPRD
114.      C
115.      C   DEPRECIATION EQUIPMENT COST
116.          IF(EQPLF.EQ.0) GO TO 30
117.          DEFFC=1./(RANPRD*EQPLF)
118.          DO 20 I=1,NJOB
119.              TEQPR=TEQPR+EQPR(I)
120.          20  CONTINUE
121.              TEQCST=DEFFC*TEQPR
122.          30  IF(EQPLF.EQ.0) TEQCST=0.
122.1      IF(EQPLF.EQ.0) DEFFC=0.
123.      C
124.      C   OVERHEAD BY LABOR, INDIRECT COSTS
125.          IF(OHFCL.EQ.0) GO TO 40
126.          OHCL=TLBCST*OHFCL/100.
127.          TOHC=OHCL
128.      C
129.      C   OVERHEAD BY FLOOR SPACE, INDIRECT COSTS
130.          40  IF(OHFCSP.EQ.0) GO TO 50
131.              OHC2=TSPCE*OHFCSP
132.              TOHC=OHC2
133.          50  CONTINUE
134.              IF(OHFCL.EQ.0.AND.OHFCSP.EQ.0) TOHC=0.0
135.      C
136.      C
137.      C   WORKING CAPITAL COST
138.          CPRD=TIME/8760.
139.          WCCST=TJBCST*(1.0+WCRATE/100.)**CPRD-TJBCST
140.      C
141.      C   PROFIT COST
142.          PRFCST=TJBCST*PRFT/100.
143.      C
144.      C   TOTAL COST
145.          TCST=TJBCST+TSPCST+TEQCST+TOHC+WCCST+PRFCST+FCST
146.      C   WRITE HEADER STATEMENTS
147.      C
148.          WRITE(6,100)
149.          100  FORMAT(/,'***** MANUFACTURING COSTS *****',/)
150.          WRITE(6,200) TSPCST,TSPCE,SPCST
151.          200  FORMAT(10X,'TOTAL SPACE COSTS= $ ',F8.2,5X,
152.              1'TOTAL SPACE REQUIRED ',F8.2,' SQFT',5X,
153.              2'SPACE COST RATE= ',F8.2,' $/SQFT HR')
154.          WRITE(6,300) TEQCST,DEFFC,TEQPR
155.          300  FORMAT(10X,'TOTAL EQUIPMENT COST= $ ',F8.2,5X,
156.              1'DEP FAC =',F8.2,' PER UNITS-YR',5X
157.              2'TOTAL EQUIPMENT PRICE= $ ',F8.2)
158.          WRITE(6,400) TOHC,FCST
159.          400  FORMAT(10X,'TOTAL OVERHEAD COSTS= $ ', F8.2,

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160.      110X, 'TOTAL FIXED/FACILITIES COST= $ ', F8.2)
161.      WRITE(6,500) RANPRD,WCRATE,WCCST
162.      500  FORMAT(10X, 'REAL ANNUAL PRODUCTION=', F8.2, ' UNITS', 5X,
163.      1'WORKING CAPITAL RATE=', F8.2, ' %/YR',
164.      25X, 'WORKING CAPITAL COST= $ ', F8.2)
165.      WRITE(6,700) PRFT,PRFCST
166.      700  FORMAT(10X, ' PROFIT RATE = ', F6.2, ' %/UNIT COST',
167.      110X, 'TOTAL PROFIT COST= $ ', F8.2,/)
168.      WRITE(6,600) TCST
169.      600  FORMAT(/, 10X, 'MANUFACTURED UNIT COST= $ ', F8.2,/)
170.      RETURN
171.      END
172.      SUBROUTINE CANCST(ACST,TACST,LF,TCST)
173.      COMMON /EFG/ DRATE,SLIFE,BCST,XINRT,TRATE,OMRT,XINFR,BLIFE,POWER
173.1     COMMON /EFH/ OM
174.      REAL INCST,INFCST,LF
175.      C
176.      C  SYSTEM AMORTIZED COST
177.      DRATE=DRATE/100.
178.      EPSCRF=(DRATE*(1.+DRATE)**SLIFE)/((1.+DRATE)**SLIFE-1.)
179.      ANCST1=(TCST+BCST)*EPSCRF
180.      C
181.      C  INSURANCE ANNUAL COST
182.      INCST=(TCST+BCST)*XINRT/100.
183.      C
184.      C  TAX COSTS
185.      TXCST=(TCST+BCST)*TRATE/100.
186.      C
187.      C  OPERATION AND MAINTENANCE COSTS
188.      OMCST=(BCST+TCST)*OMRT/100.
188.1     IF(OM.GT.OMCST) OMCST=OM
189.      C
190.      C  INFLATION SYSTEM COST
191.      XINFR=XINFR/100.
192.      INFCST=((1.+XINFR)**SLIFE)*(TCST)
193.      C
194.      C  RECAPITALIZATION SYSTEM COST
195.      EPSSFF=(DRATE/((1.+DRATE)**SLIFE-1.))
196.      RECAP1=TCST*EPSSFF
196.1     RECAP1=0
197.      C
198.      C
199.      C  INFLATION BATTERY COST
200.      BICST=((1.+XINFR)**BLIFE)*BCST
201.      C
202.      C  RECAPITALIZATION BATTERY COST
203.      EPSSFF=DRATE/((1.+DRATE)**BLIFE-1.)
204.      RECAP2=BCST*EPSSFF

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205.      C
206.      C  TOTAL ANNUAL COST
207.          TACST=ANCST1+INCST+OMCST+RECAP1+RECAP2+TXCST
208.      C
209.      C  ANNUAL COST PER WATT
210.          ACST=TACST/(POWER*LF)
211.          WRITE(6,100)
212.      100  FORMAT(/,'***** CONSUMER ANNUAL COSTS *****',/)
213.          WRITE(6,200) ANCST1,OMCST
214.          WRITE(6,201) INCST,TXCST
215.          WRITE(6,203) RECAP1,RECAP2
216.          WRITE(6,204) TACST,ACST
217.      200  FORMAT(10X,'SYSTEM ANNUAL COST=',F8.2,' $/YR',5X,
218.          110X,' OP & MAINT COST=',F8.2,' $/YR')
219.      201  FORMAT(10X,'INSURANCE COST=',F8.2,' $/YR',5X,
220.          110X,' TAX COST=',F8.2,' $/YR')
221.      203  FORMAT(10X,'SYSTEM RECAP COST=',F8.2,' $/YR',5X,
222.          110X,' BATTERY RECAP COST=',F8.2,' $/YR',/)
223.      204  FORMAT(10X,'TOTAL ANNUAL COST=',F8.2,' $/YR',5X,/,
224.          110X,' TOTAL ANNUAL POWER COST=',F8.4,' $/KWHR',/)
225.          RETURN
226.          END
227.          SUBROUTINE EXMT(EMS)
228.          REAL MRKT
229.          DOUBLE PRECISION ALD,ALS,STD,STS,CUD,CUS,CED,CES,SID,SIS,
230.          1CDS,CDD,GAD,GAS,ARD,ARS,TED,TES,SES,SED,FGS,FGD,ALR,
231.          2STR,CUR,CER,SIR,CDR,GAR,ARR,TER,SER,FGR
232.      C
233.      C  ANNUAL 1976 PRODUCTION OF MATERIALS (KG.)
234.      C
235.          ALS=3.811D9
236.          STS=1.162D11
237.          CUS=1.388D9
238.          CES=6.679D10
239.          SIS=4.90D8
240.          CDS=1.996D6
241.          GAS=2000.0
242.          ARS=5.445D6.
243.          TES=5.942D4
244.          SES=1.842D5
245.          FGS=2.632D8
246.          K=0.
247.      C
248.      C  INPUT PROJECT MATERIAL, MARKET, AND POWER STATISTICS
249.      C
250.          READ(5,100) AL,ST,CU,CE,SI,CD,GA,AR,TE,SE,FG,MRKT,POWER
251.      100  FORMAT(1F10.2)
252.      C
253.      C  STANDARD SIZE POWER SCALING FACTOR

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254.      C
255.          FAC=POWER/7300.
256.          IF (POWER.EQ.0) FAC=1.
257.      C
258.      C ANNUAL MATERIAL DEMAND FOR PROJECT (KG.)
259.      C
260.          ALD=AL*MRKT/FAC
261.          STD=ST*MRKT/FAC
262.          CUD=CU*MRKT/FAC
263.          CED=CE*MRKT/FAC
264.          SID=SI*MRKT/FAC
265.          CDD=CD*MRKT/FAC
266.          GAD=GA*MRKT/FAC
267.          ARD=AR*MRKT/FAC
268.          TED=TE*MRKT/FAC
269.          SED=SE*MRKT/FAC
270.          FGD=FG*MRKT/FAC
270.1     C OUTPUT HEADER
270.2         WRITE(6,99)
270.3     99  FORMAT('***** EXOTIC MATERIALS REQUIREMENTS *****',/)
271.     C
272.     C DEMAND/SUPPLY RATIO VERSUS CRITERIA OF DECISION
273.     C
274.         IF (ALD/ALS.GE.0.2) GO TO 10
275.     31  IF (STD/STS.GE.0.2) GO TO 11
276.     32  IF (CUD/CUS.GE.0.2) GO TO 12
277.     33  IF (CED/CES.GE.0.2) GO TO 13
278.     34  IF (SID/SIS.GE.0.2) GO TO 14
279.     35  IF (CDD/CDS.GE.0.2) GO TO 15
280.     36  IF (GAD/GAS.GE.0.2) GO TO 16
281.     37  IF (ARD/ARS.GE.0.2) GO TO 17
282.     38  IF (TED/TES.GE.0.2) GO TO 18
283.     39  IF (SED/SES.GE.0.2) GO TO 19
284.     40  IF (FGD/FGS.GE.0.2) GO TO 20
285.         GO TO 50
286.     C
287.     C WRITE APPROPRIATE OUTPUT
288.     C
289.     10  K=K+1
290.         ALR=ALD/ALS
291.         WRITE(6,101) ALD,ALS,ALR
292.     101  FORMAT(10X,'AL DEMAND=',D20.5,1CX,'AL SUPPLY=',D20.5,10X,
293.         1'AL RATIO=',D20.5)
294.         GO TO 31
295.     11  K=K+1
296.         STR=STD/STS
297.         WRITE(6,102) STD,STS,STR
298.     102  FORMAT(10X,'ST DEMAND=',D20.5,10X,'ST SUPPLY=',D20.5,10X,
299.         1'ST RATIO=',D20.5)

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300.      GO TO 32
301. 12    K=K+1
302.      CUR=CUD/CUS
303.      WRITE(6,103) CUD,CUS,CUR
304. 103   FORMAT(10X,'CU DEMAND=',D20.5,10X,'CU SUPPLY=',D20.5,10X,
305.          1'CU RATIO=',D20.5)
306.      GO TO 33
307. 13    K=K+1
308.      CER=CED/CES
309.      WRITE(6,104) CED,CES,CER
310. 104   FORMAT(10X,'CE DEMAND=',D20.5,10X,'CE SUPPLY=',D20.5,10X,
311.          1'CE RATIO=',D20.5)
312.      GO TO 34
313. 14    K=K+1
314.      SIR=SID/SIS
315.      WRITE(6,105) SID,SIS,SIR
316. 105   FORMAT(10X,'SI DEMAND=',D20.5,10X,'SI SUPPLY=',D20.5,10X,
317.          1'SI RATIO=',D20.5)
318.      GO TO 35
319. 15    K=K+1
320.      CDR=CDD/CDS
321.      WRITE(6,106) CDD,CDS,CDR
322. 106   FORMAT(10X,'CD DEMAND=',D20.5,10X,'CD SUPPLY=',D20.5,10X,
323.          1'CD RATIO=',D20.5)
324.      GO TO 36
325. 16    K=K+1
326.      GAR=GAD/GAS
327.      WRITE(6,107) GAD,GAS,GAR
328. 107   FORMAT(10X,'GA DEMAND=',D20.5,10X,'GA SUPPLY=',D20.5,10X,
329.          1'GA RATIO=',D20.5)
330.      GO TO 37
331. 17    K=K+1
332.      ARR=ARD/ARS
333.      WRITE(6,108) ARD,ARS,ARR
334. 108   FORMAT(10X,'AR DEMAND=',D20.5,10X,'AR SUPPLY=',D20.5,10X,
335.          1'AR RATIO=',D20.5)
336.      GO TO 38
337. 18    K=K+1
338.      TER=TED/TES
339.      WRITE(6,109) TED,TES,TER
340. 109   FORMAT(10X,'TE DEMAND=',D20.5,10X,'TE SUPPLY=',D20.5,10X,
341.          1'TE RATIO=',D20.5)
342.      GO TO 39
343. 19    K=K+1
344.      SER=SED/SES
345.      WRITE(6,110) SED,SES,SER
346. 110   FORMAT(10X,'SE DEMAND=',D20.5,10X,'SE SUPPLY=',D20.5,10X,
347.          1'SE RATIO=',D20.5)

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348.          GO TO 40
349.      20    K=K+1
350.          FGR=FGD/FGS
351.          WRITE(6,111) FGD,FGS,FGR
352.      111  FORMAT(10X,'FG DEMAND=',D20.5,10X,'FG SUPPLY=',D20.5,10X,
353.      1'FG RATIO=',D20.5)
354.          GO TO 50
355.      50    IF(K.GT.0) GO TO 60
356.          EMS=5.0
357.          WRITE(6,200) EMS
358.      200  FORMAT(//,10X,'EXOTIC MATERIAL SCORE=',F10.2,/)
359.          GO TO 70
360.      60    EMS=0.
361.          WRITE(6,200) EMS
362.      70    RETURN
363.          END
364.          SUBROUTINE NEA (ESUM,AEP,DYRS,NEAS)
365.          REAL NEAS
366.          DIMENSION C(45),AMT(45),PI(45)
367.          DATA C(1) /92312.0/
367.1         DATA C(2) /78517.0/
367.2         DATA C(3) /82755.0/
367.3         DATA C(4) /197303.0/
367.4         DATA C(5) /243130.0/
367.5         DATA C(6) /136215.0/
367.6         DATA C(7) /101949.0/
367.7         DATA C(8) /61417.0/
367.8         DATA C(9) /166804.0/
367.9         DATA C(10)/517502.0/
368.         DATA C(11)/367046.0/
368.1         DATA C(12)/119463.0/
368.2         DATA C(13)/193862.0/
368.3         DATA C(14)/98348.0/
368.4         DATA C(15)/117234.0/
368.5         DATA C(16)/56981.0/
368.6         DATA C(17)/119140.0/
368.7         DATA C(18)/91248.0/
368.8         DATA C(19)/162366.0/
368.9         DATA C(20)/282390.0/
369.         DATA C(21)/154408.0/
369.1         DATA C(22)/121755.0/
369.2         DATA C(23)/303306.0/
369.3         DATA C(24)/428437.0/
369.4         DATA C(25)/173590.0/
369.5         DATA C(26)/78488.0/
369.6         DATA C(27)/82005.0/
369.7         DATA C(28)/81634.0/
369.8         DATA C(29)/114477.0/
369.9         DATA C(30)/78994.0/

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370.	DATA C(31)/69641.0/
370.1	DATA C(32)/61145.0/
370.2	DATA C(33)/89025.0/
370.3	DATA C(34)/68990.0/
370.4	DATA C(35)/65971.0/
370.5	DATA C(36)/77610.0/
370.6	DATA C(37)/39222.0/
370.7	DATA C(38)/82671.0/
370.8	DATA C(39)/52207.0/
370.9	DATA C(40)/70507.0/
371.	DATA C(41)/78791.0/
371.1	DATA C(42)/59025.0/
371.2	DATA C(43)/107873.0/
371.3	DATA C(44)/51684.0/
371.4	DATA C(45)/48123.0/
372.	DATA PI(1) /1.299/
372.1	DATA PI(2) /1.877/
372.2	DATA PI(3) /1.877/
372.3	DATA PI(4) /1.471/
372.4	DATA PI(5) /1.210/
372.5	DATA PI(6) /1.570/
372.6	DATA PI(7) /1.393/
372.7	DATA PI(8) /1.512/
372.8	DATA PI(9) /1.490/
372.9	DATA PI(10)/1.491/
373.	DATA PI(11)/1.491/
373.1	DATA PI(12)/1.491/
373.2	DATA PI(13)/1.491/
373.3	DATA PI(14)/1.491/
373.4	DATA PI(15)/1.491/
373.5	DATA PI(16)/1.491/
373.6	DATA PI(17)/1.491/
373.7	DATA PI(18)/1.491/
373.8	DATA PI(19)/1.491/
373.9	DATA PI(20)/1.695/
374.	DATA PI(21)/1.688/
374.1	DATA PI(22)/1.688/
374.2	DATA PI(23)/1.688/
374.3	DATA PI(24)/1.688/
374.4	DATA PI(25)/1.688/
374.5	DATA PI(26)/1.586/
374.6	DATA PI(27)/1.484/
374.7	DATA PI(28)/1.484/
374.8	DATA PI(29)/1.484/
374.9	DATA PI(30)/1.431/
375.	DATA PI(31)/1.431/
375.1	DATA PI(32)/1.474/
375.2	DATA PI(33)/1.474/
375.3	DATA PI(34)/1.474/

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375.4      DATA PI(35)/1.474/
375.5      DATA PI(36)/1.232/
375.6      DATA PI(37)/1.329/
375.7      DATA PI(38)/1.329/
375.8      DATA PI(39)/1.329/
375.9      DATA PI(40)/1.329/
376.       DATA PI(41)/1.73/
376.1      DATA PI(42)/1.064/
376.2      DATA PI(43)/1.360/
376.3      DATA PI(44)/1.481/
376.4      DATA PI(45)/1.086/
412.       DO 10 J=1,45
415.       READ (5,200) AMT(J)
416.       200 FORMAT(1F10.5)
417.       10 CONTINUE
418.       ESUM=0.0
419.       DO 25 J=1,45
421.       AMT(J)=AMT(J)/PI(J)
422.       ESUM=AMT(J)*C(J)+ESUM
424.       25 CONTINUE
425.       READ(5,300) AEPM
426.       300 FORMAT(F10.3)
427.       AEP=AEPM*3.413E3
428.       DYRS=2*0.35*ESUM/AEP
429.       IF (DYRS.LE.12.) NEAS=7.5
430.       IF (DYRS.GT.12.0.AND.DYRS.LT.20.) NEAS=5.63
431.       IF (DYRS.GT.20.) NEAS=0.0
431.1      WRITE (6,99)
431.2      99  FORMAT (1X,'***** NET ENERGY ANALYSIS *****',/)
432.       WRITE (6,500) ESUM,AEP,DYRS
433.       500 FORMAT(10X,' ENERGY COST= ', E12.6, ' BTUS',/,10X,
434.       1'ANNUAL POWER PRODUCTION = ', E12.6, ' BTUS',/,10X,
435.       2'YEARS TO DOUBLE ENERGY COST= ', E12.6,/)
436.       WRITE (6,600) NEAS
437.       600 FORMAT(10X,'NET ENERGY SCORE=', F10.3,/)
438.       RETURN
439.       END
440.       $DATA

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