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ABSTRACT

Phase 1 of a project in curriculum design and course development identified and is now developing a two-year solar engineering curriculum in response to the immediate need for trained solar manpower as indicated by research. The student-centered curriculum involves courses flowing from device to theory, intermixing of support and technical courses in sequencing, and hands-on laboratory experience. Navarro College and three other cooperating two-year colleges have developed the curriculum for solar engineering technicians as well as course descriptions and are developing the proposed solar courses. Support courses were selected to provide prerequisite skills or knowledge, to satisfy requirements for associate degree programs, and to assure balance between technical, laboratory courses and academic preparation. The course outline provides for an integrated laboratory lecture format with general goal statements, titled modules, specific performance objectives, and laboratory activities. The program is designed for high school graduates who will attend college full-time and those currently employed desiring skill upgrading. Instructors will be regular college faculty and technical and vocational instructors hired specifically to teach the technical solar courses. A national advisory committee provides guidance and evaluation. The remainder of phase 1 will include completion, editing, printing, use, and revision of course guides and the complete curriculum package. (YLB)

A PROJECT TO
DESIGN, DEVELOP, IMPLEMENT, TEST, EVALUATE
AND DISSEMINATE AN ASSOCIATE DEGREE
CURRICULUM TO TRAIN
SOLAR ENGINEERING TECHNICIANS

INTRODUCTION

In September of 1977 the National Science Foundation approved Phase I of a multi-phase project entitled "A Proposal to Design, Develop, Implement, Test, Evaluate and Disseminate an Associate Degree Curriculum to Train Solar Engineering Technicians". Navarro College was designated as the Project Center with three other two-year colleges throughout the United States named as cooperating institutions. Through the multi-phase concept the following phases were proposed: (1) Phase I - Curriculum Design and Course Development, (2) Phase II - Pilot Test of First Year Curriculum, and (3) Phase III - Pilot Test of Second Year Curriculum.

Phase I is now in progress and Phase II is scheduled to begin January 1, 1979. Phase I is proceeding in a satisfactory manner and, to date, the two-year solar engineering curriculum has been identified and is being developed, laboratory specifications have been determined, teacher qualifications have been established, student populations have been identified, course reference materials are being completed, audio visual materials are being identified, laboratory experiments are being developed and the complete curriculum package is being assembled for final development and revision for pilot testing.

The accomplishments attained during Phase I have been brought about through the cooperative efforts of the National Science Foundation, Navarro College (the grantee institution located in Corsicana, Texas), the cooperating institutions of Brevard Community College (Cocoa, Florida), Cerro Coso Community College (Ridgecrest, California), Dallas County Community College District, Northlake Campus (Dallas, Texas), a national advisory committee and special consultants.

Phase II of the Project, scheduled to begin January 1, 1979, will have the following five objectives.

1. To perform pilot testing of the first year of the two-year Solar Engineering Technician Curriculum.
2. To secure local and state approval of the curriculum.
3. To perform a formative evaluation of the first year curriculum.
4. To revise the course guides where indicated by the evaluation.
5. To prepare the first year curriculum, in revised form, for dissemination.

Research and Justification

Through research it has been predicted that the solar industry in the United States today stands on the brink of very rapid development and commercialization of solar home heating and cooling systems. The expansion of this industry depends upon the availability of trained technical personnel who can design, install and maintain solar systems. Research in the field also indicates that this trained manpower does not exist today and implies that it could serve as the needed catalyst for a more rapid development in solar energy research and application as a national energy source.

In January of 1978 Navarro College completed a project for the Department of Energy (D.O.E.) entitled "Assessment of Need for Developing and Implementing Technical and Skilled Worker Training for the Solar Energy Industry". According to the Department of Energy study, there will be a substantial demand for trained skilled workers in the United States which will develop concurrently with the demand for solar equipment. The immediate need for trained solar manpower has been indicated by reviewing the solar installation projections made by three prominent studies:

1. The University of New Mexico Study

   Title: THE ECONOMICS OF SOLAR HOME HEATING, by William D. Schulze, Shaul Ben-David.

   Date: July 1976.

2. The MITRE Corporation (MITRE) Study:

   Title: AN ECONOMIC ANALYSIS OF SOLAR WATER AND SPACE HEATING

   DATE: July 1977.

3. The Solar Energy Industries Association (SEIA) Study:

   Title: SOLAR MARKET CAPTURE AND MARKET PENETRATION, by Sheldon Butt.

   Date: October 1976.

The SEIA study is the industries own estimate of its market potential. As such, it represents the views of those who most directly gain or lose depending on the accuracy of their perception.

The MITRE study is the product of the most intense effort by DOE to date to arrive at feasibility and market penetration estimates. MITRE estimates are being used extensively by DOE in many other analyses.

The University of New Mexico study (UNM Study) forecasts the economic feasibility of solar energy state-by-state, by year, and by application.

The solar manpower forecast made in the DOE study, as a direct function of equipment market projections, indicates the following pattern of development:

1. There will be at least 2.4 million solar units installed in the U.S. by 1985.

2. There must be a minimum of 25,000 skilled workers in the solar field by 1985.
3. Four-fifths, or 20,000, of the solar workers must be trained at the installer/mechanics level.
4. One-fifth, or 5,000, of the solar workers must be trained at the solar technician level.
5. Training for both the solar technician and the solar installer/mechanic can be accomplished at the community college level, the solar technician program being an associate degree two year curriculum, and the solar installer/mechanic program being a certificate of completion program.

As a part of the DOE study, the skills required of solar workers were identified. Also, it was found that solar workers can be categorized into two distinct categories, solar technicians and solar installer/mechanics. The solar engineering technician is a person who must possess knowledge and skills specific to solar system design, installation, and diagnostic trouble-shooting. The solar installer/mechanic, on the other hand, is defined as a tradesperson who has knowledge of solar systems and is expected to perform entry level tasks of installation and routine maintenance.

A program to train solar installer/mechanics who have no trade experience or training would include conventional heating, ventilating, and air conditioning and plumbing training, as well as solar skill knowledge. A program to train installer/mechanics can be conducted through a one year certificate program.

Since the solar engineering technician is a person responsible for the design of a solar energy system, for overall system check-out and trouble-shooting in case of the need for repair, this person is expected to have adequate knowledge and skills to perform solar related tasks of relative sophistication. The education necessary for a solar technician exceeds that of a typical tradesperson and is beyond the requirements of a solar installer/mechanic.

As a final result of the DOE study, three recommendations were made:

1. That the development of solar technician training programs begin immediately.

2. That the basic technician training program contain the flexibility to accomodate local/regional variations and future developments in the solar industry.

3. That the solar mechanic training programs now being undertaken by solar manufacturers, distributors, and some trade unions be continued. This training should also be conducted through short courses, continuing education programs, and certificate programs.

Based on these recommendations, Navarro College has been designing and developing a two year curriculum to train solar engineering technicians as the first phase of a three phase project for the National Science Foundation.

PROGRESS REPORT OF PHASE I

This Progress Report describes the activities being conducted to reach the basic objectives of Phase I. The basic objective for Phase I of the NSF Curriculum Development Project is to design and develop a two-year associate degree curriculum to prepare solar engineering technicians. The specific development activities include the following:

1. Design of the curriculum.
2. Design and specifications of courses including course descriptions and outlines, objectives, and appropriate learning activities (reading, laboratory development, AV specifications, etc.)
3. Identification of existing instructional materials.

Philosophy of Phase I

The philosophy governing the development of the Solar Engineering Technician Curriculum must be student centered. The student should first be provided a global view of the job requirements in the career field of solar energy. Beginning with the first semester, courses should flow from device to theory, rather than theory to device as is common in engineering and four year science curricula. It is important that, in sequencing, the first semester must not be filled with support courses while the technical courses are relegated to later semesters. Laboratory experiences are also extremely important throughout the technician curriculum. The student must obtain hands-on experience with solar devices early in the program while the curriculum must be sequenced in a manner which permits the student to advance to a level where success can be achieved after being placed in a job.

Definition of Solar Engineering Technician

To design an associate degree program to train solar engineering technicians, the job category must be defined. Based on an analysis of the tasks that must be performed by the individual, the Project has produced a working description of the solar engineering technician defined in terms of the activities which must be performed. These are listed below.

1. Apply knowledge of science and mathematics extensively and render direct technical assistance to scientists and engineers engaged in solar energy research and experimentation.
2. Design, plan, supervise, and assist in installation of both simple and complex solar systems and solar control systems.
3. Supervise, or carry out, the operation, maintenance, and repair of simple and complex solar systems and solar control systems.
4. Design, plan, and estimate costs as a field representative or salesperson for a manufacturer or distributor of solar equipment.
5. Prepare or interpret drawings and sketches and write specifications or procedures for work related to solar systems.
6. Work with and communicate with both the public and other employees regarding the entire field of solar energy.

Development of the Curriculum

Based on tasks analysis, research, input from a National Advisory Committee, and work performed by the Campus Coordinators and Project Director, the two-year Solar Engineering Curriculum has been developed as displayed in Figure 1.

FIGURE 1-CURRICULUM - SOLAR ENGINEERING TECHNICIAN

FIRST SEMESTER	CREDIT HOURS	CONTACT HOURS (Lecture-Lab Hours)
Math I	3	3
Energy Science I	4	6 (3-3)
Introduction to Solar Energy- (Conservation and Passive Design)	2	2
Materials and Material Handling	3	5 (1-4)
Engineering Drawing	3	3
Education and Career Planning	1	1
	16	20

SECOND SEMESTER	CREDIT HOURS	CONTACT HOURS (Lecture-Lab Hours)
Math II	3	3
Energy Science II	4	6 (3-3)
Collectors & Energy Storage	4	6 (2-4)
HVAC	4	6 (2-4)
English	3	3
	18	24

THIRD SEMESTER		
Applied Electrical Circuits & Instrumentation	4	6 (2-4)
Sizing Design & Retrofit	4	6 (3-3)
Technical Survey of Energy Sources	3	3
Introduction to Computers & Computer Programming	3	3
Introduction to Business	3	3
	17	21

FOURTH SEMESTER		
Operational Diagnosis	3	5 (2-3)
Codes, Legal, Economic, Consumerism	2	2
General Psychology and/or Human Relations in Industry	3	3
Non-residential Applications & Future Technology	3	5 (2-3)
Technical Report Writing	2	2
Solar Practicum	3 - 5	
	13 + prac.	17 + prac.

Solar Course Descriptions

The solar courses presently being developed by the participating Institutions are described as follows:

1. Energy Science I & II - This is a two semester course which covers the basic physical principles governing the reception, transfer, storage, and use of solar energy. Material in this course has been drawn from standard courses in physics, chemistry, astronomy

geography, and hydro-dynamics. Topics covered in the first semester include general energy definitions, a detailed discussion of the principles of temperature, heat and thermodynamics, and the characteristics in measurement of solar radiation. Topics covered in the second semester include hydrostatics, hydrodynamics, basic electrical considerations, electromagnetic interactions, electromagnetic waves, light and optics, meteorology, and geography.

2. Introduction to Solar Energy - The student will be introduced to solar energy. A general history of the use of solar energy will be given, and solar concepts such as the solar constant, locating the sun, and yearly changes in solar position will be discussed. An overview of collector types, physical processes of converting solar radiation to thermal energy, a general solar vocabulary, traditional and non-traditional applications, and current economic feasibility are some of the topics that will be covered. The effect of energy conservation measures on heating and cooling loads will be explored. The importance of designing energy efficient buildings will be stressed, and the effect of different types of energy efficient construction will be studied. Energy conservation measures will be related specifically to the design of solar systems. Relationships between house design and the environment will be studied, as will passive solar design. Upon completion of this course, the student should have an overall view of the total range of topics to be covered in the two year curriculum and should be able to explain the relationships between conservation measures, passive solar design, and the reduced size of active solar systems needed as a result of conservation measures.

3. Collectors and Energy Storage - Methods of collecting solar energy for home heating and cooling will be surveyed. Collector types (flat-plate, focusing, evacuated tube, etc.) will be examined in detail and the relative advantages and disadvantages of each type will be discussed. Hands-on experience with collector parameters will be obtained. Different collector types will be examined side-by-side, and collection efficiency compared. The effects of varying collector parameters (flow rate orientation, glazing, selective services, etc.) will be studied using sample collectors. Both liquid and air collectors will be examined and compared and the relative advantages and disadvantages will be explained. Chemical compatability of different collector materials and collector fluids will be examined. The effect of insulation and different insulation types will be studied.

Methods of storing solar energy, including latent and sensible heat storage will be examined. The relative merits of different sensible heat storage media (rocks, water, etc.) will be measured and compared in the laboratory. The physical construction of storage systems will be studied and different types of systems will be constructed. The effects of insulation, storage shape, flow, etc. on storage efficiency will be measured. Measurements will be made on a latent heat system, and it will be compared with the sensible heat storage for efficiency, storage density, cost, etc. Exotic storage systems for possible use in electrical generation will be mentioned.

At the conclusion of this course, the student should be able to select and install the most suitable collector for each particular heating or cooling problem. The student should be able to explain the construction of collectors, the purpose for each item in a collector and, if necessary, should be able to build, from component parts, a functional solar collector. The student should be able to explain different types of energy storage, select the type that is most suitable for a specific application, and construct an actual storage system.

4. Sizing Design and Retrofit - A solar installation will be examined as a complete system. The interrelation of the parts of a system (collectors, pumps, heat exchangers, storage pipes, ducts, controls, etc.) will be explained. Control systems and various control strategies for heating, cooling, and domestic hot water will be studied. The integration of solar apparatus with conventional auxiliary systems (furnace, heat pumps, etc.) will be explored. The integration of systems hardware into the housing structure will be discussed. The sizing of system components to meet a given percentage of heating or cooling load in a given location will be explained and calculations will be made. The components of a solar system, which have been studied individually, will be combined into a complete system. The system parameters will be adjusted for maximum efficiency, and the effect of varying parameters on the system efficiency will be measured. The effect of different control strategies on overall performance will be measured.

Design problems specific to retrofit installations will be examined. Particular attention will be paid to determining the suitability or non-suitability of structures for retrofit systems, and the importance of proper insulation and general upgrading of structures for retrofit. Upon completing this course the student should be able to design and size a solar system that will function properly in any area of the country.

5. Operational Diagnosis - The use of instrumentation and measurements to correctly set up a solar system will be explored. Common problems likely to be encountered in a malfunctioning solar system will be discussed and symptoms of these problems will be explained. Troubleshooting techniques will be studied and a systematic troubleshooting scheme will be developed. The effect of component failures on the operation of the system will be measured.

The effects of control strategy failures will be measured. Intentionally introduced defects and problems in the solar system will be identified, tracked down, and repaired. Upon completion of this course, the student should be able to set up a solar system for the most efficient operation. He or she should be prepared to maintain the system and to locate system defects and repair them.

6. Materials and Material Handling - This course will deal with the properties and handling of materials which are utilized in construction of a solar system. It will include the basics of plumbing, sheet metal workings, carpentry, roofing, glazing, concrete pouring, soldering, welding, and other related techniques. Compatability of different construction materials will be explored and problems encountered in utilizing materials will be discussed. Upon completion of this course, the student should be able to demonstrate the capability of handling and working with the materials utilized in a solar installation.

7. Non-residential Applications and Future Technology - The application of solar technology for uses other than home heating and cooling will be explored. Included will be items such as industrial process heat, agricultural crop drying, and the conversion of solar energy into electricity, both by the central power station concept and by photovoltaic cells. Although many of these techniques are not now

finding widespread applications, by the time the curriculum is completed some of these techniques may be in use. This course will be an open-ended format and material will be added as new technologies develop, come into use, or are discarded.

8. Technical Survey of Energy Sources - Energy supplies and demand will be explored on a world wide basis. The supply capabilities of traditional energy resources and the supply capabilities of future energy resources will be studied in detail. Energy conservation and environmental problems will be related to the capability of meeting future energy demands. The position of solar energy in the future mix of energy supply resources will be established. Upon completion of this course the student should be able to explain the relationships between energy supply and demand and should be aware of the relative role solar energy can play in the future.

9. Economics, Codes, Legal, Consumerism - The economics of solar systems will be explored, particularly as they are affected by governmental action. Methods of calculating economic costs and benefits will be studied as they relate to both active and passive solar systems. Customer relations, guarantees, and consumer protection will be explored, and the importance of maintaining credibility with customers will be emphasized. Solar system financing will be examined. This course will have an open-ended format since the legislative action which affects solar economics is constantly changing. Upon completion of this course, the student should be aware of the types of governmental documents and action that will affect the future of the solar industry and the importance that consumer relations will play in the future.

10. Solar Practicum - This course will be a culmination of the student's work and will involve an on-the-job field testing of the student's capabilities. It will be carried out in cooperation with the solar

industry. The student will given on-the-job experience, including the design and involvement in the installation of a "real world" solar project. Based on the results of this project, including an evaluation from industrial representatives the student's overall level of achievement will be established. A successful performance by the student during the practicum project will hopefully lead to employment opportunities.

Support Course Descriptions

The support courses in the curriculum have been selected as those courses necessary to provide prerequisite skills or knowledge to the student before attempting solar courses, those courses necessary to satisfy approved requirements fo. associate degree programs, and those courses needed to assure balance between technical, laboratory courses and academic preparation. The detailed listing of support courses follows:

1. Math I and Math II - Many community colleges offer courses entitled "Technical Mathematics". These are courses designed to teach applications and are not as theoretically oriented as the regular algebra and trigonometry courses.

   Technical Mathematics I. The slide rule and calculator, fundamental operations of algebra, linear and quadratic equations, systems of equations, functions and their graphs including the trigonometric function solutions of right triangles are studied (3-0). Credit: 3.

   Technical Mathematics II. A study is made of basic vectors, exponents and radicals, complex numbers, logarithms, solutions of oblique triangles and trigonometric identities. Prerequisite: Mathematics I. (3-0). Credit: 3.

2. <u>English</u> - The English course should be a basic compositions course designed for students who have had three years of high school English. It should emphasize grammar and the nature and structure of the language.

English Composition I. A study of the principles of grammar and composition with emphasis on language, the mechanics of writing, and the types of discourse. (3-0). Credit: 3.

3. <u>Education and Career Planning</u> - This a college adjustment course and is usually required, in some form or other, of all students entering the college.

Educational and Career Planning. Required of all students entering as a freshman. Information discussion groups are devoted to acquainting the students with college and its offerings and to give individual students an opportunity to appraise their interest and abilities. (1-0). Credit: 1.

4. <u>HVAC</u> - The desired course should give the student a good background in standard heating and air conditioning systems.

Central Heating and Air Conditioning. Installation of domestic central heating (gas and electric) and air conditioning systems; study of theory of operation of low voltage control circuits, operating circuits, and mechanical systems. Preventive maintenance and maintenance procedures. (2-4). Credit: 4.

5. <u>Applied Electrical Circuits & Instrumentation</u> - In some catalogues a suitable course is listed under the electronics technician curriculum. In others, it is listed under the air conditioning curriculum.

Basic Electrical Circuits. A course dealing with basic electricity and its application. Various electrical devices, their importance in electrical circuits, including those used in residential wiring are introduced. Methods of wire connections for new and repair service, making and testing electrical circuits and the use of electrical measuring and testing equipment are studied. (2-4). Credit: 4.

6. Technical Report Writing - This is a standard course in most community colleges: If enrollment is large enough, a special section should be offered for Solar Engineering Technicians.

Technical Report Writing. Instruction in the writing of technical reports and business letters. Attention given to the preparation and delivery of speeches pertaining to technical or business interest. (3-0). Credit: 3.

7. Computer Programming - The course should include an introduction to large computers; an introduction to mini-computers and micro-processors, and the use of programmable calculators. Basic programming and flow charting should be included and at least one programming language, probably BASIC should be taught.

Computer and Calculator Techniques. A course dealing with calculators and computers, 4-function and programmable calculators serves to introduce computer principles. Large computers are studied in both batch and interactive modes utilizing BASIC language. (3-0). Credit: 3.

8. Introduction to Business - This is a standard course at most community colleges.

Introduction to Business. A survey of modern business activities, including a brief study of basic industries, forms of organization, banking, credit, problems of management, business risks, and the relation of business to society. (3-0). Credit: 3.

9. Engineering Drawing - This is a course offered by most community colleges.

Drafting Fundamentals. Study of basic skills and techniques of drafting, including lettering; instruments and their use; applied geometry; orthographic freehand and instrument drawing; auxiliary views;

sections and conventions; dimensions and notes. (2-4). Credit: 3.

10. Psychology - This is a standard course offered by most community colleges.

General Psychology. This course is a survey of the field of psychology. Chief topics studied are the scientific methods used in psychology; the influence of heredity and environment; the control of the emotions; intelligent behavior; and the conditions governing learning, social behavior and the development of personality. (2-4). Credit: 3.

11. Human Relations in Industry - This course is found under a number of different descriptions in either the business or management ddpartments. The course credits vary from two to three hours.

Business Psychology. Fundamentals of human behavior, leadership development, organization relationships, social considerations, and communication processes that affect motivation and human behavior in the business world. Case problems are utilized. (3-0). Credit: 3.

Development of Solar Courses

Each of the participating institutions has the responsibility for developing specific courses according to a standard format designed for this project. The course assignments are displayed in Figure 2, along with a progress report statement for each course. During October of 1978 all solar courses should be ready for the final revision process.

Figure 2

SOLAR COURSE RESPONSIBILITIES

College and course(s)	Progress to Date (July 6, 1978)
Navarro College	
Operational Diagnosis	Complete and in revision stage
Technical Survey of Energy Sources	Complete and in revision stage

College and courses(s)	Progress to Date (July 6, 1978)
Non-residential application & Future Technology	In development stage 75% complete
Solar Practicum	In pre-development stage
Dallas County Community College District (Northlake Campus)	
Energy Science I	In final development stage 90% complete
Energy Science II	In development stage 75% complete
Introduction to Solar Energy - Conservation & Passive System	In development stage 25% complete
Cerro Coso Community College	
Sizing Design and Retrofit	In development stage 50% complete
Materials & Material Handling	In development stage 25% complete
Economics, Codes, Legal, Consumerism	In development stage 40% complete
Brevard Community College	
Collectors & Energy Storage	In development stage 50% complete

Course Format

The format for the technical curriculum course should provide for an integrated laboratory/lecture course. They should be written in terms of goal statements and performance objectives. (Figure three represents the format outline)

Figure 3 - COURSE FORMAT

COURSE TITLE

SECTION: ________________

Goal Statements for Section (General)

Modules (by title)

1.
2.
3.
4.

LECTURE

MODULE #1: ________________

References (by number, referred to bibliography)

Performance objectives for module

LESSON #1: ________________

Performance objectives for lesson #1

LESSON #2: ________________

Performance objectives for lesson #2

LABORATORY ACTIVITIES

Materials and Equipment

LAB ACTIVITY, LESSON #1: ________________

Performance objectives for lab activity

LAB ACTIVITY, LESSON #2: ________________

Performance objectives for lab activity

The course format sheet requires the course title followed by a one or two paragraph course description which includes the purposes of the course and the goals expected to be met by the student upon completion of the course. The description will also relate the course being discussed to other courses in the curriculum and show course prerequisites. The general information for the course will terminate with a numerical listing of the sections to be covered in the course. The course sections will then be expanded.

Each course section will begin with the title, a general goal statement, and a numerical listing by title of the modules in that section. From this point the format divides into two parallel sections, one for lecture and a second for laboratory activities. The sections are provided by module in numerical order, beginning with the title of the first module.

Following the title of the module on the lecture half of the format sheet is a list of reference materials keyed numerically to each module. The references will be very specific referring to chapters and page numbers. This will serve as an aid not only to the instructor of the course, but to the students as well for further study. The references will be followed by a statement of the overall performance objectives the student will be expected to fulfill upon completion of the modules.

The specific lessons of the module will begin immediately after the statement of overall performance objectives. The lessons will be listed numerically and will be sequenced in the order best suited for the most effective transfer of information to the student. Each lesson will be listed by title, followed by a specific performance objective, or the specified level of achievement the student will be expected to master. By arranging the format in terms of performance objectives, the student will clearly understand the performance level expected. Also, evaluation procedures for the student can be developed and implemented easily, instructors can design their institutional strategies more effectively, and instructors can better evaluate the adequacy of their instructional program.

The second half of the format sheet parallels the lecture half and is developed in tandem. First shown on the laboratory side of the format sheet is a list of materials and equipment needed to perform the laboratory activities for that particular module: This will be followed by references conveniently listed numerically. The remainder of the laboratory activity column will follow the same format as the lecture portion, with laboratory activities keyed to the lessons and performance objectives for the laboratory activity. This format should enable the instructor to coordinate the lecture portion of the module with the laboratory experiences with little difficulty.

Figure four illustrates the use of the course format for one section of the course entitled "Energy Science".

Figure 4

SAMPLE FOR CURRICULUM DEVELOPMENT FORMAT

COURSE TITLE: Energy Science

SECTION: Thermal Science

Goal Statement: Upon completing this section the student will be able to measure temperature and carry out heat-transfer calculations.

MODULES:

1. Temperature
2. Temperature measurement
3. Heat capacity
4. Heat as a form of energy
5. Heat transfer mechanisms
6. Heat transfer properties of materials

LECTURE

MODULE 1: Temperature

References by number

Performance Objectives for Module 1:
Upon completing this module the student will be able to:

a. Define temperature
b. Convert from one temperature scale to another.

LESSON 1: Meaning of Temperature

a. Explain kinetic energy.
b. Define temperature in terms of kinetic energy.
c. Relate the concepts of "hotter than" and "colder than" to kinetic energy.

LESSON 2: Temperature Scales

a. Describe the "Farenheit" temperature scale.
b. Describe the "Celsium" temperature scale.
c. Describe the absolute or "Kelvin" temperature scale.
d. Correctly convert temperature from one scale to another.

MODULE 2: Temperature Measurement

References by number

Performance Objectives for Module 2:
Upon completion of this module, the student will be able to:

a. List the temperature measurement devices that are in common usage.
b. Select the most satisfactory temperature measuring device for each situation.
c. Demonstrate competence in the use of temperature measuring devices.

LABORATORY

MODULE 1: Temperature

NO LABORATORY

LESSON 1: Meaning of Temperature

NO LABORATORY

LESSON 2: Temperature Scales

NO LABORATORY

MODULE 2: Temperature Measurement

Materials and Equipment:

a. Mercury-in-glass thermometer
b. Alcohol-in-glass thermometer
c. Bimetallic strip thermometer
d. Thermistor and associated electronics
e. Thermocouple and ass. electronics
f. Optical pyrometer
g. Dry ice, freezer, hot plate, electric furnace

References by number

LECTURE	LABORATORY
LESSON 1: Expansion Thermometers a. Describe the operation of a thermometer that operates on the principle of expanding fluids. b. Describe the operation of a thermometer that operates on the principle of a bimetallic strip.	LESSON 1: Expansion Thermometers a. Measure a range of temperatures suitable for the mercury-in-glass thermometer. b. Measure a range of temperatures suitable for the alcohol-in-glass thermometer. c. Measure a range of temperatures suitable for the bimetallic strip thermometer.
LESSON 2: Thermistors Describe the operation of a thermometer that utilizes a thermistor as the sensing element.	LESSON 2: Thermistors a. Set up and calibrate the thermistor thermometer. b. Measure a range of temperatures suitable for the thermistor thermometer.
LESSON 3: Thermocouples Describe the operation of a thermometer that utilizes a thermocouple as the sensing element.	LESSON 3: Thermocouples a. Set up and calibrate a thermocouple thermometer. b. Measure a range of temperatures suitable for the thermocouple thermometer.
LESSON 4: Optical Pyrometer Describe the operating principle of the optical pyrometer.	LESSON 4: Optical Pyrometer a. Set up and calibrate an optical pyrometer. b. Measure a range of temperatures suitable for the optical pyrometer.
LESSON 5: Selection of Measuring Devices Match the various thermometers to the measurement situation to which each is most suited.	LESSON 5: Selection of Measuring Devices NO LAB ACTIVITY

Student Characteristics

It is projected that a solar technician program will basically attract three types of students. The first type of student will select the program because of the feeling that solar energy is glamorous, having read about it in the newspaper and being interested in something that sounds new, different, or existing. Careful counseling of these students will be required to identify those with a high interest but without the proper high school background or technical aptitude to complete a technician level program.

The second type of student, and the one for whom this program is primarily designed, is the high school graduate who has selected a two year, job oriented educational program as being best in meeting his or her personal goals. This student should have adequate high school preparation and will probably be in the upper half of his/her graduating class. This student will be attending college on a full time basis and will be expected to complete the technician training program within a two year period.

The third type student is a person who is currently employed and wishes to receive training in a new career field. This type of student will probably be older, may have family responsibilities, and will likely find it impossible to complete all of the required classes during the regular day time class periods. This student may bring into the program a wide variety of skills, many of which will be applicable to the solar engineering technician curriculum. For this student, counseling is especially important since an accurate assessment of needs and capabilities must be made. It is likely that students in this category will be able to receive credit for various courses through challenge examinations; certainly the support courses may be treated in this manner. It is unlikely that students who are attending on a part time basis, even with credit given for on-the-job training or work completed, will be able to complete the curriculum in a two year period. It is also probable that colleges may have to offer special arrangements of the solar courses, specifically for part time students who must attend classes in the evening or on weekends.

Teacher Qualifications

Two types of instructors are involved with the implementation of a solar engineering technician program. One type will consist of regular college faculty members who are teaching in science or technology related areas and will be capable of teaching not only some of the support courses, but some of the solar related courses as well. These instructors might include Physics and Chemistry teachers who could offer the "energy science" course, lawyers or economists who could teach the "legal aspects and economic aspects", industrial arts teachers who could present the "materials and material handling" course, and specially trained conservationists who might teach "energy science" and "conservation and passive design".

The second type of instructor is the one who would be hired specifically to teach the technical solar courses. This person would be required to meet general state requirements for technical and vocational instructors. These requirements usually include a bachelor's degree with two to six years of related field experience or teaching experience in the technical area. It may be somewhat difficult to find persons with these qualifications to teach in the solar engineering curriculum project. At the Energy Technology Training Conference, sponsored by the Energy Research and Development Administration and the Association of American Community and Junior Colleges, in October, 1976, the problem of instructors in solar curriculum was approached and the following statement was made:

> The identification of the instructor should be approached cautiously. As witnessed by the college participants at the conference, being qualified to teach in an allied field is not enough. Potential instructors need initially to be interested in solar energy, and motivated sufficiently to pursue self-study and self-generating activities to become proficient in a bootstrap educational effort.

Educational requirements for a solar energy instructor might read as follows:

> Baccalaureate Degree and at least three (3) years occupational experience in industrial or domestic air conditioning trades. Experience should include installation, maintenance and design of air conditioning systems. In addition, candidate should have a minimum of one year solar related experience to include design and installation of functioning solar systems. Exceptional solar experience will be considered in lieu of the air conditioning requirements. He/she must be qualified to teach solar energy related courses at

both the practical and theoretical level in a one year certificate program or a two year degree program.

Such organizations as the League for Innovation in the Community College recognize that there is a lack of trained community college faculty members to teach the techniques and skills required of personnel in the solar energy industry. Therefore, the League is proposing a "concentrated national effort to provide community college faculty members with the knowledge and skills required to train or retrain individuals in the installation of solar energy systems". This will aid in establishing a trained cadre of resource personnel on the community college level who can be used as instructors in solar energy programs.

Instructor Course Load

As the semester course load is scheduled for the instructor, an attempt may be made to arrange the courses in such a manner that a single instructor, hired to teach in the solar technician program, will have a complete and balanced load each semester. Many schools cannot afford to employ a separate instructor who would only have a part time teaching load in the solar program. Course load balancing might permit more institutions to initiate the curriculum. Accordingly, in cases where other influencing factors are not significant, courses have been sequenced to provide a balanced instructor course load for both semesters, as indicated in Figure five.

Figure 5

INSTRUCTOR COURSE LOAD

Semester One

COURSES	LEVEL	CREDIT HOURS	CONTACT HOURS (Lecture-Lab Hours)
Energy Science	F	4	6 (3-3)
Conservation & Passive Systems	F	2	2
Materials & Material Handling	F	3	5 (1-4)
Sizing Design & Retrofit	S	4	6 (3-3)
Technical Survey of Energy Sources	S	3	3
		16	22

F - Freshman
S - Sophomore

Semester Two

COURSES	LEVEL	CREDIT HOURS	CONTACT HOURS (Lecture-Lab Hours)
Energy Science	F	4	6 (3-3)
Collectors & Energy Storage	F	4	6 (2-4)
Operational Diagnosis	S	3	5 (2-3)
Non-residential Applications & Future Technology	S	3	5 (2-3)
Solar Practicum	S	2 - 5	
		14 + prac.	22 + prac.

F - Freshman
S - Sophomore

It must be recognized that some schools will employ a part time instructor to teach the solar related courses and will utilize either special sections or standard sections of regular courses to satisfy some of the curriculum requirements. This must be taken into consideration in examining the instructor's course load. If, for instance, a school were to replace the energy science course with a standard chemistry or physics course and to have instructors in the welding, sheet metal, and machine shop areas teach the materials and materials handling course, an instructor could be employed half-time to teach the solar related courses during semester one. During semester two, if the energy science again were replaced with a chemistry or physics course, and the solar practicum were delayed until summer, a half-time instructor would again be able to teach the solar related course. While this is not a recommended method of introducing the curriculum into a college program, this arrangement of course sequencing may again serve to permit more schools to being teaching the solar engineering technician curriculum.

National Advisory Committee

A National Advisory Committee was assembled early in Phase I to provide guidance for the project and project personnel. This committee assisted in generating the philosophy of the curriculum development phase; provided input regarding course selection and topics to be covered, and is helping with the evalution of written course materials.

The National Advisory Committee was selected to include people with recognized credentials in either solar technology or curriculum development and chaired by Dr. Phil DiLavore, Vice President for Academic Affairs, Indiana State University at Terre Haute. Dr. DiLavore is a physicist with wide experience in scientific curriculum development, having served as project coordinator for the "Physics of Technology" program. The other members of the committee are as follows:

Mr. Peter Fry, Director of Marketing Services, Northrup, Inc., Hutchins, Texas, was associated with the Chrysler Corporation for many years and was responsible for producing educational materials for training dealers and distributors to work on HVAC equipment. He is now associated with one of the established manufacturers of solar collectors.

Dr. David Gavenda, Professor of Physics and Education at the University of Texas at Austin, is a physicist who has long been associated with scientific curriculum development. He served as chairman of the National Steering Committee for the "Physics of Technology" program.

Mr. Tom Hindes, Director of the Instructional Materials Laboratory at Ohio State University, has extensive experience in the organization and development of curricula of all types.

Dr. Milt Larson, Professor of Vocational Education at Colorado State University, is the author of several books relating to the development of technical curricula. He served as the curriculum advisor and evaluator for the Solar Engineering Applications Laboratory at CSU during the development of a course on solar design and installation.

Mr. Glen Meredith is President of Ham-Mer, an Engineering Consulting firm located in Austin, Texas specialising in industrial and institutional energy conservation. His firm has been involved in a number of solar installations and has designed the HUD demonstration project at Navarro College.

Dr. Reggie Vachon is a Professor of Engineering at Auburn University and is actually involved in the design and construction of large scale solar projects throughout the United States.

Dr. Gary Vliet is a Professor of Mechanical Engineering at the University of Texas at Austin and is quite active in the field of solar engineering. He is on the Board of the Texas Solar Energy Society (TX-SES) and is a member of the Texas Governor's panel on energy.

To date, two meetings of the National Advisory Committee have been held, one on October 3, 1977 and a second on July 6, 1978. The first meeting was conducted at the Project Center for the purpose of establishing the functions and duties of the Committee, obtaining initial guidance from the Committee and planning details of the Project. The second meeting was held at the Airport Marina Hotel (Dallas, Texas) for the purposes of (1) Soliciting input from the Committee concerning the Phase II Project Proposal, (2) Planning the role and function of the Committee for Phase II and (3) Presenting solar courses prepared to date for review and later comment.

There are two distinct types of duties developed by the Committee. The first involved the Committee acting as a whole in making decisions that affect the overall project, and the second involved the Committee members acting as individuals to help the Project Director in matters relating to their individual expertise. The Committee as a whole established the seven duties as follows.

1. To assist in completing the curriculum plan, selecting the courses for which written materials should be developed, and providing input regarding the topics to be covered in each course.
2. To assist in developing an overall detailed timetable for the project.
3. To approve an overall format for written materials.
4. To monitor the progress of the project and assist the Director in maintaining the schedule to insure that project goals are met.
5. To assist in resolving serious conflicts of two types:
   a. Between the Director and the National Science Foundation (questions of overall policy or procedure).
   b. Between the Director and the Campus Coordinators (questions of format, style, policy, etc.)
6. To assist in the evaluation of the project.
7. To provide input for periodic reports to the National Science Foundation.

A single duty was established for Committee Members acting on an individual basis as advisors to the Director of the Project:

8. The Committee Members will, on an individual basis, give general assistance in the preparation of course materials. (This will consist primarily of reading and reacting to written materials.)

Also, the duties of the Committee Chairman were clearly established as follows: (1) chair meetings of National Advisory Committee, (2) communicate with Committee Members regarding Committee business, (3) serve as liaison between the Project Director and the Committee, (4) aid the Project Director in communication with the National Science Foundation regarding Committee business, (5) advise on all phases of the Project. The general position of the Committee in relation to the Project can be summarized by stating, "the Committee advises as a group and works as individuals". In this capacity numerous comments were provided as described below:

1. The "technician", as established by the Manpower Analysis conducted at Navarro College, is an intermediate level worker with more training than an installer or "mechanic" but less than the engineering student. The curriculum should be based on a detailed task analysis, and course content should be determined by knowledge and skills needed to perform the required tasks. In addition, the required content of some support courses should be determined by the background necessary for performance of the solar tasks.

2. The philosophy of curriculum design was discussed and is reflected under "Philosophy of Phase I" on page 7 of this proposal.

3. Laboratories and lectures should be listed separately. It is easier to ensure that the required hours are devoted to laboratory work as well as the lecture time, if lab and lecture are listed separately. However, if two different people are teaching, one teaching the lecture and the other teaching the lab, there may be some problems with coordinating the materials. The lab should be designed separately but material should be included in the teachers guide to show the method in which the lab and lecture could be combined into an integrated course.

4. An important first course is one addressing the fundamental physics of solar energy. This course, while not a laboratory course as such, should immediately introduce hands-on experience. This could be accomplished with simple experiments and demonstrations. This course should include items such as radiation, absorption and reflection, heat transfer, fluid mechanics, and a number of other theoretical topics, all of them slanted toward the solar energy field and with each concept illustrated by hands-on experience.

5. Since most people think of solar systems primarily in terms of collectors, the collectors course could be placed in the first semester.

6. The materials and fabrications course should be a first semester course. This course should include manual skills such as sheet metal work, soldering and welding, as well as the knowledge of materials used in solar systems including compatibility of materials, corrosion and other topics of this nature. A possible goal for this course could be for the student to use the skills learned to build a collector.

7. The course "Technical Survey of Energy Sources" should be placed late in the curriculum, possibly the last semester, after the student is thoroughly versed in solar energy. This placement will also help maintain the student's interest level. In this way, the relationship of solar energy to other potential and available energy sources will be appreciated.

8. Included in the curriculum should be an emphasis on conservation and the design and development of passive solar systems. The student should recognize the necessity for conservation and the importance of overall house design in minimizing the size or expense of a solar system.

9. The solar industry should be approached and a request made for the donation of equipment for model laboratory courses.

10. Faculty requirements for the program should be considered in developing the overall curriculum. In the curriculum guide, required faculty competencies should be listed, the required faculty loads should be addressed and methods by which the faculty might be hired efficiently should be discussed.

11. The courses should be modularized with all courses following the same format. Modules should begin with device and work into theory.

During November and December 1977, the Director utilized individual Committee Members and their expertise in specific areas. Tom Hindes helped develop a suggested format for the courses. Milt Larson provided valuable information needed for determining the content of courses that did not flow directly from the task analysis. Several conversations were held with Phil DiLavore concerning the overall organization of the project. On December 7, 1977, materials developed at that point were sent to the entire Committee for comment and included the following: (1) curriculum philosophy and educational level, (2) project timetable, (3) course list and specific courses, (4) separate laboratory and lecture or integrated laboratory-lecture, (5) two semester Energy Science courses containing basic theory, (6) Materials Science course, and (7) format and sample format.

Based on comments received from the committee, the following decisions were made: (1) the curriculum philosophy and educational level were established as contained in the sections of this document entitled "Philosophy" and "Student Characteristics", (2) the project timetable was established, (3) the course list and titles were approved with the understanding that modifications would be made as work progressed, (4) an integrated laboratory-lecture format was established, (5) a two semester Energy Science course was agreed upon to contain basic information from chemistry, physics, geology, fluid mechanics, etc., (6) the Materials Science course was agreed upon, and (7) the sample format was prepared subject to modifications as work progressed.

From January 1, 1978 through March 31, 1978, conversations were held with several Committee Members regarding various aspects of the curriculum. Courses were combined and modified based on preliminary task analysis completed by the Campus Coordinators. Course titles were changed to reflect the modifications. The format was modified slightly and the courses were sequenced. In addition to input from the Committee, valuable suggestions were received during personal conversations with Sasumu Karaki, Director of the Solar Energy Applications Laboratory at Colorado State University; Chuck Backus, Professor of Engineering, and Donald Zillman, Assistant Professor of Law at Arizona State University; and Herb Wade, Associate Director of the Arizona Solar Energy Commission.

At the end of March, materials were sent to the Advisory Committee detailing the latest thinking on various aspects of the project. Written responses received and conversations with several committee members produced valuable suggestions and overall approval.

As stated previously, the Committee had its second meeting on July 6, 1978. The minutes of that meeting reflect a high level of interest by Committee Members concerning the progress of Phase I and the proposal for Phase II. Important input was provided in preparation for the final writing of the Phase II proposal. Also, much of the meeting discussions relate directly to Phase II planning and will be addressed in the next section of this proposal.

Of major importance concerning Phase I in the second meeting was the Committee's definition of "instructional materials" and the direction provided relative to the expectations at the conclusion of Phase I. For the purpose of Phase I, it was determined that the development of instructional aids such as audio visuals, information sheets, illustrations for classroom presentations or other types of teaching or student aids was not within the scope of Phase I. Rather, "instructional materials" is defined as the course guides that instructors will need to pilot test the first year curriculum.

The second meeting ended with committee members looking forward to the next meeting in which course guides will be examined in detail.

Timetable for Remainder of Phase I

The activities already completed in Phase I have been described earlier in this section. The remaining activities for Phase I will now be outlined.

July 1, 1978 - August 31, 1978

The first drafts of the detailed course guides are being completed in the proper format by the Project Director, Campus Coordinators, release time faculty members, and external consultants.

Course guides are being edited by the Project Director and returned to the Campus Coordinators for revision, where necessary. Prototype laboratory equipment is being designed and plans are being made to purchase or construct equipment samples where possible. Detailed bibliographies and lists of recommended audio-visual materials are being keyed to solar courses.

As course outlines are revised and completed in finished draft form, they are being distributed to National Advisory Committee members, the National Science Foundation, and Campus Coordinators for review and comment. After this first review the Project Director will coordinate revisions for reproduction of the final draft.

September 1, 1978 - December 31, 1978

At the beginning of this stage the course development will have been essentially completed. The course guides will have been written in the proper format, the detailed bibliographies will have been prepared, and lists of recommended audio-visual materials will have been completed. The solar laboratory equipment needed to teach courses will also have been identified.

Beginning in September most new laboratory experiments to be performed in solar courses will have been identified. Once identified, these new experiments should be tested by instructors and students. As the budget allows, equipment for testing the experiments will be purchased, experiment procedure sheets prepared, and experiments performed. This is especially important for first year curriculum courses.

Also, during this time period course guides must be reviewed and revised in final form. This process will require the Director, the National Advisory

Committee, the National Science Foundation and Campus Coordinators to meet and review all courses which have been developed. In most instances technical consultants will be asked to review the course outlines. Upon completion of the review process, the revised course guides will be collected by the Project Director for final editing.

By December 31, 1978, the complete curriculum package including the curriculum design, detailed solar course guides, support course descriptions, laboratory specifications, equipment lists for solar courses, references, teacher qualifications and staffing patterns, audio visual aid lists and other related information will be organized and detailed.

December 31, 1978 - February 28, 1979

The end of December 1978, marks the completion of the 1/3 time contractual obligations for the Campus Coordinators during Phase I. At this time, the curriculum package will be complete and ready for final editing and printing. Final editing will be carried out during the first two months of 1979 by the Project Director, with the Campus Coordinators interacting as needed on a consultant basis. A final report on Phase I will be submitted to the National Science Foundation.

In concluding this progress report section of the proposal, it can be stated that the Project is progressing as evidenced by the accomplishments which have been described.

Only two weaknesses have been defined, but these are being corrected. The first weakness relates to the common problem of communication between and among the participating institutions and the National Advisory Committee. Course developments can be completed much more rapidly through better communications. The second weakness relates to the feeling by personnel at the Project Center and National Advisory Committee members that the Committee has not been utilized adequately. This problem is being corrected through an increase in the number of Advisory Committee meetings held throughout the remainder of Phase I and during Phase II.