ENERGY RESEARCH AND DEVELOPMENT AT NEW MEXICO STATE UNIVERSITY - 1975

Robert L. San Martin

A university is an excellent place for many types of investigation involving energy; for instance, the development of alternative energy sources, the socio/economic impact of the development of sources, environmental impact and also the promotion of conservation of energy. This University becomes involved in many of these fields via its role of teaching, research and service. The campus is a single location where one has a diverse group of people with expertise in many areas available to solve multi-displinary types of problems.

The University in its commitment to solving relevant problems, created in January of 1974,an Energy Research and Development Institute to coordinate energy research on the campus. Currently, approximately 30 major energy projects are in progress at the University. These involve research, development and demonstration projects, and represent almost $3 million of activity. This is a beginning, and it is anticipated that this program will be expanding to best meet the needs of the people of New Mexico, the Southwest, and the Nation.

Support for these programs come from a variety of sources. The 1974 state legislature recognized the necessity of energy research and development and a

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financial committment of $2 million to allow the universities in the state to begin projects. The University receives support from the Water Resources Research Institute, national agencies and private industry. Energy programs throughout the campus involved all the college and research units. Current projects involve the areas of electric power, water for energy, environmental impact of energy developments, energy in agriculture, the use of sewage and refuse as energy sources, geothermal energy, coal energy, wind energy and solar energy.

The area of electric power has been a tradistional area for the departments of Mechanical and Electrical Engineering. The Electrical Engineering Department has for a number of years run an Electric Utilities Management Program. This program is supported by a consortium of electric power companies in the Southwest ranging from Texas to California and into Colorado. Their main effort is analyzing large power systems, work that leads to more efficient and reliable transmission and distribution of electrical energy. The University is cooperating with Los Alamos Scientific Laboratories in the interfacing of the power that one would get from either one of these superconducting transmission lines, or from a possible superconducting storage system and how this would interface with the existing conventional power systems.

Water is an extremely important commodity, especially when one envisions the possible energy developments that will take place in the West, more specifically in the Rocky Mountain region. We've talked about coal, we've talked about geothermal, but there's also solar. We are in a prime solar area in the Southwest, and this along with mineral deposits that exist is going to require considerable water supplies in its development. Mr. Lawrence and Senator Domenici both mentioned the Tularosa Basin project. We're very proud that the initial funding of this project was made to the State Water Resources Research Institute on a study entitled, "The Feasibility Study for the Establishment of an Energy Water Complex in the Tularosa Basin". As initially begun, this is an intradisciplinary intrainstitution type of project. New Mexico State University, Los Alamos Scientific Laboratory, University of New Mexico and New Mexico Institute of Mining Technology are all working jointly on this particular project. It is a boost to this project that it has recently received an additional $100,000 from the Federal Energy Administration. Another project is "A Study into the Optimal Distribution of Energy Industries in New Mexico Relative to the Limited Water Supplies within the Area". This is being undertaken as a interdisciplinary study and the goals are to define the water requirements of industries that may locate here, to predict the secondary growth that would be involved with this type of development and to develop elementary models for the particular basins that would be affected by this development. These will be interrelated and attempts will be made to optimize this type of development through the year 2000. Another study involving the analysis of water characteristics of manufacturing industries and their adaptability to semi-arid regions is in progress. This is a joint study that is being completed with the University of New Mexico. In the area of conservation in use of water, there has been a project involving the trickle irrigation of cotton, for optimizing water use efficiency and energy conservation. The goal of this project is to derive the fruits from the crop and yet use less water in the production.

Environmental considerations in energy must cover all the various energy development fields. A recent project involved the evaluation of New Mexico's environmental regulations on energy costs. This is a joint project with University of New Mexico, attempting to integrate all the various factors involved in water quality, air pollution, solid waste disposal, land use, stripmining, radiation emissions and noise generation, and see how it would effect development. In the area of environmental considerations, we have a project involving the microbial growth in minespoil materials. As spoil materials are returned to the ground what must be done to encourage revegetation, and the rehabilitation of this ground? This project addresses this particular problem.

Another area involves agriculture. There is a large project involving the entire agricultural college in the development of policies for energy use in the food and fiber ecosystem of the Southwest. The first is modelling energy consumption throughout the entire food and fiber system; from the inception, through actual consumption. It is very possible that we may find some processing steps that are great users of energy, and could be modified to minimize the energy use in that particular area resulting in conservation.

Sewage and refuse is an area where there is interest. Our city will be taking more direct steps in evaluating this energy source. The type of activity mentioned here involves ways other than direct combustion that have been proposed for recovering the energy from refuse. A study involving several departments on campus is attempting to use enzyme and microbial generators to convert waste products into primary sugards which could be converted, if desired, into ethyl alcohol or methane for use as an energy source. Projects in the area of geothermal energy, involve investigation into and a careful inventory of New Mexico's thermal springs. Chemical geothermometers are used to assess the base temperatures available in geothermal pools and to determine the hydrological potential of these areas for expanded geothermal development.

An area that has been addressed by many of the speakers today is coal. One thinks of coal as "King Coal" with regards to what will be needed in this country in the very near future. Some of the projects addressing the problems of coal gasification were described by other speakers. There is a project in the chemistry department evaluating molten catalysts for the methanation phase of coal gasification. This is an important step in the total process of gasifying coal. Any improvements will help the efficiency of existing processes. Another project is addressing the use of brackish water, which is plentiful in this state, for use in coal gasification. This particular project is investigating the primary gasification reactions to determine if brackish waters could be used in the process. The socio-economic impact of coal development is a very serious problem, and should be carefully considered. A study of this problem at the University involves the impact on the rural communities of developing New Mexico's coal resources. There is always a possibility of a boom and bust syndrome. The long range impacts of these cycles and how to handle them must be studied. Stripmining in various areas will show that recovery and rehabilitation of coal mined areas are going to be very, very important. A major project is studying rehabilitation in San Juan County. Samples have been taken of the original soils and work is proceeding to determine the best species of plants to be used for revegetation, and to

determine the optimum topographic design. As a complementary study, the movement of tract elements is overburden and native sandstone is being followed. The problems of trace elements infiltrating the water table are being anticipated.

One can use low Btu gas in many ways to further develop the coal that is available within New Mexico. A study in the chemical engineering department is investigating how low Btu gas can best be used for the solvent refining of other coals. We can possibly use low Btu gas in metal recovery type processes and in methanol production or in sulfur recovery processes as well.

The area of coal is quite important to the state and to the nation. The Energy Institute at New Mexico State University will be sponsoring a coal symposium on campus Friday, April 18th. There will be a series of invited speakers from throughout the nation. I invite all of you to attend this particular symposium. The topics that will be addressed during the symposium include the geology of coal in New Mexico, the recovery and rehabilitation of stripmine areas, coal liquefaction, coal gasification, coal combustion and power production, and the socio-economic effects of coal developments. The university also has an interest in wind energy, another possible alternative source which requires development. The astronomy department had a need for energy at a very remote location, Blue Mesa Observatory, which is approximately 18 miles from the closest electric power. At this particular location, delicate astronomical equipment is often unattended with automatic devices maintaining temperature levels. Portable fuel, powered generators and bottled gas proved unreliable for heating. A wind powered electric generator was made by refurbishing an old windmill. They have been able to produce electricity, store it in electric batteries and use it on demand. This has been the most reliable source of power for this particular site. This wind turbine is not large enough to supply the entire site, but the possibility of further development of wind power at Blue Mesa is currently being explored.

Solar energy is an area in which this university has been involved in for some time. It is quite natural for this part of the country to be concerned with solar energy because if we look at a map of the United States, the darker area is that region which receives the largest amount of solar energy. The State of New Mexico is virtually unequaled in total solar energy as a large land mass. If we look at the solar energy New Mexico receives and compare it to what is received in the large deserts of the world, the Sahara Desert and the deserts of Australia receive more solar energy than New Mexico, but only 10% more.

(Some of the current projects are listed on the following page.) These slides show three different types of collectors. On the right is one that trickles water down its front surface. On the left is a very conventional type solar collector with a tubular pattern in the metal sheet and fluid circulates through this particular metal. In the center we have a New Mexico State University invention, a thermal trap collector. In this particular application a thick piece of acrylic plastic is placed adjacent to the collector plate and therefore is able to achieve relatively high temperatures. This becomes very important in certain types of solar collector applications. One

GEOTHERMAL

An inventory of the southwestern New Mexico thermal springs is underway. These resources are having chemical geothermometers applied to them to assess their temperature base. Also, a preliminary assessment is being made of the hydrology to estimate the potential of these springs. Another project will assess the geothermal potential of most of Arizona and western New Mexico for its application to the desalination of brackish water.

ELECTRIC POWER

This has been a traditional area of work for several academic departments at NMSU. A program in Electric Utilities Management is supported by a consortium of electric power companies in the southwest and has done considerable work in analyzing large power systems, specifically the areas of transmission and distribution. Another project is addressing the problems of interfacing superconducting transmission and storage devices with a conventional power grid.

WATER

Located at NMSU is the state's Water Resources Research Institute. Most of the water related projects are administered through this institute. Programs in this area have typically been interdisciplinary and intra-institutional. A current one is a feasibility study for the establishment of a water-energy complex in one of the large closed saline water basins in the state. Such a development may be capable of producing several thousand megawatts of electric power and up to one million acre feet of desalted water per year, for several hundred years. Another investigations involve a determination of the optimal distribution of energy industries within the region relative to the limited water resources. Simultaneously, another study is underway which is analyzing the water characteristics of manufacturing industries and their adaptability to semi-arid regions. Likewise, conservation studies are underway such as the development of trickle irrigation methods for water intensive crops such as cotton, as a means of optimizing water use.

ENVIRONMENT

NMSU also houses an Environmental Institute which addresses the broad range of environmental considerations. In more directed work in energy, a study is underway which is evaluating the statewide environmental regulations and their impact on energy costs. Another project is in progress which addresses the problems of microbial establishment in minespoils as a mechanism to enhance the rehabilitation and revegetation of these areas.

> This nation has to prepare for a decade of energy emphasis as shortages continue, alternatives are sought, and lifestyles shift toward lower energy use. Many people are inclined to take a narrow view of the energy situation. Some believe the worst that can happen will be fuel oil in short supply, gasoline rationed again and utility bills higher. The consequences can, and probably will, be much more serious because the cost and availability of energy influences the cost of nearly all consumer products and services. As one of the major energy producing states in the nation, New Mexico, through the research at its universities and federal laboratories, hopes to play a major role in the nation's energy research program.

SOLAR ENERGY

NMSU is fortunate in having over a quarter of a century of experience in solar energy research. During that time the faculty and staff have published over 60 technical papers on the subject. Currently, work is in progress in the areas of solar heating and cooling, solar thermal power and clean fuel production.

In October 1975 New Mexico State University will have on campus the largest building of its kind in the nation to be both solar heated and cooled. This 25,000 sq. ft. building will have 7,000 sq. ft. of solar collectors located on its roof and will house the offices and specialized laboratories of the New Mexico Department of Agriculture. The University is also building a solar demonstration house on the campus, which will be solar heated and cooled. This full-sized laboratory will be used for developing and testing solar heating and cooling equipment. It is a 1,900 sq. ft. 3-bedroom facility and will be operational in the fall of 1975. Work is also in progress on the development and testing of various types of solar collectors.

Another solar energy study is in partnership with Egypt. The goal of this project is the design, construction and evaluation of a 5 kilowatt electrical closed system solar thermal prototype power plant and the design of a 100 kilowatt unit. The first phase of this project will be completed and operational in calendar year 1975.

Basic research is underway on the solar production of hydrogen. The method being investigated is a continuous catalytic process which would produce hydrogen from water through the photochemical trapping of solar energy.

COAL

Current programs include coal gasification, socio-economic impact, and recovery and rehabilitation studies and other coal related technology developments.

Basic studies in the evaluation of molten catalysts for the methanation phase of coal gasification are in progress. The use of brackish water for coal gasification is also being studied. The approach being implemented is an experimental investigation of the primary gasification reactions when brackish waters are used. The socio-economic impact on rural communities of developing coal resources is under investigation.

Restoration of surface-mined land in northwestern New Mexico is being approached by identifying the status of the original soils, what the overburden material will be, determining the best species for revegetation, and an analysis of optimum topographic design needed for revegetation. Simultaneously, a study is underway which identifies the movement of trace elements that one finds in many of the overburden and sandstone materials.

Another project is the development of New Mexico's coal potential via the use of low Btu gas. The aims are to evaluate the use of this gas for the solvent refining of coal, metal recovery in the associated chemical processes, methanol production and sulfur recovery.

OTHER

NMSU has begun a study on the initial development of policies for energy use in the food and fiber ecosystem of the southwest. Such a study would identify the energy consumed by the various steps and processes that are involved in the total food and fiber cycle, and lead to identifying alternatives which could reduce the energy consumption in this overall process.

A project is also ongoing in the conversion of sewage and refuse to energy sources. This study addresses the use of enzyme and microbial generators to convert these products into primary sugars which are then processed, if desired, into ethyl alcohol or methane.

goal here was to develop a solar collector that could operate at relatively high temperatures, 200°F and above, and also be relatively efficient. The work on this thermal trap collector is continuing under a university grant. A comparison of the thermal trap collector to the right collector: It is about half the size, but collects eight times as much energy from the sun on a typical day. This is the type of development needed. These collectors may give us a breakthrough in better collection of the energy at a much higher efficiency. The reason for developing this type of collector is for the application of solar heating and cooling. There are two major projects going on at the University. One involves this particular building, the New Mexico Department of Agriculture Building. It's been in the planning stage for several years and now is under construction. When completed it should be the world's first large solar heated and cooled building. This particular building is over 24,000 sq. ft. It will be heated and cooled by the power from 7,000 sq. ft. of solar collectors located on the roof. In order to have energy for nighttime use and for those periods without sunlight, we will store collected energy from the sun in two large underground tanks, each of 15,000 gallon capacity. The stage of construction may be seen in this slide showing where the ceiling support beams are currently being installed. Construction of this building began in October 1974 and it is expected to be completed in October of this year. This slide shows one of the thermal storage tanks for the building. It will hold pressurized to stop it from boiling at this temperature. Here, the storage tank is having a coating of insulating material applied to the exterior. Each tank has about 3 1/2" of insulating polyurethane foam to retard heat loss. These are the holes that the storage tanks fit into. These are located underneath the building. The two storage tanks are shown in place with one of the construction workers standing next to it to give an idea of the size of each tank. This is the cap of the tank that is inside the instrument room of the building.

Now in designing this building there was concern about many things: 1) Cost, 2) What energy savings could be realized, 3) Will it be possible with the currently available technology to undertake such a project and be successful. After many hours of discussion on all these points, it was decided that we could successfully attempt this type of project. This decision was made almost two years ago. We decided to go ahead with the solar heated and cooled building using a different type device for cooling, an absorption refrigeration cycle. This building will have mechanical refrigeration. Feasibility studies were done to determine the expectations of this system.

It is predicted that the solar heating and cooling system will provide about 80% of the building's heating, cooling and domestic hot water requirements. Why 80%, why not 100%? There are various reasons for this. We could provide 100% of the energy requirement, but we are counting against ourselves the electricity required for pumps and fans to operate the solar system. Also, if you plan for many consecutive days of sunless skies, you would build bigger storage tanks, to store more energy. It you look at covering all of these contingencies, you soon find that the cost of your storage tanks starts to approach the cost of your building, so the decision to go less than 100% solar is an economic decision. You look at the cost of your alternative fuels, what you can use as an auxiliary heat source for the building when you need it, and then you pick the eonomic optimum of all of these to decide what percentage of

your system should be solar and what percentage should come from some other energy source. Now an optimum of this sort does not apply throughout the nation. That is the optimum for this area of the country, and the optimum very strongly depends on the cost of your alternative fuel and the climatic environment. For instance, studies have shown that in my home state of Florida, if you were to have a solar heated residence, the economic optimum of operation you would want to have 15% of your heating supplied by the solar system and 85% by your auxiliary. You get some funny turnarounds when you look at developing the economic optimum.

We designed this particular building in conjunction with the senior architects of W.T. Harris & Associates, the mechanical engineering consulting firm is Bridgers & Paxton and the University's own consultants. The project was approached in a slightly different manner than is usual because it is unique. The entire building, including all associated internal equipment, was bid as an individual package with the exception of the solar collectors. The solar collectors for the building are currently in the bid process. We haven't decided on what type of solar collector to use on this building because there are so many people working on collectors and we wanted everyone to have an opportunity to develop the state of the art in that particular component of the building. We have also had some very interesting experiences in going out and trying to bid the solar collectors. No one has ever attempted to look at collectors before in this type of process. We did not want to buy the lowest cost collector; we're liable to come up with a White Elephant. So we're going through a multi-step process.

We received a variety of bids. We selected the five best collectors from these bids and now we're getting ready to comparatively test all of these collectors on the roof of the Physical Science Laboratory. We will pick the collector that best suits the requirements of the new building. This may not be the lowest cost collector.

This slide shows some of the early stages in construction of a test stand that will actually house all the collectors. Here is one of the support brackets to hold the collectors in place. We've found that the people responding to the bids have some very special problems. Legally, the University requires that any bidder post a bid bond and later a performance bond on a particular item. When a firm goes to its insurance company and requests a performance bond for solar collectors, the insurance company often respondes with, "What is a solar collector--we've never done this before--why should we do it this time--maybe it should cost you a little extra money because we're delving into an unknown area." We found that some of the small organizations that tried to respond with bids on this project had great difficulty in being bonded for this non-standard item. These are some of the non-technical problems that have to be addressed before solar developments can be realized in a large portion of this nation.

Concurrent with building a solar University building, we have a solar house under construction. We expect to have about the same amount of the energy provided by the solar system, about 80% of the heating, cooling, and hot water needs of the house. The University retained the architectural firm of Dean and Hunt in Albuquerque for this particular project. Many of

you may have noted an architect's model of this house at the entrance to the Physical Science Laboratory Building today. It is a 1900 sq. ft. residence with approximately 750 sq. ft. of solar collectors. It has been receiving a great deal of interest from the people in this area.

The types of solar heating and cooling systems we have been talking about use the arrangements shown in this slide in order to operate. One for heating applications and another for cooling type of applications. As we generated interest in this project, we have had a variety of groups join with us to become partners in this project. They have supplied us with not only information, but also materials and, in some cases, money. The local firm of Builders Block & Supply has donated all our blocks for our project. The New Mexico Sand and Gravel and Readymix Association has donated these supplies to the project. Pittsburgh Plate and Glass out of Pennsylvania is donating all the glass that we require and the Copper Development Association from the New York area is donating all the copper used along with all the solar collectors for the particular project. A cross section through the building indicates the location of the solar collectors, looking at it from the south; in one instance they'll almost reach the ground. There are some burms here that bring the round about three feet higher than the level of the building in this particular area.

The state building inspector is very concerned, as we are, about possible conflects with building codes. There will have to be changes in this area to allow people to use some of these solar systems. We have already seen some of these problems and are working at possibly recommending either changes or new codes that the state might adopt in order to handle these problems.

We picked a sight for the house south of the University golf course, near the Interstate. We hope to develop the landscape in the natural desert style. The home itself is now walled to the roof line. The angle structure you see in this slide will be supporting the solar collectors. The building should be completed in October. We are making provisions for people to take tours not only of the solar house, but, with the help of Dr. Bill Stephens, the Director of the New Mexico Department of Agriculture, of the new Agriculture building as well.

Another area of solar application will be producing electric power, solar thermal power application. We are very fortunate to have the largest solar furnace in the United States at White Sands Missile Range. We are also fortunate that the University has a two year grant from the National Science Foundation for developing the first solar thermal electric power plant. This is being done in partnership with the Egyptian government. This plant is under construction right now just outside of Cairo. The solar collectors for the plant are already available and so is the boiler. We are currently in the process of purchasing the remaining components for the system. Five kilowatts electrical energy is not very much by our standards. That is about half of what you need for a normal household. This plant will be a prototype. We hope to learn how to optimize these systems. Part of the project includes developing second generation design so that larger plants of this type can be built. Some of the decisions that have already been made include changing

slightly the type of solar collector system that will be used, and going to a system where we will have planer mirrors that actually reflect the sun's energy to the central boiler itself.

In this area we also have another project going on at the Physical Science Laboratory. One of the critical areas involves providing controls for devices that are used to track the sun. This slide shows a test set up. The decorations are not involved in the overall control loop. This particular set up is developed for accuracy, reduced cost and all of other parameters that you need in solar collector tracking systems, especially of the type that you're going to need for large scale developments for the production of electric power.

In November 1974, this University co-hosted with White Sands Missile Range the nation's international seminar on large scale solar test facilities. We had as guests at this University interested people from France, Japan and Italy, along with many attendees from the United States. The current state of the art in large scale solar power type of applications was discussed. Basically, one of the goals of the conference was to develop preliminary information for our Energy Research and Development Administration agency on the requirements for a five megawatt thermal solar test station for this country. A test station this size would be five times larger than what the world's technology has now produced in large solar installations. This test station was discussed at the conference by a variety of people, including federal representatives. Three sites within the United States were chosen for this type of development. One, the area around China Lake, California another the area around Yuma, Arizona and a third being the area of Southern New Mexico and West Texas. The federal government has announced that they will be building such a facility which will be in the multi-million dollar range. The Energy Institute is currently taking steps to organize people from New Mexico and Texas into a group to work towards locating this facility in the Southern New Mexico and West Texas area.

Another solar application that is being looked at by our chemistry department is how to use the sun's energy to break water into oxygen and hydrogen, considering that we have in the oceans large supplies of water and that hydrogen could become one of our fuels in the future. This project is proceeding and the University has applied for a patent for this particular process.

Senator Domenici mentioned the Solar Energy Research Institute. This project has advanced as far as a definitive proposal outlining what such an institute should do for this nation. This proposal represents a New Mexico consortium of the Governor's Office, the State of New Mexico in total, the New Mexico Technology University, University of New Mexico, New Mexico State University, Sandia Laboratories and Los Alamos Laboratories. Talks are going on right now and I hope that within a few months this consortium will be a multi-state consortium for work towards attracting this national laboratory to an area of ideal solar environment and also an area that has large groups of people involved in solar energy developments. I personally feel that the university structure can make a very definite contribution to our overall problems and their solutions. I think that the University will continue to be involved in this particular area and even though I expect some hard

times, times of conservation of not only energy, but many of our resources in the broadest sense, I do believe that we are going to make significant strides in this country to alleviate problems of this sort.