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the montana energy and mhd research and development institute

NCAT the National Center for Appropriate Technology
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APPROPRIATE TECHNOLOGY NEEDS ASSESSMENT CHECKLIST

Instructions: The purpose of this checklist is to assess your needs in order to determine how NCAT might better serve you. As the only research and development organization in this country focusing on the technology needs of low-income communities, it is important for us to accurately target our research and development activities. Please take the time to read this questionnaire and give some thought to your responses. You will be contacted by phone between October 9 and October 12. The interviewer will ask you the same questions you have before you. *NOTE:* DO NOT RETURN THIS FORM - we will be asking for your responses by phone.

1. To get an idea of the size of your organization, could you state the approximate annual budget of your Community Action Agency? *Check one:*

☐ *Under $1 million*
☐ *$1-2 million*
☐ *$2-4 million*
☐ *$4-8 million*
☐ *$8-12 million*
☐ *$12-16 million*
☐ *Over $16 million*

2. Are the programs of your CAA geared *primarily* to problems that are URBAN or RURAL in character? *Check one:*

☐ *Urban problems* ☐ *Rural problems* ☐ *Both equally*

3. Following is a list of some problems that various CAA programs generally address. Please state whether your CAA has an active program addressing these problems, or whether they are presently being addressed by another community-based organization in your area. *Check a response for each:*

	YES	NO	OTHER CBO
a. Access to nutritious food			
b. Food costs			
c. Lack of job training			
d. Availability of decent jobs			
e. Ability to pay energy costs			
f. Lack of conservation measures, and/or information			
g. Access to transportation			
h. Cost of transportation			
i. Availability of decent housing			
j. Cost of decent housing			

	YES	NO	OTHER CBO
k. Access to health care			
l. Cost of health care			
m. Youth delinquency			
n. Problems of Aging			
o. Family social services (such as child abuse)			
p. Alcohol and drug abuse			
q. Lack of community organizing and advocacy			
r. OTHER (specify)			

4. Of these same problems, which three are the most serious and pressing problems on a year-round basis in your community? *Refer to the above list. Specify three:*

a. ____________________

b. ____________________

c. ____________________

5. Following is a list of program areas in which appropriate technologies have been developed. Please indicate for each whether you *have a program — plan to expand your program — or need improved technologies.*

	HAVE A PROGRAM	PLAN TO EXPAND	NEED IMPROVED TECHNOLOGIES
a. Housing rehabilitation and self-help programs.			
b. Using solar heating systems to cut home energy costs (solarization).			
c. Home weatherization			
d. Consumer conservation education			
e. Attached solar greenhouses to produce food and cut heating costs.			
f. Local, and/or cooperative systems for food production (such as processing and marketing).			
g. Production and use of alternative fuels such as gasohol, alcohol and methane to reduce fuel costs or increase availability.			

	HAVE A PROGRAM	PLAN TO EXPAND	NEED IMPROVED TECHNOLOGIES
i. Community health-care delivery and nutrition education programs.			
j. Job training			
k. OTHER (specify):			

6. Of the program areas in which appropriate technologies have been developed (listed above), which has the greatest potential for helping the poor in your community. *Specify one:*

7. Following is a list of appropriate FOOD technologies that may help low-income people. Please indicate for each whether you *have a program — plan to expand your program — or need improved technologies:*

	HAVE A PROGRAM	PLAN TO EXPAND	NEED IMPROVED TECHNOLOGIES
a. Community gardening			
b. Training in food production methods.			
c. Food-producing solar greenhouse or coldframe construction.			
d. Nutrition and diet guidance.			
e. Local food processing, canning and production.			
f. Alternative food marketing systems (e.g. cooperatives).			
g. Small-scale animal production (such as fish farms, chickens).			
h. Food stamp outreach and advocacy.			
i. OTHER (specify):			

8. Of the appropriate FOOD technologies listed above, which has the greatest potential for helping the poor in your community? *Specify one:*

9. Which types of assistance listed below do you feel are most needed in addressing FOOD problems in your area? *Check a response for each:*

	BADLY NEEDED	SOMEWHAT NEEDED	NOT NEEDED
a. Funding for local demonstration projects.			
b. Information on successful or unsuccessful programs.			
c. Consumer self-help materials.			
d. Improved or expanded training materials for CAP personnel.			
e. Information on new technical developments and program possibilities.			
f. Technical assistance on CAP projects.			
g. OTHER (specify):			

10. Following is a list of appropriate HOUSING technologies that may help low-income people. Please indicate for each whether you *have a program — plan to expand your progam — or need improved technologies.*

	HAVE A PROGRAM	PLAN TO EXPAND	NEED IMPROVED TECHNOLOGIES
a. Passive solar retrofits for space heating (such as Trombe wall, solar wall panels, sunspaces).			
b. Attached solar greenhouses.			
c. Alternative low-cost building materials and methods, (such as recycled materials).			
d. Development of low-cost modular housing.			
e. Low-cost housing designs.			
f. Housing cooperatives and homesteading.			
g. Housing rehabilitation/home repairs (such as self-help projects).			

11. Of the appropriate HOUSING technologies listed above, which has the greatest potential for helping the poor in your community? *Specify one:*

12. Which types of assistance listed below do you feel are most needed in addressing HOUSING problems in your area? *Check a response for each:*

	BADLY NEEDED	SOMEWHAT NEEDED	NOT NEEDED
a. Funding for local demonstration projects.			
b. Information on successful or unsuccessful programs.			
c. Consumer self-help materials.			
d. Improved or expanded training materials for CAP personnel.			
e. Information on new technical developments and program possibilities.			
f. OTHER (specify):			

13. Following is a list of appropriate ENERGY technologies that may help low-income people. Please indicate for each whether you *have a program — plan to expand your program — or need improved technologies.*

	HAVE A PROGRAM	PLAN TO EXPAND	NEED IMPROVED TECHNOLOGIES
a. Low-cost solar space heating.			
b. Low-cost solar hot-water systems for homes.			
c. Attached solar greenhouses.			
d. Optimal weatherization.			
e. Furnace retrofitting.			
f. Crisis resource supply (such as heaters, blankets, clothing, wood, coal).			
g. Wind-generated electricity.			
h. Small-scale hydroelectric power.			
i. Wood heat or wood substitutes.			
j. Alcohol fuel (such as gasohol).			
k. Methane gas production.			
l. OTHER (specify):			

14. Of the appropriate ENERGY technologies listed above, which has the greatest potential for helping the poor in your community? *Specify one:*

15. Which types of assistance listed below do you feel are most needed in addressing ENERGY problems in your area? *Check a response for each:*

	BADLY NEEDED	SOMEWHAT NEEDED	NOT NEEDED
a. Funding for local demonstration projects.			
b. Information on successful or unsuccessful programs.			
c. Consumer self-help materials.			
d. Improved or expanded training materials for CAA personnel.			
e. Information on new technical developments and program possibilities.			
f. OTHER (specify):			

16. Does your CAA have an active weatherization program?

☐ *YES (if yes, answer question 17).*
☐ *NO (if no, skip question 17 and go to question 18).*

17. Of the following, which are most needed to improve your weatherization program? *Check a response for each:*

	BADLY NEEDED	SOMEWHAT NEEDED	NOT NEEDED
a. Better home audit techniques (such as work estimation, instrumentation, and analysis.			
b. Professional weatherization schooling.			
c. Development of improved weatherization materials.			
d. Better information on performance, quality, safety and use of weatherization materials and techniques.			
e. Better availability of CETA labor.			
f. Regulations permitting use of Non-CETA labor.			
g. Broadened income eligibility standards.			
h. Modified regulations and codes.			
i. Consumer education.			
j. Information and training on furnace efficiency.			
k. Information and training on modification for alternative fuels.			
l. OTHER (specify):			

18. Of the weatherization program needs you have listed above, which areas need technical development? *Specify one or more:*

19. Do you feel that attached solar greenhouses have greater potential value in your area primarily as a HEAT PRODUCER or as a PROTECTED ENVIRONMENT TO GROW FOOD? *Check one:*

☐ *Heat producer.*

☐ *Food-producing environment.*

☐ *About equal value.*

20. Below are listed some primary methods of assisting the poor. Please rank their importance to the poor in your view. *Rank 1 (highest) through 5 (lowest):*

___ *Advocacy for the poor.*

___ *Employment for the poor.*

___ *Self-reliance for the poor.*

___ *Services for the poor.*

___ *Transfer payments for the poor.*

21. As you know, NCAT is funded by CSA in large part to provide assistance to Community Action Agencies such as yours, by researching, developing and helping implement "appropriate technology" programs addressing problems of low-income people. What information or services would you like to see NCAT provide in the future?

technology

What are the signs of an established corporation? In the world of research and development, success is measured by a large and qualified staff, a maximum number of contracts awarded, healthy and continual growth, a record of efficient performance and constant diversification into new ventures of national scope.

In three short years, MERDI has established itself and has in fact displayed remarkable growth. In the Technology Department, this success can in part be attributed to the effective and flexible use of specialized expertise through a matrix theory of organization among the five Technology divisions—Engineering, Environmental, Socioeconomics, Applied Research and Computer Support.

Within these divisions, a standard matrix method of planning a specific project both vertically (a division as a whole) and horizonally (across several divisions, selecting needed expertise) assures the best technological support is provided to all levels of Institute activity. Expertise is used only as required, each employee is usually involved in a number of projects and the most efficient application of MERDI talent is made.

Environmental, chemical, electrical and mechancial engineering knowledge is supplied to the MERDI/CDIF Department and the rest of the Institute using this matrix system. Specific research efforts, engineering skills, social and economic expertise and computer capabilities are available and can likewise be directed to such MERDI Projects as the National Center for Appropriate Technology (NCAT).

The Technology divisions are intricately involved in every aspect of Institute work. For the MERDI/CDIF Department, for example, assistance is provided in assessing any social and environmental impacts of the Department of Energy Component Development and Integration Facility (CDIF) being built south of Butte.

Seeking work on new and independent ventures, however, is as important a goal to the Technology Department as providing support to existing projects. While present efforts in the Environmental Division are contained in matrix-organized support to the rest of MERDI, planning is underway for work with the Environmental Protection Agency (EPA) on a variety of its pollution-related programs.

This goal of expansion is shared with the Computer Support and Applied Research managers, who are enlarging their present staffs so as to possess the capability to take on original, outside contracts. The work of the Applied Research Division for the Department of Energy on materials for molten-carbonate fuel cells is already recognized as a viable contribution to the national program on second-generation fuel cell power plants.

Providing in-house support, pursuing outside contracts for research, recruiting to complement the existing staff—these are the immediate concerns of the Technology Department to assure continuing Institute growth and establishment. Throughout all policy and planning, however, is a desire for MERDI to fullfill an increasingly important role in conducting national research programs; work currently being done at home in Montana and finding success in state applications benefits energy concerns nationwide.

MERDI Technology studies of the environmental and socioeconomic impacts of the CDIF are setting a standard for planning future MHD power plants in this country. The siting methodology being prepared and the unique siting of MHD plants defined could have national implications.

Results of Institute research in Montana can be applied appropriately to similar problems in other states. Technology support in writing the Glasgow base EIA will enable MERDI to produce a reference document and guideline for re-use studies on any other national program or institution that has outlived its usefulness. Likewise, future Institute efforts to examine the feasbility of using geothermal sources to heat buildings around Montana will save fuel expense in addition to promoting interest in geothermal energy elsewhere.

MERDI is a Montana born and bred entity, a research and development firm proud of its location and its staff, more than half of which are Montana natives. The establishment of the Institute and many initial successes have been accomplished inside the state. MERDI has enjoyed healthy growth since its founding, and this growth assures that the ever-present company goal to expand the scope of research and development work beyond state an regional boundaries shall continue.

computer support

In the long journey from an idea to a proposal to a contract, through technical work, field work and final conclusions, the evolution of a MERDI project is defined by its use of various Institute resources. Through the flexible matrix organization among divisions and Departments there are experts in many disciplines, assistance available in planning and management, a technical library, and one essential service used in every facet of Institute activity — Computer Support.

The outstanding computer capabilities MERDI has acquired and the experienced staff of analysts and programmers often helps assure the success of Institute functions; projects requiring computer support range from attitudinal surveys to wind velocity studies. With computer assistance in field data analysis and aid in studying existing research in specific fields, these projects can reach the most timely and accurate completions possible.

Computer capabilities at MERDI currently include teletype terminal access to the time-share system of the DEC 11/70 computer at the Montana College of Mineral Science and Technology in Butte. In addition, a Data General computer system is operated at MERDI, coupled with various data sets that are used to accessing large IBM or CDC computer systems.

The Data General Eclipse C330 computer system is also used primarily as an analysis tool by the technical and engineering staff. As presently configured, the system includes a 256 KB central processing unit supported by various peripherals including a line printer, card reader, operator's console, large disk and magnetic tape units.

Day-to-day computer time and expertise is in high demand throughout the Institute, with support to the MERDI/CDIF divisions and other divisions doing work related to MHD being a major responsibility of the computer staff. An extensive pre-operational data base is being organized for MERDI/CDIF which will be used in the continuation of information collection after start-up of the Department of Energy Component Development and Integration Facility (CDIF) in late 1979.

Much MERDI attention is being focused on the areas where a potential impact of the CDIF is possible — environmental conditions, numerous social and economic factors — and it is the Computer Support Division that is providing access to baseline information for 1977-78 so that future impacts can be measured accurately.

In addition, computers are helping to store gathered data, organize sampling and monitoring schedules and define results on the current impact measurement efforts of the Water Quality/Biological and Air Quality/Trace Elements tasks in the Environmental Division. For the MERDI/CDIF Meteorological Data Station, information is being compiled on ambient temperature, wind speed and direction, solar radiation and barometric pressure. Similar data organization and interpretation has been given to the Socioeconomic Division's Community Attitudinal Survey and CDIF Construction Worker Profile to assure full benefit of these impact studies.

A MERDI/CDIF Data Acquisition System is also being readied by computer engineers for the scheduling and flow of real-time analog and digital data, the recording and presentation of this data and the evaluation of test performance.

While MHD-related programs demand much of the MERDI computer staff attention, the division's expertise is applied in many other areas. The Engineering Division used computers to tabulate results of the 1978 Home Energy Survey conducted in Butte. For the MERDI involvement in the re-use studies for the Glasgow Air Force Base, computers are helping to determine whether wind measurements at three different altitudes are sufficient to support a wind power generation facility there.

Not all computer efforts are directly contract-related, however. Plans are being made to use computers in-house at MERDI for a Management Information System that will not only include data on the payroll and accounting departments but on personnel, technical document files and property control as well. Computer engineers will also soon be helping streamline MERDI/CDIF inventory control.

In this manner, the work of the Computer Support Division will continue to be an essential contribution to Institute growth and success.

socioeconomics

One of MERDI's original goals was to establish a Rocky Mountain regionally based research and development capability for energy development. Initially, MERDI concentrated on problems associated with large-scale systems, including MHD. The interrelation between such large-scale systems and regional economic development quickly became apparent to MERDI management; thus, the Socioeconomic Division was established to analyze the problems associated with regional economic development and to provide assistance and data to federal, state and local agencies. MERDI considers socioeconomic factors to be prime issues in energy development.

The philosophy of the Institute which the Socioeconomic Division now helps to enact also involves a general desire to make projects adaptable to society, from a social as well as economic standpoint. MERDI's socioeconomists are charged with the task of analyzing and examining the implications of Institute undertakings upon the human environment.

The overall goal of making technology more responsive to society is reflected in all Socioeconomic Division activity. One key element is determining the attitudes of a project's affected population; recently, specific attitudinal surveys and studies have been administered and results combined with baseline data to measure the social and economic impacts of projects.

Socioeconomic studies have been a major element in the process of siting, planning and designing the Department of Energy Component Development and Integration Facility (CDIF) in Butte's Industrial Park. First, detailed information about the economic atmosphere (employment and income) in Butte was gathered and analyzed in order to establish an economic profile of the community. As a result, economic variables can be measured both prior to and during the construction of the CDIF.

Next, the Socioeconomic Division administered a Butte-Silver Bow Community Attitudinal Survey to determine how residents feel about the existence of the CDIF. Finally, a Construction Worker Profile is being conducted in three phases during 1978 to learn about the local/non/local composition of the construction workers and other pertinent information in order to allow quantification of the work force impact on the area.

Several other MHD-related projects have received Socioeconomic support. In conjunction with the Environmental Division, a siting methodology for an American MHD plant is being prepared; the previous work in power plant siting is being reviewed and combined with studies to learn if and how MHD plants differ and what the best siting approaches would be.

As part of MERDI's Environmental Development Plan (EDP) to the Department of Energy, socioeconomists are making recommendations concerning social and economic impacts and mitigating measures unique to MHD generation.

In another level of activity, working with the Glasgow Project, MERDI socioeconomists are preparing portions of the Environmental Impact Assessment (EIA) on the various development alternatives being considered for the inactive Air Force Base in northeastern Montana.

Each alternative being posed requires specific socioeconomic analysis and a study of its impact on the human environment. To determine the perceptions, desires and attitudes of Glasgow area residents relating to economic development, the socioeconomists are conducting an attitudinal survey to complete the full examination of the Glasgow re-use issue from a socioeconomic point of view.

In the future of the Institute, the work of the Socioeconomic Division to examine the humanistic implications of projects will increase in importance and scope, both as support to other divisions and in administering contracts of its own. Work will be expanded to include participation in the many socioeconomic programs in the federal Departments of Housing and Urban Development (HUD); Health, Education and Welfare (HEW); and Transportation. This may also involve exploring aspects of the human condition — health care, the arts and humanities, and human behavior.

Environmental and Engineering

Official policy of MERDI and the Department of Energy states that environmental research be conducted hand in hand with the development of new technologies. Concern for the environment is a relatively new concept in the industrial world; little consideration was given to environmental protection when the technologies in use today were being developed. It is now obvious to industry that incorporating a study of environmental effects into all technology development will assure environmental protection, excellence in engineering and savings of dollars.

MERDI's Environmental Division helps the Institute fulfill its role in energy development by providing expertise for all environmental considerations to be made; MERDI has the largest MHD environmental research staff in the country.

Baseline information on water and air quality is being gathered by the division as part of its effort to monitor possible impacts of the Department of Energy Component Development and Integration Facility (CDIF) in Butte.

As part of the national MHD program, the Environmental staff travels to MHD laboratories and facilities across the country for review of other MHD test results. Emphasis is presently being placed on research of trace elements and sub-micron particles, with a study planned on nitrogen oxide emissions.

The division is also helping to prepare MERDI input to the Department of Energy Environmental Development Plan (EDP) for MHD generation. This work will assess potential environmental problems arising from the MHD process.

MERDI environmental specialists were also largely responsible for an MHD Engineering Test Facility (ETF) screening process recently completed on environmental, economic and social impacts of an MHD facility as they relate to the siting of future American plants.

Technical assistance is being supplied for the Environmental Impact Assessment (EIA) MERDI is compiling on the inactive Glasgow Air Force Base in northeastern Montana. Engineers use sophisticated multi-sensor instrumentation to monitor air quality and meteorological parameters at the base.

MERDI's environmental experts are interested in expanding their work into such areas as waste treatment and disposal processes and the environmental impacts of geothermal energy. As MERDI addresses new and alternative energy technologies, appropriate environmental measures shall continue to be a high priority.

Facilitating the most effective use of the nation's renewable energy sources, with emphasis on the resources of Montana, is the primary objective of the Engineering Division research and development program. Closely associated with this is a continuing effort to increase the efficiency of present uses of non-renewable energy sources; new technologies must be pursued and conventional technologies improved.

MERDI engineers currently supply support to other divisions as an ongoing activity, including engineering assistance to MERDI/CDIF and other projects in general MHD work, written evaluations of inventions submitted to the Center for Innovation (CFI) on such criteria as technical feasibility and structural integrity, and assistance to the Glasgow Project on reviewing alternative re-uses for the base.

The Engineering Division is also actively pursuing work on other forms of energy conversion. One project under consideration is a development of the goethermal sources at the Montana State Hospital at Warm Springs, where geothermal energy could complement the existing fossil-fueled hot water heating facility.

As fuel cell technology develops, the Department of Energy is building units for operational tests. These 40 kw systems will be provided to gas utilities as continuing funding is allocated; MERDI engineers are working with several Montana-based utilities on this program.

Future activities in energy conversion will enlarge the overall scope of projects to include such areas as electric, active thermal and passive solar energy, generation of power from wind sources, and biomass conversion from agricultural and wood products.

Perhaps the most prominent goal of MERDI engineers is to provide assistance to the state of Montana in its efforts to improve its energy source position. For example, the division plans to actively participate in the siting efforts for the Northern Tier Pipeline program, which will bring much-needed crude oil to Montana's landlocked refineries.

applied research

Ceramics materials research and development is an important part of the effort of the Applied Research Division in determining the best materials for use in MHD components and fuel cell systems. A small but impressive ceramics laboratory at MERDI hosts the main activities of this division — studying ceramics applications for use in an MHD channel, and working on advanced fuel cells — and research is conducted by a highly-skilled core staff of engineers and technicians.

The development of ceramics materials is an extremely old field which was a refined art during the construction of the pyramids in Egypt. The technical understanding of ceramics, however, is of recent origin as significant progress has occurred primarily in the last two decades.

Ceramics efforts at MERDI stem from a need for new materials to line the MHD generator walls, for the extremely high temperatures required in the MHD process restrict the use of metals, which cannot withstand the heat without excessive cooling — resulting in a loss of efficiency. Ceramic materials can accept high temperatures, but must also be developed to resist the corrosion and erosion from the coal slag which shortens the life of components.

The seeding of potassium into the MHD channel is also detrimental to the life and performance of whatever material is used.

In MERDI's Applied Research Division, laboratory samples are made with a highly pure form of aluminum oxide, which when fired are close to the theoretical density — the density of a perfect single crystal. Ceramics fabrication is an important function of the laboratory, which contains dry and isostatic presses, several furnaces and delicate weighing and measuring apparatus. Samples are tested for wettability, conductivity and diffusivity.

The fuel cell materials work being accomplished addresses a similar problem as that of MHD channel components, namely, finding materials that can withstand heat and last a significant amount of time in a corrosive atmosphere.

The fuel cell is an electrochemical energy conversion system that operates on the same principle as an electric storage battery. However, the electrodes are exhausted in a battery, whereas oxygen from air and processed fuel are continuously fed to the fuel cell electrodes, which act only as a catalyst support and current carrier. The fuel and oxygen are electrochemically combined via separate electrodes in an electrolyte atmosphere, producing an electron flow through an external load connecting the electrodes. Water and carbon dioxide are by-products.

Fuel cell energy systems have the potential to provide nearly pollution-free energy with a high and constant efficiency level. The first generation, phosphoric acid fuel cell systems, may be used commercially within three to five years; the second generation, molten-carbonate and solid electrolyte systems of higher efficiency and temperature, may be available within 10 to 15 years.

Applied Research work is addressing both molten-carbonate and solid electrolyte systems; and although as yet a relatively small effort, this work has placed MERDI as one of three independent agencies in the country studying molten-carbonate fuel cells. The Institute plans to participate in the application of the 40 kw fuel cell feasibility units being built by the Department of Energy, the production of which could benefit many remote areas of Montana as well as throughout the United States.

The division is also planning to expand operations into photovoltaics research to generate electricity from solar and thermal energy sources. Another new program in Applied Research is an extension of work done previously for the United States Office of Naval Research (ONR) and ongoing MHD work. Sponsored by the OWR, this contract calls for MERDI to evaluate thermal transport properties and relate these to the microstructure of various engineering ceramic materials.

The MHD activities of this division in assessing the materials for MHD channels are related to the university research programs the Institute coordinates at the Montana College of Mineral Science and Technology (Montana Tech) and Montana State University (MSU).

Coordinating with other Institute programs and working in areas of its own, the Applied Research Division is helping to make advanced technologies — such as MHD and fuel cells — into practical realities.

the engineering test facility

The national magnetohydrodynamics (MHD) program includes many levels of experimental MHD work, ranging from small laboratory tests to test facilities large enough to eventually operate competitively with other power plants and demonstrate the commercial viability of MHD electrical power generation. Butte is the location of one of the first large test facilities that will operate for substantial periods of time; the Department of Energy Component Development and Integration Facility (CDIF) is scheduled to begin operating in late 1979, with MERDI acting as the managing contractor.

Existing law specifies that a second larger facility, the Engineering Test Facility (ETF), be located in Montana. Construction of the ETF will probably begin in three to five years; it will be the first facility in this country designed from its inception as a completely integrated, coal-burning electrical generator with an MHD topping cycle and a conventional steam power plant bottoming cycle — the normal manner for applying MHD to electrical generation.

The goals of the ETF will be to scale data from small facilities up to a size near commerical demonstration, to establish a data base for such a scaling up in size, and to integrate the MHD topping and steam bottoming plants at the smallest size that can safely by expanded to commercial plant scale.

This incremental building of MHD systems is required because the MHD process, like most physical phenomena, is so complex that theory cannot reliably expand the small-scale experimental data to the very large sizes required for commercialization. Building intermediate-sized facilities such as the CDIF and ETF is cheaper than risking major errors in going directly from laboratory scale to commercial size.

The CDIF will have a peak capacity of 50 megawatts thermal (MW_t); the latest plans for the ETF set its capacity at between 250 and 1000 MW_t. Test results from the CDIF and laboratories across the country will be combined to design the ETF MHD topping plant.

MERDI hopes to participate in the future design, construction and operation stages of the ETF. Present activities at the Institute related to the ETF are coordinated within the Projects Department. The ETF Coordinator manages those tasks pertaining to the ETF and acts as a focal point for all other work within MERDI that is applicable to ETF study. Key tasks include ETF siting methodology, MERDI's MHD Environmental Development Plan (EDP), the MHD trace elements research and emissions minimization studies, and the Montana State University (MSU) subcontract task for MHD plant control studies.

The direct ETF work at MERDI relates to facility siting. MERDI is now completing a siting methodology that is applicable to fossil fuel electrical generation facilities in general, but is intended specifically for the proposed ETF. The method involves applying several steps of screening which will progressively narrow the area of interest from an entire state to a small number of specific sites of the size required for the power plant.

MERDI has also implemented a study of local, state and federal laws and regulations that might affect MHD plant siting decisions. This effort has defined a framework of permits and applications that must be obtained before construction, identified the most expedient order in which to obtain these permits, and established the time requirements for complying with the complex maze of approvals. This study applies directly to Montana and forms an excellent starting point for determining the needs in other states.

When the siting methodology has been completed and all information submitted to the Department of Energy MHD Division, the site selection committee may use this information in selecting a location for the ETF. Once a site is selected, an Environmental Impact Statement (EIS) will be prepared.

Through the management of future tests at the CDIF site and planning more advanced facilities, including making site recommendations to the Department of Energy, MERDI is actively fulfilling its role in the national MHD research and development effort

Glasgow

What do you do with a $200 million, nearly 6,000-acre inactive military base in northeastern Montana that is complete with housing for 5,000 people, churches, recreational facilities, a supermarket and hospital, extensive commercial and industrial buildings and a 13,500-foot runway?

The answer is not an easy one. While Glasgow Air Force Base has outlived its original, intended usefulness, it certainly displays great potential for the development of any one of a variety of exciting re-uses beneficial to the area residents. MERDI, under contract to the Old West Regional Commission, is contributing its expertise to help the Glasgow community and all of the region of Valley County examine this potential from a number of different approaches, from an integrated agricultural facility to a complete coal gasification plant to a modular solar home manufacturing center.

The Glasgow base was built in 1955 as an Air Defense Command Base. When Air Force operations were phased down in 1968, the community faced economic instability and a drastic drop in employment; since that time the base has housed an alcoholic rehabilitation clinic, some small manufacturing activities and a Family Development Center.

But the potential for something larger, permanent, more economically attractive and innovative exists — if the right combination of resources and community support can be found.

Determining the most appropriate and sound re-use of the Glasgow base is a goal MERDI shares with the Montana International Trade Commission and the Valley Industrial Park. It is the residents themselves, however, who are fulfilling the most active role in helping decide the base's future.

It was these 14,000 Valley County residents, many of whom are employed in agricultural-related occupations, who were the target of an attitudinal survey conducted by MERDI to learn the peoples' feelings on each of the proposed re-uses as well as on economic growth itself. The results of this survey will be combined with other sociological, economic and environmental studies MERDI has done in Valley County and incorporated in the Environmental Impact Assessment (EIA) the Institute is compiling on the base and the advantages of each of its proposed development concepts.

A 300-foot meteorological tower was erected to measure air and climatological conditions on a daily basis. This and other research will be used in the development of a data base characterizing such factors as wildlife habitat, vegetation, aquatic life and general human environment in the area.

Each proposed re-use is different and requires a unique set of feasibility examination criteria. One idea capitalizes on the natural attributes of northeastern Montana by producing fuel alcohol from the area's rich grain crops. Methane derived from feed lot wastes can be used in the gasohol production, and by-products in the form of distillers dried grain can be returned to the feedlots as hog and cattle feed.

Manufacturing concepts under consideration include the modular solar homes; wind electric generation equipment and the operation of a wind electrric turbine facility; or a general alternative energy development, demonstration and manufacturing center to distribute energy equipment and information to both private and public segments of the population.

The recent boom in Montana coal production and exports has created a demand for rail cars for coal shipment. In conjunction with the Montana Trade Commission, MERDI is also investigating the possibility of a rail car maintenance and repair operation at the base.

Another interesting alternative being discussed is the construction of a Peace Base, which would serve as an international disaster relief organization to respond to national and international disasters and provide assistance to lesser-developed countries. The Glasgow Peace Base would also serve as a model for developing countries to organize their own relief organizations.

A final decision on the base re-use will probably be made and announced in early 1979. The activity to study the Glasgow base and resolve the best possible development may serve as an example for other institutions in the country requiring re-use consideration.

PLEASE NOTE: THE PRECEDING PAGES WERE TREATED AS A UNIT IN THE ORIGINAL DOCUMENT.

Wittow

Power Alternatives Study

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PROPOSED MONTANA RENEWABLE ENERGY PROGRAM

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PROPOSED MONTANA RENEWABLE ENERGY PROGRAM

from

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January 28, 1979

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INTRODUCTION: MONTANA RENEWABLE ENERGY PROGRAM

Montana, through state government leadership and state policy, leads the United States in its commitment to financial support of alternate renewable energy resource development and utilization. Public support of this program is widespread and based upon a sophisticated understanding of the logical match between the values and lifestyles of Montana with the positive social, economic, and environmental impacts of extended development of those renewable energy resources of sun, wind, water, and plant residues that already contribute so much to Montana's agriculture and lifestyle. It is recognized that the on-going national energy problem offers a great opportunity to integrate new energy production systems into the economy of Montana in such a way that they will enhance job opportunities for labor, expand economic opportunity for old and new businesses, and enrich the people by providing new technical, scientific, and business challenges. The colleges, universities, technical organizations, and businesses, as well as the emerging generation of young men and women will participate in and benefit from this program. The Montana Renewable Energy Program represents an unique way to simultaneously develop and enrich the state without compromising the quality of life or degrade the environment.

The Montana Department of Natural Resources and Conservation (DNRC) has had a very active program since 1975 which has supported numerous research, development, and demonstration projects th ughout the state. To date, the key accomplishments of this program have been the creation of a very healthy public awareness, understanding, and support of alternate renewable energy, widespread demonstration of the potential of solar space heating throughout the state, and the initiation of limited research and development activities in other renewable resource areas.

Montana has made a significant contribution to the overall United States energy R&D activities through the DNRC program. In turn, the state program has received considerable benefit from the national programs; however, the national program by its very nature will not satisfy all of Montana's needs. There are unique economic and environmental problems in Montana which must be addressed before full use can be made of national program information and results. Furthermore, the national energy R&D effort has received the benefits of Montana's developments that with various degrees of adoptation can be used in other states and regions. Much of the past state program support has had this as one of its objectives. Now, however, is the time for a significant expansion, integration, and extension of the program. A properly structured, funded, and managed plan of research, development, demonstration, and commercialization is necessary in order for the state to fully benefit from the renewable resources available.

The Montana Alternative Renewable Energy R&D program must be more fully and formally integrated into the national U.S. Department of Energy programs. It must also be extended to include a strong commercialization effort and be expanded in terms of resources devoted to the total program activities.

This document contains seven specific subprograms for wind, biomass (agriculture and forest products and residues used for direct combustion, the production of alcohol, and the generation of methane), geothermal, solar, and small scale hydroelectric renewable energy sources. The proposed duration of each of these subprograms is six years if the funding level requested is provided. At the end of this time, the technologies and supporting Montana business structure will have been developed for those renewable energies which have proven to be economically viable. State support beyond the six years will be minimal and will be limited mainly to coordination and information exchange. No large scale funding of development or demonstration projects should be necessary.

The support for this program is based upon a match of almost five federal dollars for every state dollar contributed. This match is not arbitrary but is based upon the concept that there is at least five times as many opportunities to use the results of this program outside Montana as within the state. Simple equity dictates that the division of funds for support be based upon the probable benefits to be obtained by each of the parties participating in the program.

The long range objective of this proposed Renewable Energy Program is to ensure the proper place of these resources in Montana's future economy. Diversification of energy sources will be just as important in the future as it is now. The utilities and their electric distribution system will become more valuable. Eventually, replacements for natural gas and liquid fuels must be found either by a complete energy form replacement or from gases and liquid fuels derived from biomass or from coal for some finite time period. Here again, the large energy companies and their distribution systems will continue to play a leading role. A new and important member of the energy team, the farmer/rancher and communities, is developed by this program.

Montana is an agricultural state with very little in-state processing of the products of beef and grain. Furthermore, our ranchers and farmers pay high transportation costs to get these products to the processing points and markets. The proposed program will provide some energy self-sufficiency and a significant extension of the agricultural activity into the processing area. The economic diversity of the farm, ranch, and forest communities will be expanded by energy "crop" growth and processing. The program provides Montana the opportunity to produce new, needed energy products and to participate in the processing of the products--a double economic impact.

The proposed subprograms are to be integrated into the Montana Department of Natural Resources and Conservation, Energy Division's "Montana Alternative Renewable Energy Sources Program Plan" published in January 1979. This present DNRC plan is for a two year program using funds from the coal severance tax as provided under the present allocation scheme. The DNRC plan projects funding of approximately $800 and $1,100 thousand for the next two years and will require additional funding in future years, before all objectives are met. What is proposed here is a significant expansion in effort of the DNRC plan while maintaining its program philosophy, management, and control. This expanded effort will answer the question of the usefulness to Montana of its renewable energies and, at the same time, will develop the necessary Montana businesses so that future state energy planning can be based upon technical and economic experience in renewable energy sources.

A primary motivation for the continuation and significant expansion of the present DNRC program is based upon the projected economic return to the people of Montana. The great majority of the important renewable energy resources are owned or controlled by individual land owners in Montana, e.g., biomass, solar, wind, and geothermal. A statewide program using these resources will, in addition to directly benefiting the resource owner, create the supporting businesses and manufacturing activity. Thus, one objective of the Renewable Energy Program is increased economic activity within the state at the individual and small-to-intermediate business level. This program is not dependent upon large corporations moving into the state, but rather, the creation within Montana of new businesses. By the year 1985, this expanded program has the potential of generating business activity in the millions of dollars which will directly benefit the citizens of Montana.

Agricultural/forest products and residues (biomass), geothermal, and wind are the three renewable resources with major subprograms that will be fully developed and commercialized under this plan. Farm and forest residues will be used for production of alcohol and methane and for direct combustion to produce heat and possibly electricity. Wind will be used for electricity generation. Geothermal resources will be used for space and industrial/agricultural heat. Full commercialization means to perfect the applicable technologies for Montana, establish the economics of utilization, create the supporting industrial base, and finally manufacture/build and install the system/facilities throughout the state. Montana capital and Montana citizens can do this via indigenous internal growth and with only a relatively minimum initial funding from the state and national government.

One element of the biomass portion of this program is directed to community- or county-size alcohol plants of a nominal 10^6 gallons/year output which would be fully integrated into the local community. A plant of this size can be built, owned, and operated by the community or individuals with minimal outside assistance. The initial market for the alcohol and the by-products would be the community and surrounding region. Support for five plants is proposed.

The second major element of the biomass program is the direct combustion of forest or farm residues in community-size heating plants and for individual residential-size heating units. Many regions within the state have residues which because of climate, soil, or harvesting practices must be disposed of frequently at some expense to the land owner. These residues can be converted into an additional cash crop. Support for four plants is proposed.

During the six years of the program, alcohol plants and direct combustion plants will be partially funded, and testing and evaluation of home-size furnaces and stoves will be continued. The degree of state financial support will be limited to design and 90 percent or less of the construction costs of the facilities. At the end, the technology and operating costs will be established to such a degree that the succeeding plants established in the state can be fully financed by private funds.

The last element of the biomass program is biogas generation. Three sizes of biogas (approximately 65 percent methane) facilities will be developed under the biogas subprogram. One community waste, supplemented with agriculture or forest residues, biogas generator facility will be designed and constructed. Two dairy farm or feed lot size facilities will be installed, and finally a smaller farm or ranch size model will be developed. Three design iterations are provided for in the small size and a total of nineteen units will be purchased for ranch and farm testing and evaluation.

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The integration of a community-size biomass program will also include appropriate supporting agricultural activities. For example: alcohol production creates high protein feed which can be used to feed cattle, and the manure from the cattle can be used to generate methane which in turn can be the heat source for the alcohol production.

The wind element has two major portions--first, the individual land owner wind generation concept and secondly, the large utility-owned wind farm concept. The land owners in Montana possess an enormous wind energy potential which, with the development of properly scaled and designed wind electric or direct mechanical generators, can be "harvested" for farm and ranch use. In addition, it can be fed back into the electric grid system. The farmers would be paid for any excess electricity they generated by the utility company; hence, the land would provide a second cash crop. Support for 60 farm-size (20 KW) wind generators is proposed. In addition to the siting of individual wind generators, Montana possesses numerous prime sites, some in conjunction with hydroelectric generation facilities that could be used for large wind farms with a generation capacity of as high as a few hundred megawatts. The Bureau of Reclamation, Corps of Engineers, and the utility companies will be encouraged to establish wind farms with a generating capacity of 250 MW by 1986, an amount equal to that to be generated on farms and ranches. Besides this electric generating capacity, this commercialization plan will create the manufacturing, erection, and maintenance industries in the state to support this renewable energy re-use.

The geothermal hot water resources of the state will be evaluated for community and industry-size facilities for space heating and industry/agricultural applications. A prime site in the state will be developed to provide a central community heating system. If an appropriate user can be identified, a program will be developed that will demonstrate the use of geothermal heat in industry or agriculture. Support for two geothermal sites is proposed.

The solar and small scale hydroelectric subprograms are funded at less than one million dollars each for the four year period. These subprograms require less state support because of state-of-the-technology due to past state and federal funding. Three tasks remain to be completed in the solar subprogram. These are: the evaluation of the solar demonstrations that have been funded, assistance in providing commercially available low cost solar panels for homes, and assistance in the design of solar heating systems for commercial buildings, apartments, or communities. The small scale hydro-electric subprogram will provide for the design and cost analysis of up to twenty hydroelectric generation sites in the state and funding to support up to 90 percent of the construction for ten sites. The electricity output from these sites will be limited to no more than 20 KW. Bradley Lake - 70KW

It is recommended that the Energy Division of DNRC continue the management of this expanded renewable energy program with assistance from major subcontractors for each of the renewable energy resources. By properly structuring the contractual responsibility and work, this program can be managed without an increase in the permanent staff of DNRC. One program objective is to establish within the state the technology and management capability for renewable energy sources. This is to be done by building up Montana private industry and business and not by an expansion in the number of state employees. The major portion of the work will be performed competitively in response to "Requests for Proposals" (RFP) and only a limited amount will be by unsolicited proposals. During the first three years, three or four temporary staff personnel will be needed in the Energy Division to start the program, establish office operating procedures and policies for the expanded effort, and provide the necessary close subcontractor direction required during the initial phases of the subprograms.

The key to program control in this plan is the annual in-depth total program review by subprogram element performed by a review team composed of legislators, DNRC subcontractors, and nationally renown experts. All activities will be reviewed, and any necessary budget adjustments will be proposed to the Montana state legislature and the U.S. Department of Energy for the coming year. It is vital that the program remain dynamic and that adjustments in expenditures be allowed and encouraged in a public policy directed manner so that advantage can be taken of unexpected program accomplishments or opportunities. In the same respect, expenditures should be cut or terminated in any subprogram that does not meet the projected economic pay off for the state.

The total funding recommended for these programs is $46,800 thousand. This is the amount obtained by adding all the subprogram totals in this plan plus an additional $5,225 K for DNRC management during the six years of the program. Montana's share is $8,600 K and is based upon projected return from the coal tax revenue. It is recognized that the state legislature can only make a two year commitment, and that is all that is necessary from the state and the U.S. Department of Energy to start the program. If successful, the remaining funds would be requested from the 1981 and 1983 legislature and the U.S. DOE. For full funding of the first two years, the state must provide $900 K in 1979 and 1,100 K in 1980 and the federal government $2,700 K and $4,400 K in each of the two years. The funding level requested is significant, but the program is structured so that each succeeding year's budget is spent only if the prior year's activities were successful.

The program will be coordinated with the Department of Agriculture and Small Business Administration Energy Loan programs. The USDA Business and Industrial loan program can become a vital part of this program in supporting the development of the required industrial base in Montana. In addition, the products developed must be "approved" by the USDA so that the farmers and ranchers can obtain FHA loans in support of purchase. Public Law 95-315 changes the Small Business Act to provide funds for energy related activities and facilities.

This document details a flexible, diverse but integrated expanded alternative renewable energy program that simultaneously addresses major national needs as well as the unique requirements of Montana. This program is designed to serve the broad public policy needs of Montana through stimulation of development in the private sector. Furthermore, this program recognizes and addresses the needs for new community scale technology that will allow the communities to have at their command technology that will not be imposed from outside the state by organizations that have optimized the production for their benefit. Moreover, these technologies and energy sources will reverse the long term trend of Montana's economy of being based upon exporting unprocessed agricultural and natural resources. Unlike coal, where processing involves significant environmental impacts with existing technology, the development of alternate renewable energy resources can be developed with minimal negative impacts.

COMMUNITY SIZE ALCOHOL PRODUCTION SUBPROGRAM

Introduction

As our petroleum supplies decrease, energy will become a larger portion of living costs if we maintain our current life patterns. The farmer is aware of this since he depends on gasoline, fuel oil, and electricity. The costs of these resources have been escalating much more rapidly than farm products. Today, the farmer is an importer of energy. The future could be different--as these "conventional" resources decrease, other energy sources will become cost competitive.

The Great Plains of the United States is the largest and most productive area of renewable energy sources in the world. This region represents by far the most significant asset of our country; and in the future, in addition to food, it will become an energy producer.

It has been estimated that 75 quads of electricity could be generated from wind in the United States without affecting the present weather patterns.[1] This is equivalent to the present yearly total energy consumption in the U.S. The wind energy subprogram section describes in detail how Montana's farmers and land owners will benefit from this resource. Wind is only one new farm crop; the other two important new Montana farm or forest energy crops are liquid fuel and biomass residues for direct combustion. This section will present a program for liquid fuels.

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1 "Wind Energy Resource Parameters," M. R. Gustavson, Proceedings, National Conference, American Wind Energy Association, March 1978.

With the present technology base, the most appropriate liquid fuel from farm and forest products is alcohol. Certain European and South American countries have had extensive active alcohol production facilities for 30 to 40 years which use farm and forest products. Experience has shown that anything up to 20 percent alcohol has no effect on a vehicle's engine performance,[2] and with engine adjustment, 100 percent alcohol can be used. Sometime in the near future, depending upon OPEC pricing policy, gasoline could reach a price where large scale production of alcohol from farm products will become a reality. No new technology is required; however, improved total system plant operation and by-product utilization will hasten the date that alcohol becomes competitive. In addition, it is possible that new farm crops may be developed that will yield a higher alcohol return per acre.[3]

There is the possibility that new environmental laws covering gasoline additives could greatly benefit the use of alcohol in gasoline. The price paid by petroleum companies for gasoline is a closely guarded secret; therefore, the real value that alcohol might have is difficult to determine. Tests have shown that for 80 percent octane base stock gasoline, each one percent of alcohol improves the octane by about one percent. For higher octane base stocks, the improvement is less.[4] Alcohol also might have other qualities, such as suppressing pre-ignition. Any government requirement to use other additives, or alcohol specifically, in gasoline would have a great impact on alcohol consumption.

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[2] Public presentations at Annual National Gasohol Commission Meeting, Chicago, Illinois, November 1978.

[3] "Alcoholic Fermentation of Jerusalem Artichokes," L.A. Underkofler, et. al, Industrial and Engineering Chemistry, Vol. 29, No. 10.

[4] Private communications, Cenex and Conoco refinery personnel, December 1978.

Of course, the interest of the Montana rancher or farmer is to raise the sale price of his current products, i.e., $4.00 or $5.00 per bushel for wheat rather than the current price. In some areas of the U.S., this may not be a simple economic problem because if the price is increased, more marginal regions can be converted or returned to farming resulting in larger production and a lower price paid per bushel.

The real farm objective is to increase the cash return per acre while maintaining or decreasing farm expenses of time and money. The average cash return on wheat acres during the past couple of years has fallen from a high of $111.00 to a low of about $75.00 per acre per year.[5] The return might be increased in the future by introducing a new second major crop that would be grown on some of the present grain acres and would be used to produce alcohol. This new crop would reduce the wheat output and, hence, raise the price paid for wheat; as a result, the wheat acres would produce a higher price per acre. Under the present petroleum costs, what must be the characteristics of this new crop? Assume the alcohol could be sold in large amounts at 80¢ per gallon, this amounts to 40¢ per gallon with current federal tax credit, and produce a profit for the distiller. In order to obtain $120.00 per acre, the farmer would need a new crop that would produce about 240 gallons of alcohol per acre compared to the typical current wheat production of about 65 gallons per acre. These numbers assume an inexpensive community-size batch plant and sale of the protein by-product as feed at 30¢ per gallon of alcohol produced.

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[5] Montana Agricultural Statistics, Vol. XVI, Montana Department of Agriculture and U.S.D.A.

The weakness in the previous case is that there is no established or fully characterized farm crop that can be raised in Montana, with the same or less farm inputs, that will produce four times the alcohol output as wheat. An extensive effort by agricultural researchers has not been made to develop such a crop. This problem certainly merits considerable attention. Hopefully, as the price of gasoline increases, the development of a new crop and supporting farming practices with increased alcohol yield per acre will be successful; and a portion of the Montana acreage can be converted to this alcohol crop.

The immediate objective of the proposed alcohol subprogram is to establish alcohol plants in Montana which use Montana-grown feedstock and produce at least the same economic return to the farmer as the current return from food production. There is a probability that a near term increased return is possible; however, this is dependent upon economic factors and markets outside of Montana which are very difficult to predict and control. With the present price of gasoline in the U.S., the best that can be expected is an equal return; however, as gasoline prices increase, an increase in farm revenues will be received. This program will develop the facilities, management, and technology in Montana communities so that Montana farmers and businessmen will be able to select their own role in the future liquid fuels industry in the U.S. The farmers and their communities are knowledgeable of and competitive in the role of food production. This program will extend that competitive advantage to alcohol production.

The long term objective is to significantly raise the dollar return per acre through the best combination of energy and food production on the farm. This will be possible with the local know-how established under this program.

The two key elements in the economics of alcohol production are marketing of the protein remaining from the feedstock and minimizing the energy required to produce each gallon of alcohol. Significant advances have been made in reducing the energy requirement from 200,000 Btu to 40,000 Btu and less per gallon.[6] Even at this lower level, the question remains as to whether or not the total process from crop planting to alcohol production is energy positive. The protein market is a problem that can be solved on two levels. First, protein can be sold on a local basis for cattle feed; in which case, this will probably limit the amount of alcohol that can be economically produced and consumed within each community. The second possible solution is to establish a national or international market for human consumption of the protein; in which case, a much larger quantity of alcohol could be produced. The identification of this possible large market will be pursued continually throughout the program.

The above discussion has centered on crops raised for alcohol production. Forest waste products have been used in Oregon to produce alcohol, and much research is being conducted in converting farm wastes (e.g., straw) to alcohol. If this becomes technically and energy efficient, the possibilities for greater economic return per acre are significantly increased. In addition, by using biomass wastes and a low energy intensive process, a net positive energy return is assured.

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[6] Public presentations at Annual National Gasohol Commission Meeting, Chicago, Illinois, November 1978.

Community Size Plants

In the past few years, much has been written about alcohol produced for fuel from agricultural products or wastes.[7,8] The almost universal conclusion of these reports has been that alcohol cannot be produced at today's price for grain and be competitive with gasoline. In reaching this conclusion, certain basic assumptions were made about the price of grain, plant size, and market; and given these assumptions, the conclusion drawn seems to be correct. The plant and operational concept for alcohol production in this renewable energy subprogram is different from that proposed by any previous alcohol study, and under certain conditions can produce alcohol that is competitive with gasoline in Montana. There appears to be a very high probability that the range of conditions under which alcohol production is economical can be expanded significantly once operational experience is gained from an alcohol production plant which is integrated within a local farming community.

The concept of this program is to locate the first plants in communities that have the most favorable economic position. As experience is gained and construction and operational costs are lowered, communities with a smaller economic edge can be included and successful plants constructed. The typical factors which enhance the economics of a plant for a community are: use of existing facilities, high local gasoline costs, continued excess farm produce, high transportation costs for farm produce, local cattle feeding, and high cost for protein feed supplement.

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7 Grain Alcohol in Motor Fuels, J. G. Kendrick and P. J. Murray, Report No. 81, Department of Agricultural Economics, University of Nebraska, April 1978.

8 Feasibility of Ethanol from Grain in Montana, R. Stroup and T. Miller, Research Report No. 118, Montana State University, January 1978.

The first plants will be designed with flexibility in mind to operate using existing farm produce; in Montana, these are primarily grain products. Later, other crops producing a greater return of alcohol could be grown on a portion of the available acreage after research had verified the economics of such crops. The United States Department of Agriculture (USDA) will be encouraged to support this type of research during the program.

At the present time, Brazil has over 400 operational alcohol plants and is supporting the construction of additional plants. International construction companies are supporting the Brazilian program; in addition, some of the major construction firms in the U.S. have built, or are interested in building, alcohol plants. To date, the designs proposed by these companies for the U.S. have been the large capacity plants of 10 to 20 million gallons per year. Vulcan Inc. has proposed a two million gallon per year plant for $12 million for the USDA loan program. There is one small company in the U.S., ACR Processing Corporation, who has joined with the Grain Processing Corporation to design smaller plants which use either a batch or continuous process approach. They have designed plants of a few hundred thousand to a few million gallons per year which require less than 40,000 Btu of energy per gallon of alcohol produced and which are operated by a small staff.

A recent ACR design was submitted for the $15 million USDA loan program plant in southeastern Colorado. This design was for a continuous process plant with significant automation, and the projected total construction cost was a few million dollars; i.e., a couple of dollars per gallon per year.

The variation in plant costs can be seen when this is compared to the Vulcan design also submitted under the loan program for a group of potatoe farmers in eastern North Dakota.

Under an Old West Regional Commission contract, MERDI, in participation with a group from Glasgow and ACR, have performed a conceptual design for a batch plant which is more suitable to the Glasgow needs than these more expensive continuous process plants. The plant and the integration of alcohol production at the community level which is being proposed in Glasgow is the concept that is recommended for the first plants under this program. Tables I, II, and III provide some of the preliminary characteristics and costs for the Glasgow plant. During the next month these numbers will be further refined.

For the Glasgow plant, the grain supply will come from the plant owner's fields. There is indication that ranchers in the area will purchase the distillers grain as feed at the price indicated. The remaining question is what will be paid for the alcohol produced? Discussions have been held with the Montana Petroleum Association and distributors in Montana to determine the extent of interest. This, of course, is the key to selling alcohol. Studies[9] have shown that there is support for gasohol as a better product at a higher price than regular gasoline. There is also an indication of a projected increase in demand for premium unleaded gasoline. Adding 10 percent alcohol to unleaded regular gasoline will produce a product almost equivalent to unleaded premium. Given the economics of Table III, the 4¢ per gallon federal tax reduction, funding support for capital and operating expenses from this program of 21¢ per gallon, then unleaded regular/alcohol mixture

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9 Iowa Development Commission, "Consumer Acceptance and Market Potential of Gasohol," October 1978.

TABLE I

Preliminary
Specifications for Glasgow
Alcohol Plant

Type:	batch
Capacity:	120 bushels per cook (960 bu/day)
Cycle:	3 hours per cook, 36 hours fermentation
Feedstock:	Barley (2.0 gallons ethanol per bushel)
Fuel:	Coal (Montana; 10,000 Btu/lb)
Boiler:	Low pressure (atmospheric pressure cooking)
Beer still:	3 feet diameter
Production rate:	1920 gallons and hydraus ethanol per 24 hour day.
Grain storage:	30 days supply (30,000 bushels)
Product storage:	33 days operation (21,000 gal.)
Coal consumption:	6.25 lb/gal. (50,000 Btu/gal; 10,000 Btu/lb) 6 tons/day
Stillage production:	13,400 lbs/day (14 lb/bu)
Fermenters:	12, 10' d x 12' overall height
Fermentation house:	32' x 96'
Boiler house:	24' x 32'
Distillation house:	30' d x 72' height
Boiler:	200# tri-fuel (coal, oil, or gas)
Coal storage:	Undetermined
Waste water disposal:	Undetermined

TABLE II

Preliminary Cost Estimate for Glasgow Alcohol Plant

Grain Handling and Preparation	(Undetermined)
Cooking, Fermentation and Distillation	$247,500
Boiler	90,000
Fermentation and Boiler Buildings	45,000
Distillation Column Enclosure	30,000
Grain Storage	(Undetermined)
Coal Storage	(Undetermined)
Product Storage	19,000
Gasoline Storage	7,000
Erection and Piping (20% of equipment & boiler)	67,500
	($506,000)

TABLE III

Preliminary Cost of Production for Glasgow Alcohol Plant

	$/gal.
Feedstock (Barley at $160/bu.)	0.80
Energy (Coal at $38/ton plus 10% for electricity)	0.13
Labor ($10/hr. 2 men each shift)	0.25
Cost of Working Capital (See footnote 1)	0.0735
Management (All components, $30,000/yr.)	0.0435
Interest and Debt retirement (See footnote 2)	0.137
Total	1.434
Sales of Distiller's Grains and Solubles (7 lb/gal. @ 0.075/gal)	0.525
Net Cost per Gal.	0.91

No Allowance for Taxes or Profit.

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[1] Working capital, 6 months of feedstock, energy, labor, and management at 12% (.12 x 50,800 = 0.073).

[2] Capital investment of $550,000; a mortization of 12% loan in 10 years.

would sell for 3¢ per gallon more than the regular. The proposed $2 per barrel government rebate, or 5¢ per gallon subsidy, has not been included in these calculations.

The Glasgow plant would require about 30,000 Btu's per gallon of alcohol if the distiller's grain is not dried. The significantly reduced energy requirement is not the result of any new technology but rather a very complete coupling of all energy generated and needed. This same approach is possible in the larger plants designed by other engineering companies in the U.S. The problem is that there has not been a great need in the past to reduce energy consumption in the conventional alcohol plants designed by these companies. ACR has been working on reduced energy consumption for ten years, primarily in small plants, and has thus worked up the right combination of system tradeoffs.

In essence, there is the possibility of two general size plants for Montana. The larger 20 million gallon size plant, costing $20 million, must have a strong national or international market secured for the alcohol and by-products before construction would be feasible. Five plants of this size would use about one-third of the annual Montana grain production; however, any success would certainly encourage the corn growers in the East to do the same; thereby, developing strong competition. This is not an impossible objective, but it is one where we do not have control over all of the critical elements. As mentioned, this avenue should be continually pursued; however, caution is necessary.

The smaller community size plants appear to be best in Montana, with the market in the surrounding area. Initially, this approach will not impact grain prices. A source of feedstock must be secured, possibly by the grain farmers owning the plant. Then, a market must be secured for the alcohol and distiller's grain. This market information is essential for finalizing the plant design and operation, and this is an iterative process that is dependent upon the condition in each community.

With the present price of gasoline and the use of wheat or barley as the feedstock to the plant, alcohol production will not be a big money maker. The proposed program will provide the feasibility study, plant design, market identification, partial construction cost, and initial start-up and operation to the selected communities who have expressed an interest in such a facility. In addition, the program develops in Montana farm communities the technical and managerial know-how to enter into large-scale liquid fuel production in the 1990's. Any new high-alcohol producing crop or new technology for processing biomass waste will advance the date when alcohol production contributes significantly to farm and forest income.

Technical Program

A technical and management alcohol plant team will be formed which includes personnel experienced in farm products and operation, alcohol production plant design and construction, marketing, and plant management and operations. This team will prepare briefing material on all aspects of the program to be presented to interested communities. The information and experience gained in the Valley County alcohol project will be valuable to this team.

The next step in the program is for interested communities with the appropriate farm or forest product to form a private or community government affiliated organization that is a single point of contact. This organization will contact the state and express an interest in an alcohol plant. The alcohol plant briefing team will come to the community and conduct educational type meetings to explain the state support, possible plant size, operational considerations, funding requirements, typical economic return, etc. Printed material will be made available. The community organization will then decide if it would like to be considered as a possible plant site under the state program.

Members of the alcohol plant team will return to the community and assist them in preparing a detailed proposal to the state for support. Information on feedstock, market potential, plant size and location, operational and management concept, expected dollar return, and desired financial assistance will be generated. The community organization is responsible for submitting the proposal to the state. The state will select at least five communities to be supported during the program. Depending upon the level of funding requested, additional plants could be supported.

Hopefully, at least one large size plant (20 million gallons) can be established during the program. The same initial assistance will be provided for a community desiring a large plant; however, design and construction must be provided by private financing.

For the selected small plant communities, the next assistance step is the detailed engineering design of the plant and firming up the feedstock supply and product marketing commitments from farmers, gasoline dealers, and cattle feeders. A construction bid will be obtained from the plant design and the responsible community organization will finalize their construction funding support request to the state. It is desired that some community funding or in-kind contribution of at least 10 percent be included in each plant.

Construction supervision assistance will be provided by the plant team, and training of key plant operations will begin as soon as practical. The team will provide assistance throughout the check-out and during the first year of plant operation.

The five or more plants will not be constructed all at once but will be staggered a few months so that experience can be gained from plant to plant. A period of 18 to 24 months will be required from the time the alcohol plant team begins working with a community until a small size plant is operational.

A specific in-state ongoing crop research program is important to identify better crops for alcohol production in Montana. This research should be done at Montana State University. Much work is being done on a national level for waste or residue alcohol production which would have a great impact on the economics; the results of this research will be closely watched. The sooner wheat or barley can be replaced by a less expensive and higher alcohol producing plant, the sooner the farmer will receive greater economic returns. Any agricultural research program is long term so it is important to begin working with the communities with the alcohol plants as soon as possible on a gradual and experimental basis.

The alcohol plant team will provide technical and management support to the communities for the full four years of the program. A n important function will be exchanging information among the Montana plants and in assessing and disseminating research efforts that will benefit these plants. The team also will be available to provide information to communities who might desire to construct their own plant without state assistance. At the conclusion of this four year program, the construction and operational costs of the plants and the supporting in-state technical knowledge will be available so that interested communities can develop alcohol plants using consultants and commercial financing at minimum risk.

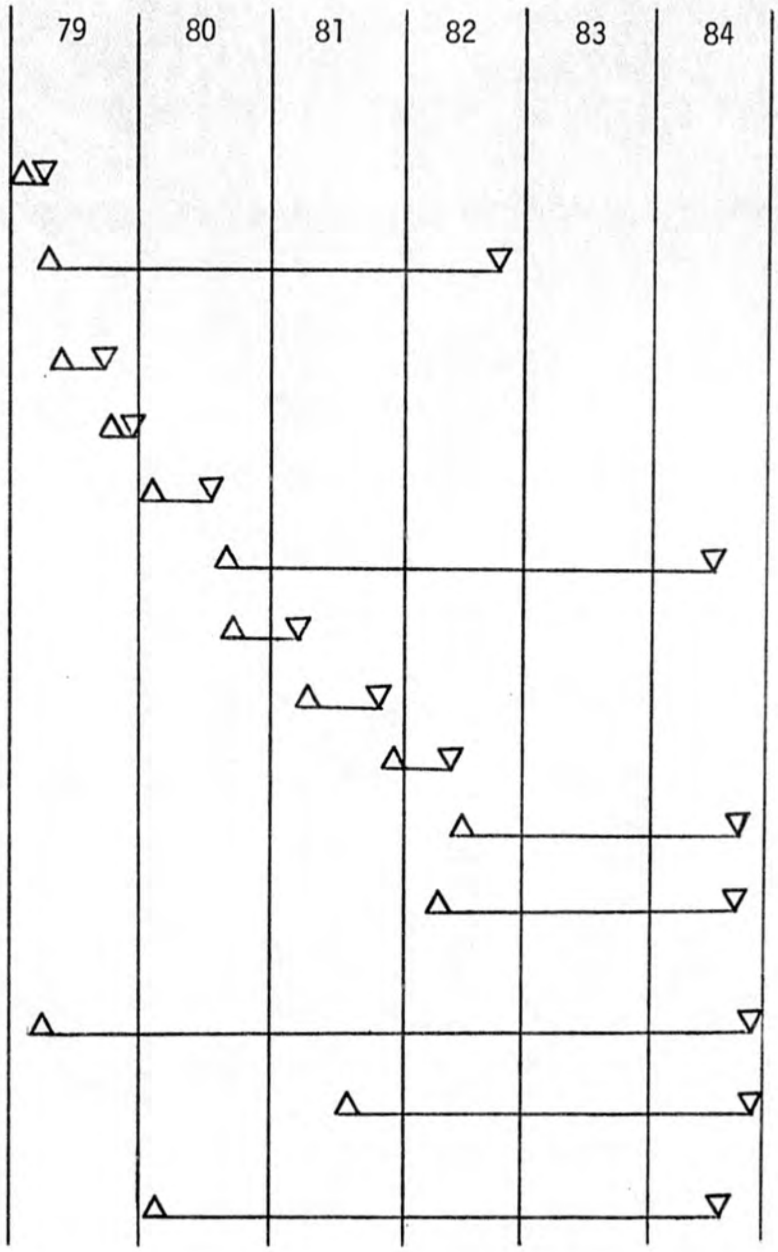
Additional Issues

The price of gasoline or any EPA ruling on gasoline additives could have a very significant impact on alcohol economics. The probability is that the impact will be favorable. Other states have considered a reduction in the state gasoline sales tax during the first few years of a plant. This lost income would have to be made-up from some other source, and this sales tax reduction is not recommended for Montana. Another possibility is requiring that alcohol be added to all gasoline used in the state--this is a forced subsidy to alcohol production. Property tax relief could be considered for the first few years of a plant.

There is consideration of using a few cents "check off" on wheat to generate a fund which could provide financial assistance for construction. This concept would support this proposed program.

Schedule and Cost

Schedule of Program Elements



- Formation of plant team and briefing document preparation
- Briefings to interested communities, as requested
- Selection of 1st community for support
- Support to 1st community
- 1st plant construction
- 1st plant operation
- Selection of 2nd and 3rd communities
- Support to 2nd and 3rd communities
- 2nd and 3rd plant construction
- 2nd and 3rd plant operation
- Selection of 4th and 5th communities and support, construction, and operation
- Crop research support in Montana
- Information exchange and dissemination
- Support to communities desiring a large size plant if requested

Major Cost Categories by Years (Dollars in Thousands)

	79	80	81	82	83	84
. Alcohol plant team	700	700	550	400	300	200
. Plant design and construction assistance	300	550	200	600	1050	1150
. Initial operation direct support	0	100	150	200	200	250
. Instate crop research	150	150	200	200	250	200
Total cost	1150	1500	1100	1400	1800	1800

It is proposed that these yearly total costs will be shared by state and federal by a one to five ratio.

DIRECT COMBUSTION OF BIOMASS SUBPROGRAM

Introduction

Montana is a state with plentiful resources of biomass waste from farm and forest activities. These residuals have a Btu content per pound between Montana lignite and bituminous coals. One use of these resources is in the production of liquid fuels which is covered in another section. In this section, a program is proposed for the direct combustion of biomass for the production of heat and, possibly in some limited community-initiated uses, for the generation of electricity. For heat production, two sizes of combustion are to be supported; one is a community-size central heating plant distributing hot water in towns, and the other is for individual stoves or furnaces for homes or small businesses. This later combustion program couples directly with the active and passive solar heat research and demonstrations that have been funded previously throughout the state. Community-size electrical generating plants will not be supported in the program. This would be a secondary benefit that might be considered by any community or rural cooperative once a central heating plant has been established. The electrical generating technology and cost trade offs between local generation with MPC and MDU back-up, and MPC and MDU full time power costs, can be determined without additional development or demonstration. Communities with central heating plants may or may not wish to consider this additional option which, if selected, would be at their own expense. This program does not contain funding in support of studies, development, or demonstration for electric generation.

The renewable biomass mass can be estimated from Montana's farm and forest production. Considering only wheat crops from the farm, and assuming that a pound of wheat produces a pound of straw, about 4 million tons of straw are produced from the 8 million plus acres under harvest in the state.[1] At present, the great majority of this straw is marketed or plowed back into the soil. Dependent upon the price that would be paid for straw used as a fuel, substitutes could be found, and some of this straw could be used as fuel. In one area south of Ft. Benton, about 100,000 tons of straw are available each year; therefore, an assumption is made in the calculations below that at some price, yet to be determined, one million tons would be available annually in Montana. The annual forest harvest in Montana had been about 200 million cubic feet per year.[2] Using representative data from the forest service on residues from sample forests in Idaho, Wyoming, and Montana, about one million tons of usable residue would be available on the ground after logging this amount of lumber. Thus, from farm and forest, two million tons of biomass are available each year in Montana. The present coal mining operations produces 30 to 40 million tons/year; thus, the renewable biomass resource is small compared to the coal resource. However, this annual statewide biomass supply is adequate to heat 50,000 homes from central heating plants and to provide ten tons of processed biomass fuel per year as heat for another 50,000 homes.[3] The point can be made that if the

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1 Montana Agricultural Statistics, Vol. XVI, Montana Department of Agriculture and USDA.

2 R. V. White and C. E. Keegan, "The Wood Products Industry in Montana," Montana Business Quarterly, Summer, 1978.

3 Individual homes 10 x 50,000 = 500,000 tons; Central plants: (2,000,000 - 500,000) tons x 2,000 lbs/ton x 8,000 Btu/lb = 24×10^{12} Btu
50,000 homes x 60,000 Btu/hr - home x 4,000 hrs x 50% total system efficiency = 24×10^{12} Btu.

resource numbers are off by a factor of five, there is still sufficient renewable energy for 20,000 homes. One object of the program is to define the resource.

The present cost of natural gas delivered by the utilities in the state is around $2 per million Btu. The cost for electric or fuel oils is about two to four times the cost of natural gas. The cost advantage of natural gas is significant, and any centralized heating plant using biomass cannot compete with natural gas delivered to the homes for heating as presently priced when fuel and capital costs are considered. There does appear to be a strong possibility that biomass would be cost competitive with electricity and fuel oil. The communities in Montana that should be considered for the demonstrations are therefore those without natural gas. In addition, because the cost of a hot water distribution system is expensive, the communities must have a relatively high density business and housing area.

As in the case of the other programs, the development steps follow in order, such that if at anytime it is determined that the concept would not be cost competitive to existing systems, the program can be terminated without additional cost. Because of the existing technology base, very little hardware development and testing will be required. By the time that large hardware expenses are necessary, the system costs will be known, and a go/no-go decision can be made on an economics basis. This program therefore requires only a commitment of money on a step-by-step process. The state will be in the position to stop the program if at any time the system's technical or operational cost goal cannot be met. In addition, the selected communities will be expected to make a cash or in-kind contribution of at least 10 percent of the installed system cost.

An example of the sequence of steps that must be accomplished is:

1. Identification of communities in Montana that are interested in such a centralized heating concept;
2. Preliminary study of community energy needs;
3. Identification and quantization of renewable biomass resource in region;
4. Study of collection, processing, storage, and transportation methods that are possible;
5. Preliminary design of heating plant and distribution system;
6. Initial estimate of cost foe delivered heat to users;
7. First decision by community to continue program;
8. Selection by state of communities that will receive further state support;
9. Decision by community on ownership and operational concept of heating plant;
10. Detail study of fuel costs aimed at minimizing capital and operational costs and maximizing return to land owner;
11. Layout design of heating plant and distribution system;
12. Commitment for required fuel supply at negotiated price;
13. Second estimate for cost for delivered heat to users;
14. Study of home and business heating unit costs and financing amount and method that will be required;
15. Second decision by community to proceed;
16. Sign-up of prospective customers;
17. Detail design of heating plant and distribution system along with continued work on fuel collection, etc.;
18. Final community approval on project;
19. Construction;
20. Plant and distribution system check-out;
21. Home and business hook-up; and
22. Operation.

It is proposed that four communities be selected for support through construction and check-out under this program with at least one using forest and one using farm biomass. Two would be started and would enter the construction phase before the second two would be selected by the state. The first two plants would be operational before construction on the second two plants would be started. Steps 10 through 21 will require about 20 months. Additional communities would be supported through step 17 if there is interest.

During the course of this program, the technical design, fuel processing, construction, and operational skills would be developed within the state, so that additional interested communities could develop their own plants through the established commercial capability.

The hot water distribution system developed under this program is quite similar to that proposed under the geothermal program. The community-size biomass heat plant technology is an excellent addition for any community that develops a geothermal supplied heat system that goes dry after 10 or 20 years.

The second element to be considered under this program is direct research and development support to furnace and stove manufacturers and biomass fuel processors. Improved stove and furnace design for lower manufacturing costs, improved efficiency, and pollution minimization must be developed. This must be done in conjunction with a detail study of the collection and processing of biomass fuels for direct home and business use. Fuel preparation and delivery costs must be minimized. The owner is buying Btu's, not just a stove and fuel, and the whole business structure must be analyzed and developed within each community to provide this at minimum cost. Any expanded use of biomass will not come about by a significant increase in the weekend family trips to the woods to cut a load of firewood for the pick-up. For expanded use, the process must be commercialized with the resulting capital equipment and small businesses being established.

This stove and furnace program will directly support the passive and active solar heating programs that have already been supported by DNRC. In Montana, a biomass burning back-up heating system is ideal. Two to three tons of biomass fuel per year should be more than adequate for any properly designed solar home.

Resource and Need Assessment

In western Montana, the forests provide an extensive renewable biomass resource. As an example of the state output in 1976, twenty-five percent of the harvested roundwood products came from Lincoln County, 19 percent from Flathead County, and 13 percent from Sanders County. Four communities in this area without natural gas are Libby, Eureka, Thompson Falls, and Polson. Six hundred and sixty million board feet were harvested from these three counties in 1976, which is slightly lower than the average harvest over the past ten years.[4] There has been a general trend of decreasing harvest from public lands which is the major acreage in these counties during the past ten years; therefore, the harvest in this region might not be expected to be increased.

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[4] R. V. White and C. E. Keegan, Ibid.

An average of the forest types and harvesting methods in a USDA Research Paper[5] on the northern Rocky Mountain region indicates that 5,000 ft^3 are harvested per acre, that after harvest, 35 tons/acre of residue in fines remain and three inches and greater are left on the ground. Computing the total acres harvested using the average yield per acre and the annual production gives 22,000 acres, with a biomass residue of 770,000 tons. This residue has a Btu content of 10^{13} Btu. Furthermore, if it is assumed that only one-half of this residue is collected and processed, this gives a total of 5×10^{12} Btu available per year from these three counties.

In 1970, there were approximately 80,000 people in these three counties; of which, say 20,000 are serviced by natural gas. At three people per home, the remaining occupy 20,000 homes. An estimate of heat need would be 60,000 Btu/home for 4,000 hours/year, or a total heat need of 4.8×10^{12} Btu. Thus, the biomass supply is approximately equal to the need for home heating when only one-half of that available is collected. If 770,000 tons are sold to the home and central heating plants at a cost of $30 per ton, this would represent an economic activity of $23 million per year for the local economy within these three counties. The $30 per ton is about $2.15 per million Btu and is equivalent to electricity at seven mils per kilowatt hour, or fuel oil at 32¢ per gallon.

The biomass resource in this region can certainly be a cost competitive fuel if it can be delivered at $30 per ton. One significant factor in

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[5] R. E. Benson and C. M. Johnston, "USDA Forest Service, Research Paper INT-181: Logging Residues Under Different Stand and Harvesting Conditions, Rocky Mountains."

determining whether or not this would be possible is the price of transportation which depends upon the harvest area and the use areas within these counties. One of the first steps of the program is to identify specific interest within the state. The four cities mentioned represent about 8,000 people or maybe 2,000 to 3,000 homes and businesses that could be heated by centralized hot water systems. There is certainly ample forest waste available on an annual basis to supply these homes.

In the grain growing regions of central and eastern Montana, a renewable resource equivalent to the quantity of forest biomass is available. The principal crop products of Montana are wheat and barley which, as an example, accounted for over 200 million bushels in 1975. The majority of the straw from this grain is presently marketed, plowed back, and used by the farmer in some beneficial manner. There is a real need for much of this straw; however, since it must be disposed of before a new crop is planted, disposal is more important than efficient use. What is implied here is that if there was another cash market for straw then some portion of that which is presently available could be made available for this market. The variation in the straw grown from one year to the next is sometimes as high as 1,000 pounds per acre or about four million tons statewide.

On the Highwood bench east of Great Falls, there is a 100,000 acre area on which year around wheat farming is practiced. The soil and climate conditions are such that the straw remaining after the wheat harvest cannot be plowed back into the ground. This straw must be removed from the ground in the couple of weeks between harvest and planting. There is not a sufficient local market to use the available supply; therefore, this straw is "disposed of" in the easiest manner possible. As a renewable energy resource, this straw, at an average of one ton per acre, represents 1.4×10^{12} Btu annually, which could satisfy the heating needs of approximately 20,000 people, assuming an overall heating system efficiency of 60 percent.

The cost for baling and collecting straw from wind rows in the field after harvest has been computed[6] to be $4.15 per ton, plus an additional charge of $2.70 per ton for hauling to the edge of the field (one mile is the assumed average distance per trip). These baling and hauling costs of approximately $7 per ton are for large round bales; the small rectangular baling costs are $12 per ton.

Straw can be burned directly as collected from the fields; however, for any widespread use involving long hauling, this will probably not be economical. (This conclusion should be verified by further study to determine the critical hauling distance at which densification of the straw becomes economical). There are many processes by which straw can be compacted[7,8] to 55 lbs/ft^3 which is about the same as coal. In this densification process, the straw is usually pellitized to uniform size and dryed to 10 to 12 percent moisture, making it a fuel which is very competitive in Btu content, combustion, and handling characteristics to western coal. In addition, the pellets have increased resistance to moisture absorption. The energy input for the complete processing is estimated at eight percent of the

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6 J. D. P. Partridge and D. G. Hodgkinson, "Manitoba Crop Residues as an Energy Source," Proceedings of Forest & Field Fuels Symposium, October, 12, 13, 1977, Winnipeg, Canada.

7 J. LaRue and G. Pratt, "Problems of Compacting Straw," Ibid.

8 R. K. Broeder, "Successful Marketing of Pelletized Field Residues," Ibid.

energy in the straw.[9] The total operating and capital cost of the densification plant has been estimated to be between $9 and $10 per ton.[9]

The straw densification plant considered above for the 10^5 tons on the Highwood bench area would have to operate 333 days to process the total tonnage available. During the course of the year, the straw could be transported from the edge of the fields to a central plant in the region. This transportation cost would add another $4 per ton to the final straw cost. Assume that bulk hauling of the pelitized straw in 20 ton trucks for a one-way distance of 50 miles would add another $5 per ton, this gives a delivered cost of processed straw of $25 per ton. Assuming the farmer is paid $5 per ton in the field, the price of the straw 50 miles away ready for combustion would be about $2 per million Btu. This represents a competitive price for fuel in many regions of Montana. One of the first elements to consider under this program is the refinement and verification of these calculations. In addition, other farming regions need to be identified that could provide a dependable, renewable biomass resource that could be used by a community or sold to individuals for their own private heating system.

Technical and Development Issues

The program objective is to determine the economic feasibility of biomass as a fuel in homes, businesses, and central heating plants. There

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9 T. B. Reed and B. Bryant, "Energetics and Economics of Densified Biomass Fuel Production," Solar Energy Research Institute Report.

are no critical technical unknowns in this proposed concept for the direct combustion of biomass. Certain steps in the process are well understood, and the equipment and technology are fully developed with little possibility of improvement. At the farming/forest end of this process, probably the least cost effective steps are in collection and densification. This represents 2/3 of the costs in the straw example illustrated. These two processes have not been examined by any equipment manufacturer to date, and there may be a possibility of reducing the cost. Transportation (most probably done by truck) costs to the combustion site and storage costs are well established. Central plant combustion is well characterized, and the technology exists to meet all pollution standards at the same combustion efficiencies of coal. Although the majority of the designs for the present direct combustion home-size heating units have been around for years, there is considerable need for improvements in combustion efficiency and in minimizing emissions. These two factors become more critical as more and more units are installed and as weatherization programs make homes more air tight. Research and development work in these areas, using Montana fuels, will be necessary and can be accomplished at DNRC's supported Anaconda Combustion Facility.

The first issue that must be resolved for any community interested in a heating plant or widespread usage of individual heating units is to identify a dependable renewable energy supply. In the case of farming activities, this is easy; however, in the forest regions, the distances between harvest and combustion site will vary from year to year, and this variation must be fully explored and considered in determining lifetime costs of any system established.

Probably the single most costly item of a central plant system is in the hot water distribution system. There are a few examples of this in the U.S., e.g., the Boise, Idaho geothermal system, which can provide cost estimates. The more numerous and furthest advanced technically are those in the European and Scandanavian countries. In the small towns of Montana, this may be the one factor which will prevent the central plant concept from being cost effective. Extensive study and a conceptual hot water distribution system design for a representative town must be initiated at the start of the program.

The ownership and operation of a community-size plant are issues that must be resolved by each community individually since the ten percent cost or in-kind contribution are closely related to these issues. Of equal concern to the possible hot water users is the cost of home installation of heating units and what to do with the existing heating systems. Another point that needs to be considered by the community is whether or not the central plant will be operated year around or just in the cold months.

For an individual home or business use of biomass for heat, there are fewer economic questions. The major issue today is in establishing enough users in one region to justify the cost of the collection and densifying equipment. Assuming that an average home would use six tons of biomass per year, the Highwood bench straw processing facility example would provide biomass for 16,650 homes. Smaller processing plants and the use of fewer tons of straw will certainly have to be studied if only direct home combustion was used, since the signing up of that many customers initially would be doubtful. The advantage of central heating plants for towns and individual heating units in the less dense living areas is certainly apparent if the maximum use of a region's renewable resource is to be made.

During the early stages of the program, all critical issues will be studied, and costs will be determined. If the projections are favorable, detail design of facilities and equipment will be made, and any required development programs will be undertaken. Communities and individual businesses interested in biomass fuel marketing and equipment marketing and servicing will be supported to the maximum degree possible. Direct support of a large-scale project will be provided once economic feasibility has been established. Each step must be justified on the projected economic feasibility, and if this cannot be done, the program is redirected or terminated.

Additional Issues

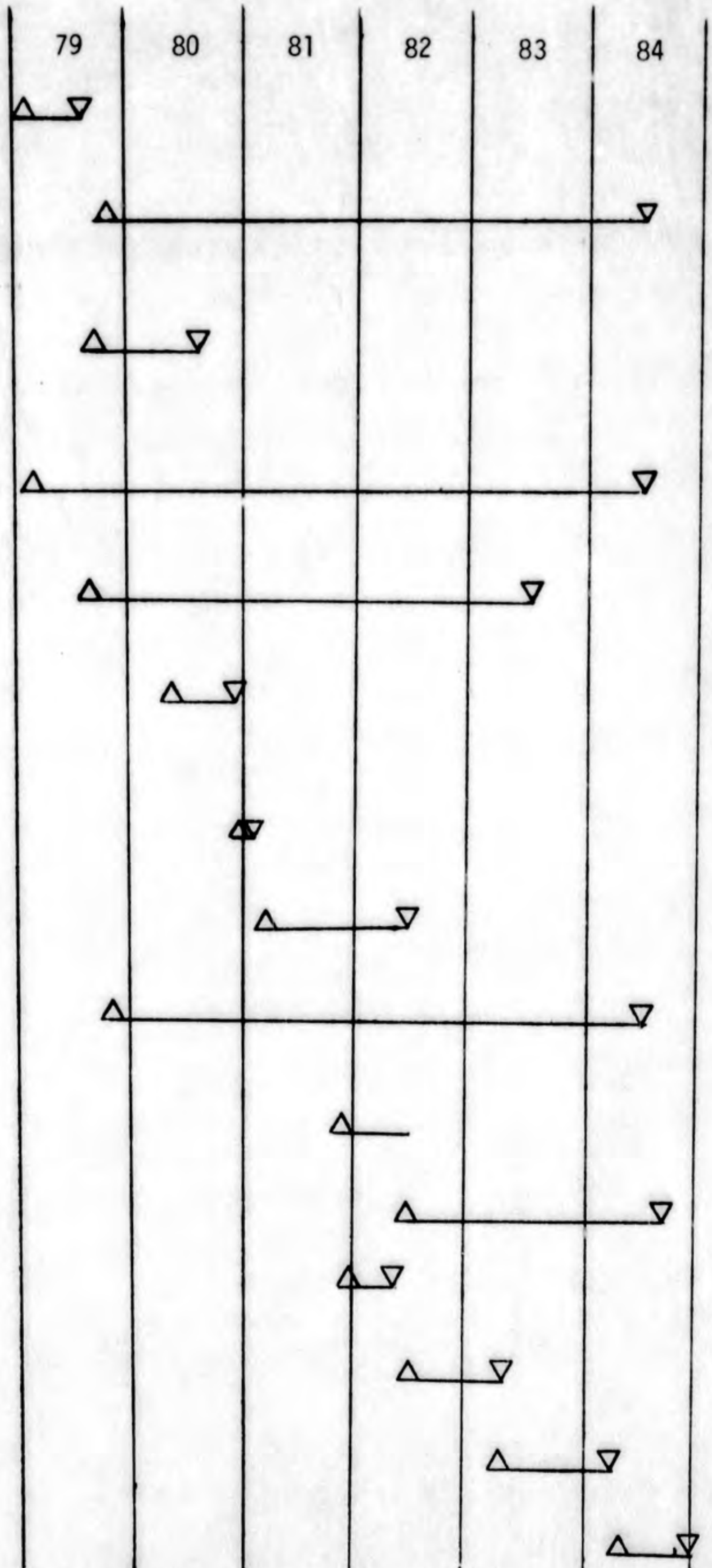
The central heating plant concept may be in the area of a community utility. The legal implications of this need to be fully explored.

If new farm/forest equipment is required, Montana firms or national farm equipment firms should be encouraged to establish manufacturing plants in Montana for this equipment.

Tax incentives to businesses supplying renewable fuels could be considered.

Schedule and Cost

Schedule of Program Elements



. Formation of "plant team" and briefing document preparation

. Supporting development program on collection and fuel processing equipment

. Initial costing for typical community--identification of critical technical and cost elements (Steps 1 through 6)

. Test and evaluation of home-size furnaces, stoves and Montana biomass fuel

. Briefing of communities and biomass fuel suppliers as required

. Support to first two communities, farm and forest fuel supply study, designs, and costs (Steps 7 through 16)

. Final community approval and detail design (Steps 17 through 18)

. Construction of first two central heating plants

. Establish biomass fuel supply system for plants and homes

. Construction of hot water distribution system and installation of home units

. Check-out and plant operation

. Selection of third and fourth communities

. Support for third and fourth communities, design, and costs

. Construction and set-up of plant, fuel supply and distribution system

. Check-out and operation

Major Cost Categories by Years (Dollars in Thousands)

	79	80	81	82	83	84
. Biomass combustion plant team	350	350	300	300	200	200
. Test and evaluation of home-size units and fuels	200	200	200	200	100	100
. Plant and distribution system design	0	0	145	0	400	0
. Plant and distribution system construction (additional financial support from communities required)	0	0	1200	1650	2550	4850
. Biomass fuel supply equipment development	60	150	200	225	160	150
. Support to fuel supply "companies"	40	100	150	175	200	100
Total Cost	650	1355	2195	2450	3610	5400

It is proposed that the yearly costs are shared between state and federal government at a one to five ratio.

BIOGAS GENERATION SUBPROGRAM

Introduction

There has been national and international interest and activity in the generation of biogas (approximately 65 percent methane, CH_4) from municipal sewage and animal manures since before World War II. Both community and large dairy farm size facilities exist in the United States. In addition, units down to the size of 50 pounds of manure a day exist in other countries. Biogas generation is not in widespread use in Montana; however, there are numerous facilities in other northern states.

The DNRC has supported a study on the potential in Montana for biogas generation, and there appears to be three sizes of facilities. The smallest is for the generation of a few hundred cubic feet of methane per day for home and farm/ranch building space and hot water heating. The next larger unit is that associated with a dairy or cattle feeding activity and would use the manure from a few hundred cattle to supply the gas for all heating needs for the activity and surrounding homes or small businesses. The last facility is one that would use municipal waste and possibly agricultural or forest residues. Montana communities without natural gas service and with additional biomass residues are the most likely candidates for the first facilities of this size.

Available Technology

The basic principles of biogas generation or methane fermentation, also called anaerobic digestion, are widely used in modern sewage treatment plants and involves the decomposition of organic matter in an oxygen-deficient atmosphere. The process involves three stages: first the proteins, carbohydrates, and fats are dissolved; next, non-methanogenic bacteria convert the soluable organics into organic acids; and last, methane-forming bacteria reduce the organic acids and other oxidized compounds to methane (CH_4) and carbon dioxide plus traces of other gases. The process is usually maintained at 95°F for optimum performance but biogas can be generated between 40°F and 140°F. The equipment required is simple: feed mixer, pumps, piping, and reactor tank. The overall conversion efficiency is dependent upon the degradation of the volatile feed material and for certain materials and facilities it is as high as 60 percent.

In addition to the biogas produced, the degradation of the feed material can transform the organic nitrogen into ammoniated nitrogen to yield a more stable residue for application as fertilizer or soil conditioner. For the small ranch or farm digester, with cattle manure used as the feed stock, the process improves the value of the manure as fertilizer.

Additional research into the digestion process and economic analysis of components and different combinations of feed-in and fertilizer-out are needed before the optimum designs for use in Montana will be known for small size facilities. Design and cost information are better known for community size sewage facilities.

Program Tasks

The majority of the program activity will be directed toward the farm, ranch, cattle feed lot, and dairy farm use. In the area of large facilities, a study will be made of communities for municipal size biogas generation. The key elements of the study will be the community need and the additional biomas waste available. Adequate large scale technology exists so that minimum research and development is required. Design trade offs with emphasis on total system costs, including community participation, will be performed.

Selection will be made of one community in Montana for the construction of a biogas generation facility and methane distribution system. As in the other community scale renewable energy subprograms, the community will make the final decision and state financial support will be limited to system studies, design, and up to 90 percent of the actual cost of construction.

In the range of the middle size facilities, support will be provided for two facilities. Hopefully, one dairy farm and one feed lot size facility can be found. Interested individuals and organizations will be asked to submit a request for consideration. The program will provide initial design and cost estimates as requested. The selection of the two facilities to be supported will be based upon the applicability and appropriateness of the facility as a demonstration in Montana and the amount of construction cost sharing provided by the owner. Additional research and development of components and processes may be required in support of specific design problems during the course of this segment of the program.

For the small scale farm or ranch digestor supplied by 25 to 100 cows, a development program is necessary. At the present time, the most appropriate design for the Montana environment and farming practices is unknown.

Trade off studies followed by equipment development and testing need to be performed. Such questions as the relative benefits between insulation and digestor heating during cold weather operations must be answered. The correct digestor size as a function of feed and service time, fertilizer use, and methane gas need must be determined. Flexibility in digestor loading is important so that variable output can be obtained from any one design. The number of designs and the interchangeability of components between designs must be considered so that advantage can be taken of mass production.

Information will be collected and analyzed from Montana farmers and ranchers to determine the appropriate design for maximum use in the state. From this information, a design will be developed that will emphasize minimum total system cost. The labor in feeding the digestor series of digestors will be manufactured and tested, and during the course of the program three models will be made. Each succeeding model will include design improvements. Two digestors using the first design, five using the second, and finally twelve using the final design will be manufactured and tested. Farmers and ranchers will be asked to participate in all testing. The necessary test instruments and digestors will be provided at minimum cost for the first two models. Additional cost support will be expected from the farmers and ranchers who are selected for the twelve digestors made with the third design.

An important factor that must be considered is that the capability for commercial manufacture of the digestor, once the best design has been determined, must also be developed during this program. In addition, design engineering capability in the state must be developed for the larger biogas systems through this program.

Additional Issues

The community size waste facility that generates and distributes methane from biomass and waste will be a "utility". Under the present state laws, this could be a problem.

There are research and development activities in biogas throughout the country and the world. This program must keep pace and make use of appropriate results from this extensive work.

Schedule and Cost

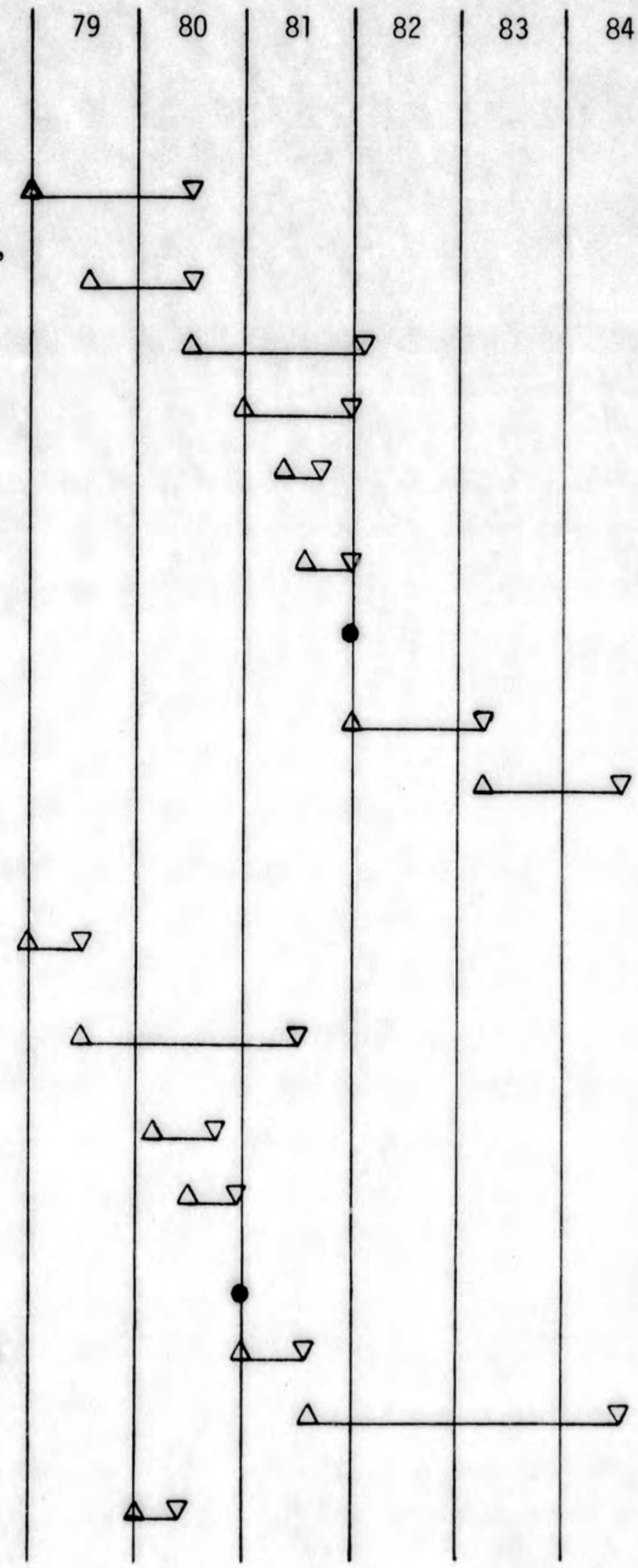
Schedule of Program Elements

1. Community methane generator

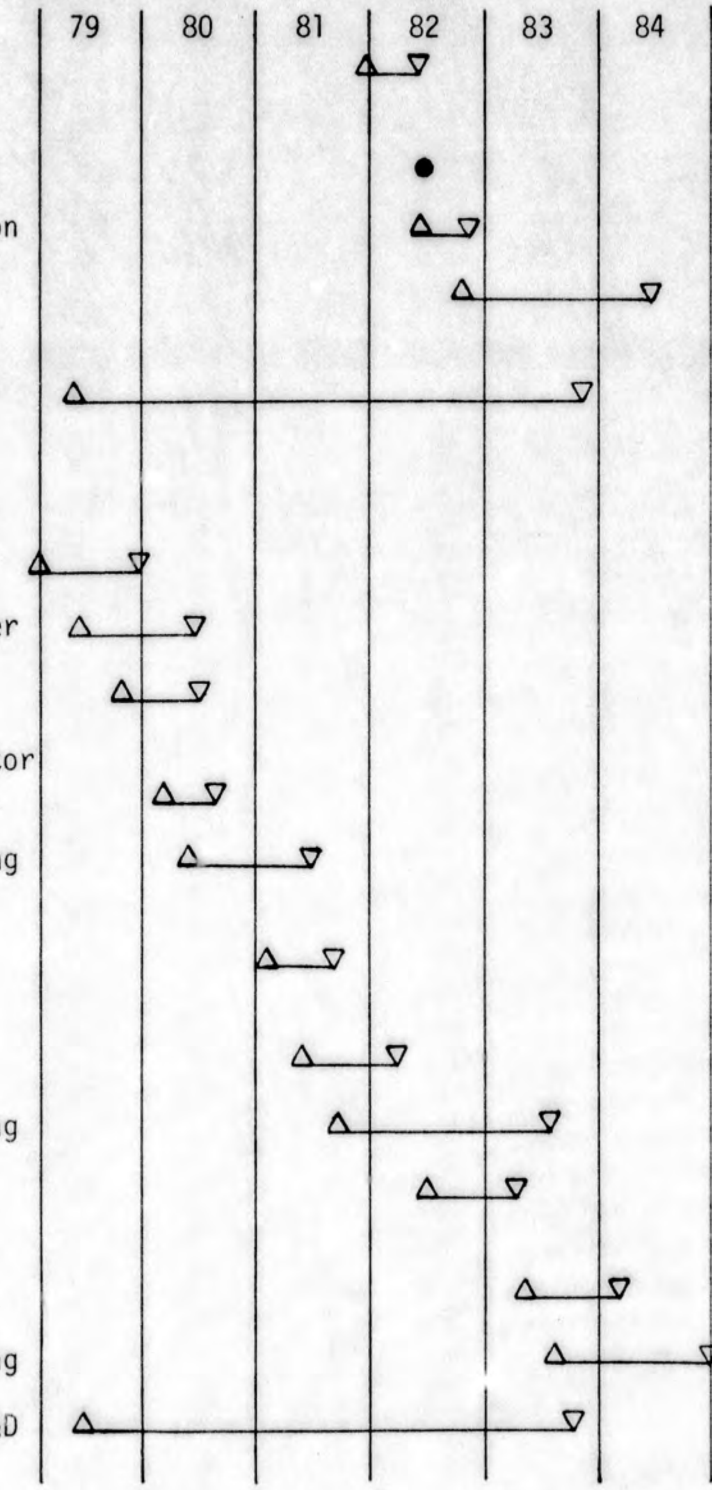
- Survey of possible sites in Montana
    - Initial designs of possible sites, cost estimates
    - Community participation and input
    - Community design to continue
    - Selection of site by State
    - Final design and operational cost estimates
    - Community decision to continue
    - Construction of facility and distribution system
    - Check out and operation

2. Feed lot/dairy farm facility

- Initial design of typical facility for Montana
- Request by owners for biogas facility
- Selection of two possible sites for first installation
- Detail design and cost estimates
- Decision by owners to continue and level of contribution
- Selection by state and construction
- Check-out and operation
- Selection of two possible sites for second installation



Schedule and Cost (continued)



. Detail design and cost estimate

. Decision by owner to continue and level of contribution

. Selection by state and construction

. Check-out and operation

. Necessary component and process R&D

3. Farm or Ranch size digestor

. Information on Montana needs and initial design

. Evaluation and discussion with user

. Final design and costs

. Competitive purchase of two digestor per first design

. Farm/Ranch installation and testing

. Design modification-second design generated

. Competitive purchase of five digestors per second design

. Farm/ranch installation and testing

. Design modification-third design

. Competitive purchase of twelve digestors per third design

. Farm/ranch installation and testing

. Necessary component and process R&D

Costs (Dollars in Thousands)	79	80	81	82	83	84
1. Community methane generator	50	65	120	500	290	100
2. Feed lot/Dairy farm facility	75	85	155	190	205	200
3. Farm or Ranch size digestor	75	150	175	210	190	300
Total Cost	200	300	450	900	685	600

WIND ENERGY SUBPROGRAM

Introduction

The Department of Energy's wind program has received increased funding during the past years and has $60 M for FY79. The major objective of the national program is developing the technology for small and large wind generators and the methodology for wind energy assessment. Montana can benefit from the "base" provided by the national program, but in order to make wind generation a reality in Montana, much remains to be done. It is not realistic to expect private investment to cover all of the costs.

Presently, wind generators cost anywhere from $300 to $2,000 per rated kilowatt generated (depending upon rated output and design wind speed) plus installation costs. One important reason for this cost is the limited number of wind generators manufactured to date and the "handcrafting" of the components. During the past few years, less than 100 wind generators of greater than 15 KW capacity have been manufactured. Comparing the technology, individual components, and operating environment of a wind generator to that of other systems that are mass-produced, the present prices of the few available models seem higher than would be necessary under mass production. If generators were sold at $200 per kilowatt, a 25 KW generator costing $5,000 installed at Great Falls would generate $2,000 in electricity @ 2¢ per KW/hour in an average year.

A relatively small amount of state funds can stimulate the wind electric generator industry in Montana and establish a leading position for the state in the manufacture of wind generators in the United States. Once established, this manufacturing capability would have as its marketing area the northern Rocky Mountains and Great Plains region--an area in the United States that represents a significant wind energy region--and one which may be exploited first due to the existing land ownership patterns, established electrical grid network, and the large amount of hydroelectric generation.

Contributions to the wind program have been made by previous Department of Natural Resources and Conservation (DNRC) funded projects. Limited wind potential assessment, measurements, wind generator manufacturing, and small-scale wind generation operational experience has been gained. The U.S. Department of Energy's (DOE's) wind program has advanced to the point where Montana can take advantage of the program results. This coming year, 1979, is the time to expand the wind program in Montana because of the status of the federal program and the projected electric energy needs for Montana by the mid-1980's.

Resource Assessment

The United States DOE has estimated the average annual wind energy potential in Montana as 250 to 400 watts per square meter of wind.[1] Projecting this into electrical generation capacity and using only one percent of the land area in Montana, over 5,000 MW could be generated. As a comparison, the feasible extraction limit of wind energy within the United States for the generation of electricity has been estimated to be equal to the total energy used in the United States in 1977.[2]

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[1] BNWL-2220 Wind 5, July 1977, Battelle Pacific Northwest Laboratories.

[2] "Wind Energy Resource Parameters," M. R. Gustavson, Proceedings: National Conference on American Wind Energy Association, March 1978.

The wind potential in Montana is divided into two general regions. Western Montana is characterized by high peaking winter winds; whereas, the winds in eastern Montana are more constant throughout the year. The western region wind energy will combine well with hydroelectric generation, which peaks in the summer, to provide a year-around renewable energy resource. In western Montana, existing and small-scale hydroelectric (either low or high head) projects for which the technology exists can be developed to match a portion of the wind-generated electricity. Significant wind energy exists in eastern Montana, although in general, the yearly average is less than for western Montana. As an example of the potential, Glasgow in northeastern Montana has approximately 70 percent of the wind energy potential of Clayton, New Mexico, the site where the DOE installed their first large generator. Wolf Point, Montana has almost 80 percent of the Clayton site. Current studies are underway by the Corps of Engineers to use hydroelectric generation as peaking electricity. This concept would work well with a large wind generation system.

The area along the Yellowstone River between Livingston and Big Timber has been rated by DOE as the number two area in the United States for wind energy potential. Whitehall and Great Falls are also rated in the top twenty-five in the United States.[3] This rating was established by using data from weather stations and is limited to fourteen towns in Montana. Additional data from utilities and the USDA is also available. Information must be gathered from every county in Montana with suspected adequate wind

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[3] "Wind Power Climatology of the United States," Jack W. Reed, SAND74-0348, Sandia Laboratories Energy Report.

energy to generate electricity. This will be done early in the program to further expand the existing data base. Only the better sites will be selected initially for the installation of generators to provide a maximum available positive cost "cushion" for the first wind systems. Once design, fabrication, and operational improvements have been made, systems can be installed throughout Montana at sites with lower wind energy potential.

The table below gives the average annual wind energy from the 14 sites listed for Montana.

Montana Average Annual Wind Energy

Site	Watts/Meter^2	Maximum Month	Minimum Month
Glendive	149.5	222.0	111.4
Miles City	115.2	161.9	87.8
Wolf Point	179.9	326.4	124.2
Glasgow	133.0	198.6	101.7
Billings	173.9	237.2	99.0
Livingston	500.5	1058.7	233.7
Lewiston	140.8	198.4	82.4
Havre	114.7	155.4	74.9
Great Falls IAP	304.5	509.4	136.3
Great Falls Malstrom	169.3	263.8	80.1
Helena	90.6	145.5	34.9
Whitehall	344.7	710.4	167.7
Butte	104.8	158.7	76.8
Missoula	50.1	75.8	19.5

The extreme western portion of Montana probably has low wind energy potential in the valleys but could have significant wind potential on mountain ridges or at elevated heights. These sites may not prove economical because of high siting costs.

Commercialization

It is important to understand what is meant by commercialization of wind or any other energy source.

Within the Northern Great Plains and Northern Rocky Mountain region there are projections for increased electric generation capacity of 5,000 to 20,000 MW and greater by the year 2,000.[4] "Commercialization of wind" encompasses a plan and program that will enable wind-generated electricity to provide as much of this increased capacity as possible. To be competitive with other generating systems, the cost of wind generators at the factory must be close to $300 per kilowatt in 1978 dollars since wind generators have a lower capacity factor than conventional generating facilities. A typical design objective for a wind generator would be to obtain a 40 percent utilization for a "standardized" average 12 mph wind.[5] Higher capacity factors at lower average winds are possible, but the cost per kilowatt generating capacity would be higher. There are cost advantages for wind systems--low site construction costs, shorter construction periods, and no fuel cost--all of which will be needed in order to make these systems competitive, especially with mine mouth coal generating plants. Cost disadvantages include higher maintenance costs due to number of units and their dispersed locations and higher utility grid hook-up costs. The initial capital cost per kilowatt generating capacity must be low, and this can be greatly enhanced by mass production. As pointed out earlier, wind generation

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[4] BPA and Missouri River Basin Estimates.

[5] Design Study of Wind Turbines, 50 KW to 3,000 KW, ERDA/NASA/9403-76/2, General Electric Company, December 1976.

couples best into a generation system that has a high percentage of hydrogeneration. This coupling can enhance the relative value of both systems.

Thus, commercialization includes the establishment within Montana of the capability for wind energy assessment, manufacturing, installation, maintenance, repair, and energy utilization. This must be done in great part with private resources; however, the state can stimulate and support the critical early market for wind generators when the cost per machine is high and the generation is a marginal economic activity. In addition, commercialization includes establishing the acceptance of wind generators in Montana and encouraging the purchase of generators by individuals and utilities. If one assumes a figure of one man-year of manufacturing per 100 KW and one man-year of installation, control, maintenance, and repair per 10 MW generating capacity per year, along with the assumption that 5,000 MW would be manufactured and installed in Montana and neighboring states, then a significant economic return is possible. The manufacturing and support businesses for this number of wind generators would generate about 3,000 jobs that would continue through the year 2,000. The last element of commercialization is insuring the landowner benefits directly and adequately as a function of the generated energy value, and not simply for bearing the inconvenience of the generators on his land. A statewide generating system selling power throughout the region could generate revenue for Montana farmers and ranchers.

Technical Program

There are two major divisions in the technical program because of the wind generator size--a farm or ranch size ∿ 25 KW and a utility size from 250 KW to a few megawatts. The final size/sizes will, of course, be determined by those sizes that provide the highest economic return. One major objective of the program must be to determine the optimal sizes for these two major uses. The current U.S. DOE sponsored designs for 40 KW generators probably represent the largest size a farmer can install with minimal help and maintenance by himself. This size generator is similar in size and complexity to other farm equipment. The large utility size in the few hundred KW to megawatt capacity will also be heavily influenced by the advantages of mass production, installation costs, total wind farm reliability, and small crew maintenance costs. The important point to remember is that, while for each specific need and location there will be an optimum size, customized generators cannot be manufactured at low cost. What is the best for Montana must be determined early in the program.

Wind Energy Assessment

The DOE has collected and evaluated the recorded wind energy measurements from the National Weather Bureau and other government and private agencies. The result of this evaluation is that Montana appears to have a significant wind potential; however, these measurements are not of sufficient detail and accuracy to establish the good sites and the economic return from wind generators. A statewide effort to measure the wind energy in every county is needed. Twenty-five portable self-contained anemometer systems, using 10 meter towers, will be purchased. These small towers will be moved around the state, and within a four-year period can map the wind energy potential with sufficient accuracy to establish the economic feasibility of farm and ranch size units. These stations will be installed by a combination of professional and local people with routine maintenance and data tape collection performed by local personnel. The high school science departments will be asked to participate in the program. All data will be reduced and evaluated at a central facility.

In addition to the 10 meter towers, five 30 to 50 meter towers, instrumented at two levels, will be installed at prime high wind sites across the state to determine the wind velocity profile and energy at potential utility wind farm sites. These towers will be installed and maintained by professionals, and this data will also be processed at a central facility. The first year of wind data will also be used in generator design and size selection.

Within four years, this mapping of the wind energy potential of Montana will provide the most comprehensive wind data base for any region in the world; however, it is just the minimum required to adequately assess the potential, design wind generators, and determine the essential electric generation economics for a region the size of Montana. In comparison with petroleum and coal exploration, projected costs for wind energy assessment are significantly less for the potential energy return.

Operational Objectives

No basic research program on wind generators is proposed because this is being done under the federal program. The federal program is also supporting the manufacture of wind generators from a few kilowatts to megawatt capacity. The Montana program objective is to use this base created by the United States DOE and address specific technical and operational problems in Montana so that the economics of electricity generation on the farm and ranch and by utilities can be established. At the same time the economics are being determined encouragement and support will be provided to industries in Montana, so that once the optimum configurations and sizes have been established, production can be initiated. It is felt that only by using mass production methods will wind electric generators ever become competitive with conventional generators and be used for any more than remote site operations.

As mentioned previously, one question that must be answered is the proper generator size for the individual Montana ranch. A single generator size is not essential, but the fewer the number of models, the higher the return from mass production. In addition to generating capacity, the size will be influenced by installation and maintenance costs. It is also important to determine what size generator can be handled by the farmer/rancher and his help. The maintenance expense is one of the high costs of wind when compared to conventional systems. If this can be done by the land owner, in addition to his other work, wind electricity generated on the farm or ranch can be more competitive. It is necessary to test various wind generator systems in Montana in order to determine the correct sizes and the maintenance costs and requirements. The correct generator size for the utility wind farms is a similar problem and must be determined by considering the same factors. Experience in the Montana environment is essential to determine operating costs in Montana.

An equally important factor is to determine the utility interface requirements for safety, local monitoring, control, and switching. The degree of difficulty will be different for each utility, although many technical problems will be common. Collection and distribution problems of each rural utility and its supplier must be worked out. In the next ten years, wind generated electricity can become a significant part of the rural utilities source; however, it will not be the most important source. The existing sources will still be the most important, therefore, the wind electricity must be smoothly worked into the existing system. The conventional generating and interconnected distribution system, along with wind generators located at the other sites, will provide the back up or storage system when the wind is not blowing in a specific location.

The purchase and installtion of generators must be so scheduled that it answers the technical and cost questions and supports the development of the manufacturing and supporting businesses required to establish a wind energy industry in the state. Therefore, the operational objectives cannot be separated from statewide business objectives. Preference will be given to Montana-manufactured machines, and thus, out-of-state manufacturers will be encouraged to establish facilities within the state. Tax and other incentives should also be considered.

The first systems purchased will be thoroughly instrumented and detail operational maintenance and performance records maintained. Overall performance and economic value will be evaluated. This information will be made available to the manufacturer for any necessary corrective action. A series of machines will be purchased over a three-year period so that the manufacturer can plan and make improvements from model to model. At the end of the three-year period, it is planned that sufficient model iterations and numbers will have been manufactured so that mass production designs and costs are known, and the manufacturers can go into mass production.

Farm/Ranch Program

Over the three-year period, 40 to 60 farm and ranch size wind generators will be purchased from at least two manufacturers. The initial generators will be purchased and installed using 100 percent state funds. By the end of the program, the landowner will be expected to pay a small portion of the purchase price and all of the installation cost. DNRC has already supported one Montana manufacturer, and his generator will be installed this fall on a ranch or farm in Montana. During the three-year period, three to four model iterations should be possible with each model becoming less expensive. After the operational tests, each generator will be evaluated on performance and cost. The manufacturers with the most successful generators will be funded for newer models. The poorer performing generators will have to be improved at the manufacturer's expense and will be tested again under the state program if requested by the manufacturer.

The state will be establishing and developing the product and market by the continued refinement of the operational and performance specifications for the machines purchased. This is an extremely important responsibility since it will define the characteristics of the generator the manufacturers are in a position to mass produce at the end of the program.

The federal small wind generator program being conducted at Rocky Flats in Colorado includes the purchase, testing, and evaluation of generators in the one to 100 KW range. The winds of the Rocky Flats site are such that frequent high stress conditions are induced; however, sustained moderate winds are not typical. An expansion of this federal program will include the purchase of two machines per state for testing within each state. Montana will participate in and benefit from this program. It is not DOE's intent to solve all the state specific problems with such a limited program, but rather to provide public wind generator awareness and visibility. The federal funds are doing much to stimulate manufacturers across the country, the Montana program will do even more and may cause some to move to Montana.

Utility Program

The federal large wind generator program supports the manufacture and testing of 200 KW and 2 MW generators. Five of the 200 KW size generator sites have been selected and have been or will have generators installed soon and a two megawatt size is scheduled for testing. All of these are government purchased machines with utilities sharing the cost of operation and testing. The testing and demonstration of large wind generators in Montana must be coordinated with the federal program. At the present time, there are no federally funded programs for the testing of large wind generators in Montana.

The critical unknowns in any utility size wind generator "farm" concept is the operational cost and total system reliability. Under the present federal program, there are no plans to develop this information anywhere in the United States, much less in a region with an environment similar to Montana. The Bureau of Reclamation has a plan to install up to five 2 MW size generators at Medicine Bow, Wyoming in the 1985 time period. Information from this project will come too late to be used in satisfying Montana needs; it may not have the most cost effective size generator, and it will not have an adequate number of generators to determine true "farm" operational and maintenance costs.

There is a problem of how to determine the most cost effective large size generator for a utility system. The larger machines are quoted at a lower price per kilowatt, although only limited numbers have been manufactured. There may be an advantage in purchasing large generators; however, the expense to determine the representative wind farm operational costs will be very large if 20 large 2 MW generators are used. The "utility" program proposed is to install a couple of 2 MW generators to determine the operational characteristics in the Montana environment, and a larger number of 200 KW machines to determine the total wind farm system costs. A federal agency will be sought to finance a majority of the cost of this program element. Utility participation will also be encouraged.

A 5 MW size wind farm using 200 KW size generators is proposed so that answers to some of the critical questions may be determined. This is the size of generator currently being built by the DOE and the large size wind generator with the largest number manufactured to date. In order to have the government participation in the first wind farm in Montana, the site selected should be associated with government electricity generation. Areas of greatest potential are Ft. Peck Dam, Gibson Dam, Tiber Dam, or Yellowtail Dam. Studies are underway at all four sites for expanded electric hydro-generation (Gibson and Tiber have none at the present time). The wind energy potential is known only for the Ft. Peck Dam area; although from the surrounding terrain and climate conditions, Gibson, Tiber, and possibly Yellowtail could have significantly greater wind potential. Installing 5 MW capacity using the 200 KW size machines can be done sooner and cheaper than the proposed Bureau of Reclamation Medicine Bow demonstration. An extensive effort will be made to interest the government into installing a 5 MW wind farm in Montana as the first step in the utility program. In addition, a request will be made in conjunction with Montana utilities to the DOE to install two of their 2 MW generators at known high wind potential sites in Montana.

Once production and operational costs have been established in the Montana environment, the utilities can be expected to show interest if these systems are competitive with conventional generating plants. Wind farms can be constructed, generator by generator, and therefore have a gradually increasing generating capacity which is an important construction cost advantage. The direct financial contribution that can be made to the utilities under this program to establish their own wind farm is limited to wind energy assessment and system studies; however, tax and rate incentives to the utilities are surely of interest and should be considered. The utilities should be encouraged and assisted in establishing 200 to 250 MW of generating capacity by the 1983 time period. As electricity demand grows, new installations should follow quickly at the prime sites across the state once wind electric generation has been proven competitive.

Site Selection Methodology

Any major utility wind farm will come under the state Major Facility Siting Act, and utilities would be expected to comply with this act and the established procedures. The proposed small government wind farm will be located at a site selected by the participating government agency. The individual farm or ranch size wind generator program has different site selection problems and would not come under the Major Facility Siting Act. The initial wind generators will be located on farms or ranches with high wind energy potential and where the performance monitoring costs will be minimized. In the early stages, a significant amount of "professional" time will be required at these installations. The farmer will be expected to contribute some time in routine maintenance. Later in the program, lower wind potential sites will be selected, and more contribution by the land owner will be expected. In general, in the early phase, specific ranchers and farmers would be asked to allow wind generators on their ranches or farms, and toward the end of the program, interested farmers or ranchers would "bid" for wind generators by sharing in purchase and installation costs and in operational monitoring and maintenance.

Farmers and ranchers have been used throughout in the program description; however, it should be noted that all land owners would be equally considered.

Additional Issues

Certain legal, technical, and economic issues can significantly contribute to the wind program. These are:

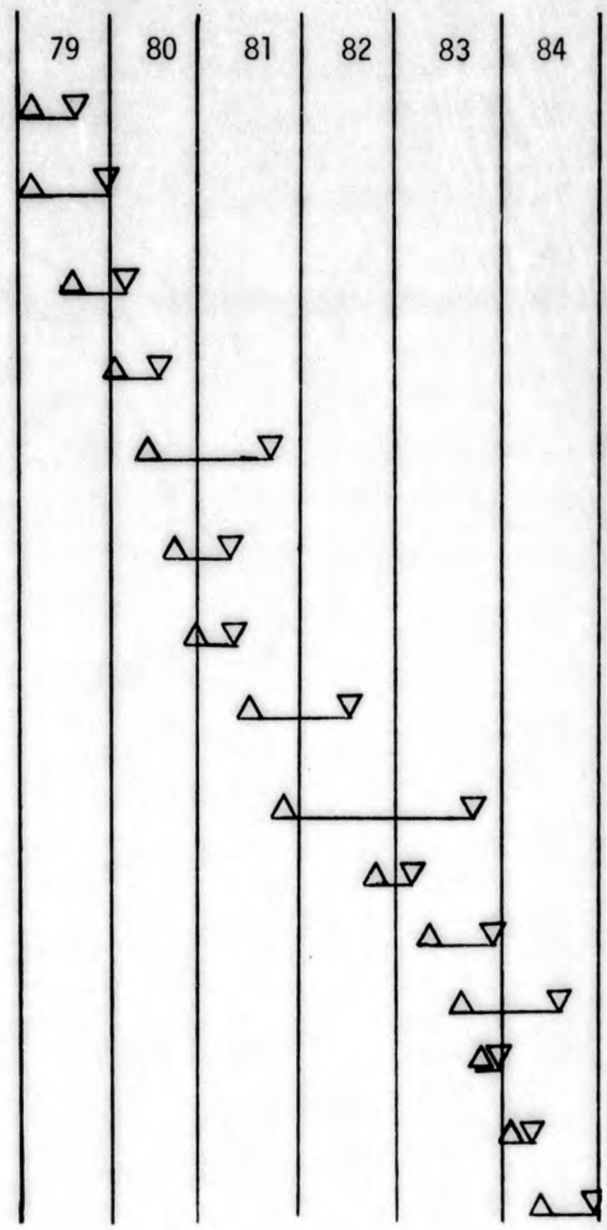
1. Early identification and selection of the optimum size for the wind generators. This will focus the manufacturing effort which at the present time is considering generators from 1 KW to 3 MW.
2. Wind right laws. Who owns the wind; is it similar to sun rights or water rights?
3. Possible tax credit for wind generator electricity purchase and use.
4. Possible requirement for utilities to first purchase farmer or rancher generated electricity at a fair return to the landowners and at a fair price to the utility recognizing their real costs. Some specific rate structure for wind generated electricity might be considered.
5. What are the environmental effects, visual, etc.?

An early favorable resolution of these issues could certainly enhance and benefit the proposed program.

Schedule and Cost

1.a. Wind Energy Assessment Schedule.

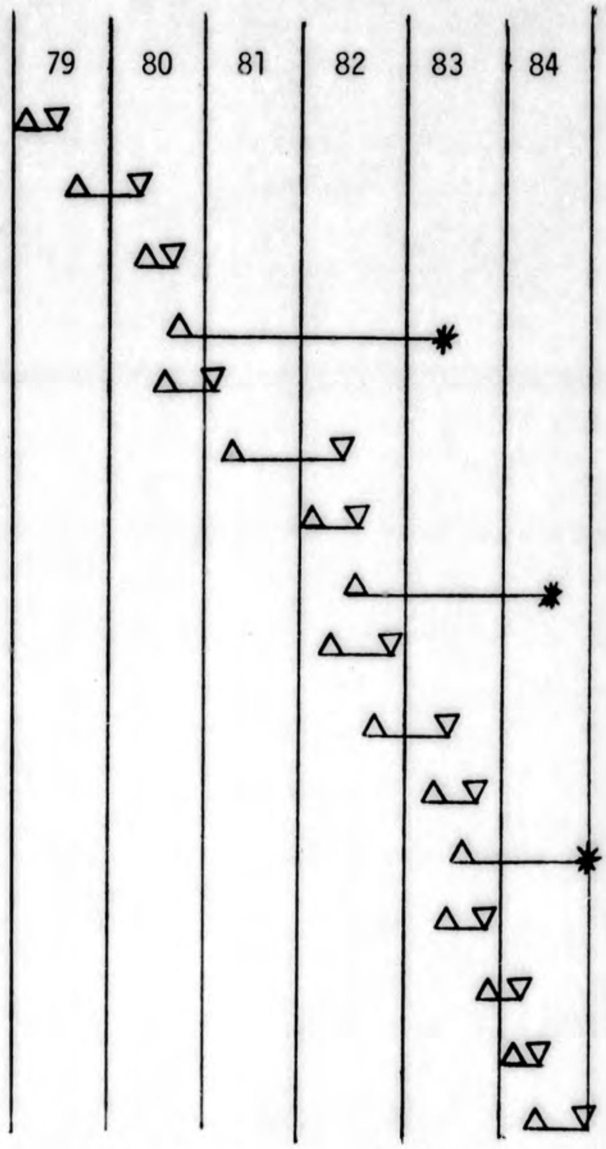
- Site selection of 13 prime sites in state
- Establish cooperative program with communities/schools around sites
- Purchase of equipment: 10 small and three large tower systems
- Installation on prime sites
- Data collection and evaluation--check out performance of anemometer systems
- Purchase of additional towers and systems (15 small and two large)
- Selection of second sites
- Installation of new anemometers (move older ones to second sites)
- Data collection and evaluation
- Selection of third sites
- Installation of anemometers
- Data collection and evaluation
- Selection of fourth sites
- Installation
- Data collection and evaluation



1.b. Wind Energy Assessment Cost.
(Dollars in Thousands)

	79	80	81	82	83	84
. Site selection, data collection and evaluation	90	140	200	200	200	60
. Anemometer and tower equipment cost	105	100	90	0	0	0
. Equipment installation and maintenance	40	40	110	150	100	40
1.b. Total Cost	245	260	400	350	300	100

2.a. Farm/Ranch Program Schedule.



- Develop generator specifications
- Purchase 5 generators (1st model)
- Installation
- Test and demonstration
- Develop Specifications for 2nd model
- Purchase 10 generators
- Installation
- Test and demonstration
- Develop specifications for 3rd model
- Purchase 20 generators
- Installation
- Test and demonstration
- Develop specifications for 4th model
- Purchase 20 generators
- Installation
- Test and demonstration

* indicates end of state funding support, land owner required to continue supplying performance data for two years.

2.b Farm/Ranch Program Costs
(Dollars in Thousands)

	79	80	81	82	83	84
. Develop specifications and monitor performance	60	120	150	200	250	50
. Purchase of wind generators	90	150	250	325	470	225
. Installation and maintenance	70	70	100	200	130	180
2.b. Total Cost	220	340	500	725	850	455

3.a. Utility Program Schedule

Montana Federal Site (5 MW @ 200 KW each)

. Site selection

. Site design

. Manufacture of generators

. Installation

. Testing

Montana Utility 2 MW Site

. Site selection

. Site design

. Manufacture of generator

. Installation

. Testing

Montana Utility (25--200 MW Site)

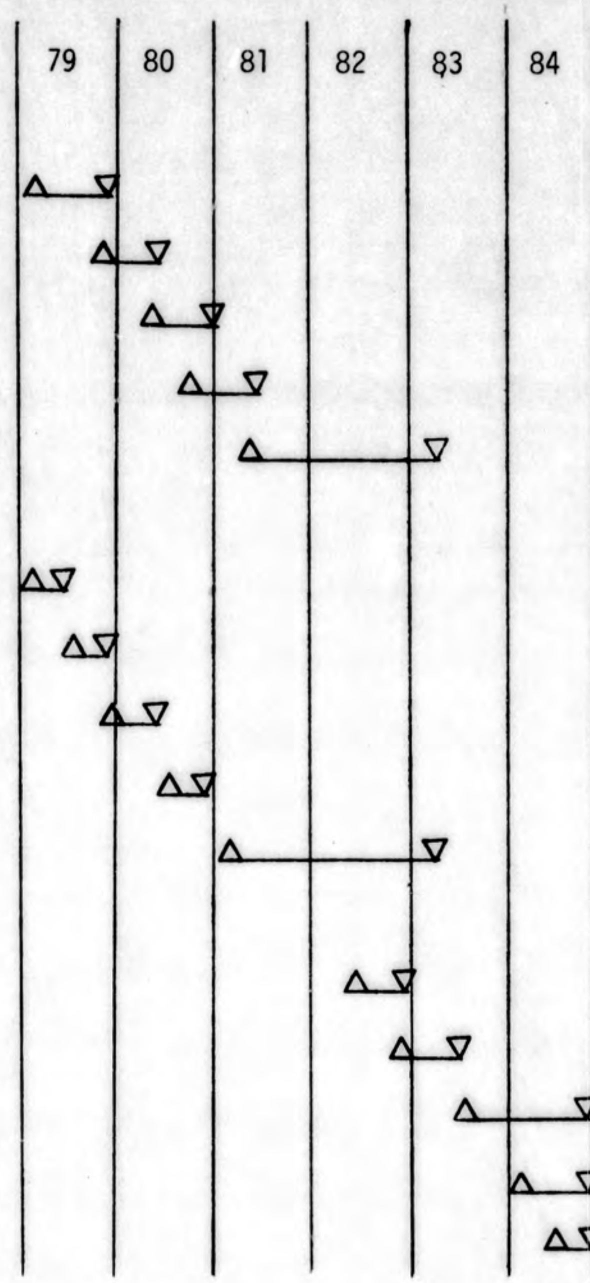
. Site and generator selection

. System design

. Manufacture of generators

. Installation

. Generation



3.b. Utility Program Costs
(Dollars in Thousands)
State Funds Only

	79	80	81	82	83	84
. Participation in site selection, design, and generator selection	75	90	75	75	50	0
. Site evaluation	85	90	75	50	0	0
3.b. Total Cost	160	180	150	125	50	0
Total Cost 1.b. + 2.b. + 3.b.)	625	800	10[illegible]0	1200	1200	555

GEOTHERMAL SUBPROGRAM

Introduction

The use of geothermal heat, usually directly from hot water or steam, is considered to be a renewable energy resource. Whether or not this is true depends upon the source, the period of time, and the use rate. The heat content of the earth's near surface is certainly very large, and if the water resource is not depleted by use, the energy resource available is large compared to conventional nonrenewable resources.

The present United States Department of Energy (DOE) geothermal program is structured more closely to the needs of Montana than any of the other federal energy programs. There is an extensive effort in resource assessment and, even more significantly, in geothermal demonstrations. Use of geothermal hot water for space heating is widespread around the world, although not extensive in total amount of energy delivered. One of the earliest modern commercial residential systems is that of Boise, Idaho, which was established in 1890. This geothermal resource has been selected along with other across the United States (Warm Springs State Hospital in Montana) as a demonstration project for expanded use of geothermal resources. In addition to space heating, the DOE is interested in supporting demonstration projects in agricultural and industrial use of geothermal resources.

Montana possesses significant, known geothermal resources, and there is a high probability that larger resources are available across the state. The surface flow rates of the hot springs vary from a few gallons per minute to a thousand, with temperatures of up to 180°F. The potential for artesian hot water wells is also high, especially in eastern Montana. There is need for continued assessment of the geothermal resource throughout the state.

In addition to assessment, there is a need for additional geothermal demonstrations of community space heating and agricultural or industrial applications. These demonstrations should be dispersed as widely as possible across the state; however, recognizing that the geothermal resource must be matched with a local use requirement, the Montana program objective is to select at least one community space heating and one agricultural or industrial use demonstration. In selecting sites, it is important to consider that a geothermal resource can be expanded by the use of direct biomass combustion, and therefore, the proximity of a biomass resource could be considered.

Demonstration Technologies

There are few technical unknowns that will require extensive research to support a geothermal demonstration. This does not imply that site specific experiments and tests are not necessary, especially in the area of material and geothermal water compatibility. Drilling and pumping (if necessary) technologies are well in hand as are those necessary for the heat distribution system. Heating and metering units are available for space heating requirements. The specific subsystems that would be required for any agricultural or industrial use may or may not be available; therefore, some R&D may be required.

Resource Assessment

The location of many hot springs are known in Montana with sufficient water flow and temperature such that they could be used for a low grade heat source. In addition to flow rate and temperature, another important parameter is the dissolved solid elements and amount. The surface conditions do not necessarily represent those present at distances below the surface, specifically the water temperature is considerably higher. This probable temperature increase significantly enhances the energy potential of a geothermal resource.

Three specific examples of hot springs in Montana are at Bozeman, Ennis, and Springdale. The surface output of these springs are:

Place	Flow Rate	Temperature	Solid ppm
Bozeman	30 gpm	130°F	436
Ennis	20 gpm	181°F	1030
Springdale	1315 gpm	139°F	268

For each of these springs, it is expected that there would be significant additional flow at increased temperature from wells drilled in the spring area. The projected available Btu output on a continuous basis for each of these three sites is over 10^8 Btu/hr which is equivalent to 700 gallons of gasoline per hour.

In addition to hot springs like these, there are known artesian hot water resources in the Madison formation in eastern Montana. Some gas and oil wells drilled in this region have been hot water producers. Insufficient detail information is known on the underground water resources and temperatures, although projections have been made that indicate a significant resource.

As an element of this program, detail evaluations of known sites and analysis of oil and gas well information across the state will be made. In regions with high potential and high possible use, exploratory wells should be drilled. The overthrust belt and Madison formations should be studied in depth.

Demonstration Projects

Once the statewide resource assessment has developed an adequate data base, conceptual studies will be made of at least two sites for a community heating and an agricultural or industrial application. From these studies, one site will be selected for each use. Beginning with the conceptual designs and throughout the project, participation by the community will be encouraged for the central heating concept. For the agricultural or industrial use, a company or individual will probably have to be identified. In both instances, a 10 percent minimum of in-kind or direct financial contribution to the project construction cost is required. As in the biomass projects, system design and costs are refined from step-to-step with the community or individual given the option of proceeding to the next step or dropping the project.

A brief listing of the step-by-step process proposed for geothermal development is given below. The concept and principle of community review, participation, and approval is carried through the program as in the Direct Combustion of Biomass Subprogram. The steps are not listed in the same detail as in the Biomass Subprogram; however, it can be seen that community and state approval is required before any major commitment is made of the next funding increment.

1. Site resource assessment;
2. Preliminary design and initial capital and operating cost estimate;
3. Community (or company) and state decision to proceed;
4. Resource verification and development, if necessary;
5. Detail design of source, distribution, and end use systems. Up dated cost estimates;
6. Firming up of user commitments;
7. Community (or company) decision to proceed;
8. Construction of source, distribution, and end use systems; and
9. Check-out, user hook-up, operation.

Additional Issues

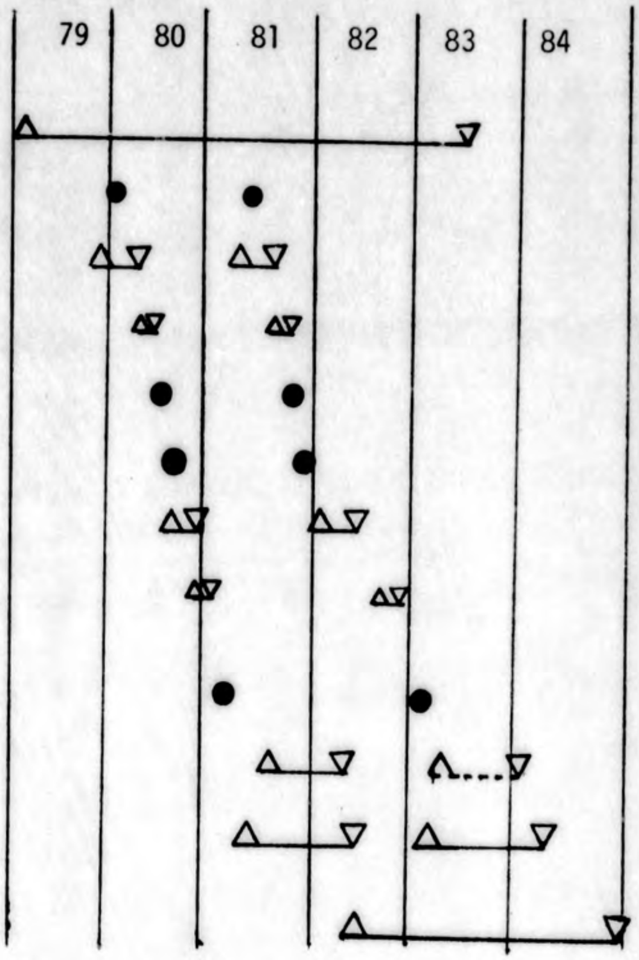
Hot springs locations in Montana have been known since the times of the Indians. The better sites have been under private ownership since the nineteenth century. Other sites, still within the public domain, can probably be found; however, the best approach may be to develop those sites already under private ownership.

Hot geothermal water is considered a water resource; therefore, water laws must be complied with. This could become a problem with any extensive use regardless of whether or not the water was reinserted into the ground. Other states, e.g. Oregon, consider certain geothermal resources as a mineral resource, making development easier.

Schedule and Costs

Program Element Schedule

- Resources Assessment
- Study Sites Selection (2 at each time)
- Conceptual Designs
- Initial Cost Estimates
- Selection of Site by State (1 at each time)
- First Approval by Community/owner
- Detail Design
- Final Construction and Operational Cost Estimates
- Final Approval by Community/Owner
- "Signing Up" of Customers
- Construction of Facility and Distribution System
- Check-out and Operation



Costs (Dollars in Thousands)	79	80	81	82	83	84
. Resource Assessment	200	310	275	200	100	0
. Designs and Community Coordination	165	340	360	300	200	0
. Construction			1000	900	1600	400
. Check Out Initial Operation				100	100	150
TOTAL COST	365	650	1635	1500	2000	550

It is proposed that the yearly costs be shared between the state and federal government at a one-to-five ratio.

SOLAR SUBPROGRAM

Introduction

Since 1976, DNRC has supported demonstration projects utilizing solar energy. A review of these projects can be found in the Renewable Alternative Energy Program Report to the 1979 Montana Legislature. In addition, the Montana Energy Office published in May 1978 the Montana Solar Plan. These two documents cover the activities and interest in Montana in solar energy. In this section, a program is proposed that will complete the state support to solar energy use. Because of the past state support, this subprogram differs considerably from those proposed for the other renewable energies in that only a few major tasks remain, and no state funded large demonstrations are required.

Program Tasks

There are three major tasks remaining to be done in the solar program. The first is a task that is a portion of each subprogram but has not been specifically discussed in the other sections. This is the task of performance monitoring and evaluation of demonstration projects followed by information dissemination to the public. A selection will be made of the most appropriate projects around the state for instrumenting, and these will be monitored during the 1979 to 1980 winter period. The project performances will be analyzed, and the results will be published and made available to the public.

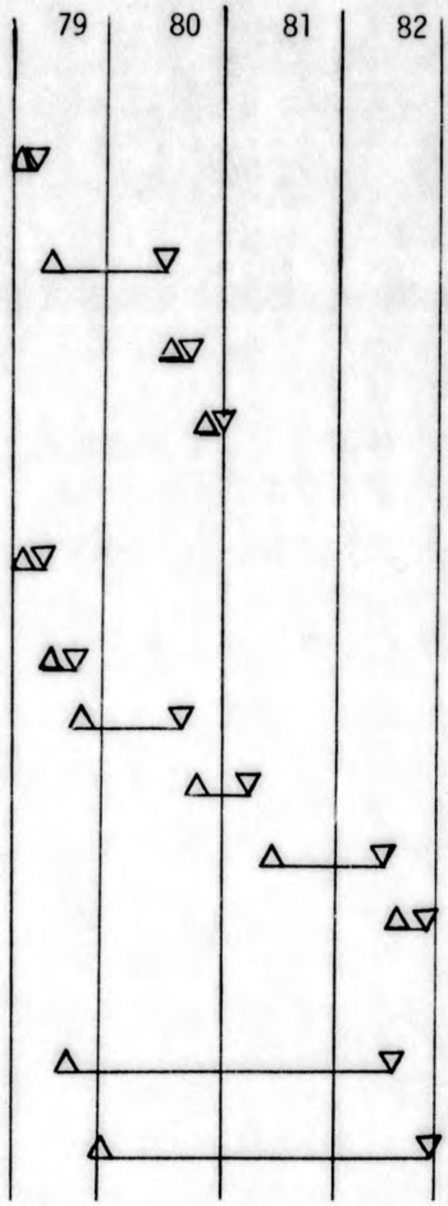
The second task is to promote the development, manufacture, and sale of low cost solar collectors for home size units. Design and material compatibility with the Montana environment must be established for low cost collectors that can be sold through local builders or hardware stores. A multi-award, competitive, phased contract program for Montana firms is proposed to accomplish this objective. At least two companies will be carried through the full program so that product selection options are assured for the consumer. Both air and liquid systems will be considered with emphasis placed on designs with low cost and mass production capability.

The last task is for the support of designs and cost evaluations of passive and active solar heating systems for private buildings and apartment complexes. No funds will be provided for the construction of demonstration projects; however, support will be given to projects interested in obtaining funding from federal agencies. There are numerous designs and projects across the United States from which valuable information can be obtained. This task will provide funds for Montana architects and consulting engineers to design and make cost estimates on solar-using facilities. The concept is to provide funds for the increase in design cost associated when solar use is considered. The present or new building owner is expected to pay all design costs associated with conventional facility design. The building owner pays all construction costs. This program provides the additional funds necessary to assess a solar option for a facility and, in addition, enhances the design skills of Montana architects and consultants in using solar energy for other customers.

Schedule and Costs

Program Element and Schedule

1. Solar demonstration evaluation
   - Selection of solar demonstration sites for performance monitoring
   - Instrumentation installation and measurement
   - Site performance evaluation and analysis
   - Publication of results
2. Solar Panel Development
   - Development of solar panel characteristics objectives for Montana
   - Multi-award phase one development
   - Panel evaluation and selection for follow-on
   - Multi-award phase two development
   - Panel evaluation and analysis
   - Publication of results
3. Solar "Building" use design assistance
   - Continuing evaluation of design assistance requests
   - Design assistance grants on selected projects



Costs (Dollars in Thousands)	79	80	81	82
1. Solar demonstration evaluation	40	50	60	50
2. Solar panel development	125	165	110	70
3. Solar "Business" use design assistance	50	65	100	85
TOTAL COST	215	280	270	205

Program ends in 1982.

SMALL SCALE HYDROELECTRIC SUBPROGRAM

Introduction

The use of water to generate electricity in Montana is widespread, and all of the possible large scale generation sites have plants or have been studied. There are many smaller dams used for irrigation or flood control which do not have generators. There exists adequate technical capability within the state to perform the required design and cost estimates to determine whether or not these sites could generate electricity economically. This program will not support this type study, but rather, it has as its objective the support of hydroelectric generators on small streams of a few kilowatt capacity for individual land owner use. The key criteria are that the maximum generating capacity is limited to 20 KW and that the electricity is for on-site consumption.

Program Tasks

This program differs in that no state funds will be used for energy resource assessment. The first task will be the preparation of an information and "how to" report for individuals interested in assessing their own small scale "hydro" resource. This report will be made available to individuals in the state at their request. After reading the report and assessing their own resources, individuals may desire to make application to the state for assistance in establishing a small scale hydroelectric system. Program assistance is limited initially to design and total system cost estimates. After which, the state and individual must mutually agree that the construction of the proposed system would be beneficial to the state (from a demonstration point of view) and to the individual. If the proposed system is not selected for additional funding support, the individual may use the information generated and proceed at his own expense. For those sites on which both the state and individuals agree, the program will provide construction funding support of up to 90 percent of the cost. The individual is expected to provide the additional construction costs and all costs for operation and maintenance. The state will provide limited direct on-site technical assistance if requested by the individual during the check-out and first few weeks of operation.

The individual will be expected to maintain a record of the system performance for one year after check-out. Bimonthly informal reports will be written by the individual for which he will receive $150 per acceptable report. Any cost for special instrumentation required to monitor the system performance will be paid in full by the program.

The individual is expected to pursue all questions and legal expenses associated with water use and rights. The water rights situation at the proposed site must be explained in the initial request to the state for assistance. The water rights issue must be cleared up completely at the individual's own expense prior to any decision by the state to assist in system construction.

It is expected that request for consideration will be received from 50 to 60 sites, that 20 will be selected for design assistance, and that ten will be selected for construction assistance.

There exist commercial small scale hydro systems; therefore, only limited component development support will be required for Montana or site specific technical problems. Funds are provided to solve these problems as they develop.

Schedule and Costs

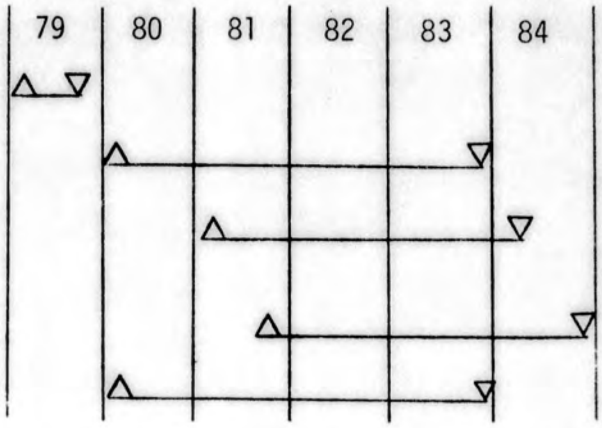
. Small Scale Hydro Information Preparation

. Design Assistance to Interested Individuals

. Construction and Check Out Assistance for Selected Sites

. Performance Evaluation and Monitoring

. Required Development Support of Components



Cost (Dollars in Thousands)

	79	80	81	82	83	84
. Information Packet Preparation	40	0				
. Request Evaluation and Design Assistance	0	50	60	85	40	
. Construction and Check Out Assistance	0	0	85	110	140	40
. Montana and Site Specific Development Support for Components	0	50	100	75	50	
TOTAL COST	40	100	245	270	230	40

DEPARTMENT OF RESOURCES AND CONSERVATION

SUPPORTING PROGRAMS

In support of the technology subprograms outlined in the proposed renewable energy program, the DNRC will have activity in the following four areas: Human Services, Incentives, Standards and Practices, and Program Management. The specific activities to be performed under each of these areas are described in detail in the DNRC January 4, 1979 Montana Alternative Renewable Energy Sources Program. What is included here is the recommended funding level for these areas required to support the expanded technology program proposed in this plan.

DNRC Program Area	79	80	81	82	83	84
Human Services	85	105	210	220	250	210
Incentives	20	35	100	135	75	50
Standards and Practices	110	160	300	315	490	305
Program Management	140	210	345	405	460	490
TOTAL COST (Dollars in Thousands)	355	510	955	1075	1275	1055

This budget is not a percentage of the total program dollars but is determined from an estimate of the work required under each area. In addition to the management budget shown above, there are funds for management included in the budgets under each subprogram by the major subcontractor selected.

BUDGET SUMMARY

These figures are compiled from each of the subprograms described in the plan. (Dollars in Thousands)

	79	80	81	82	83	84	Total
Subprograms							
. Biomass	(2000)	(3155)	(3745)	(4750)	(6095)	(7800)	(27545)
Alcohol	1150	1500	1100	1400	1800	1800	8750
Direct Combustion	650	1355	2195	2450	3610	5400	15660
Biogas	200	300	450	900	685	600	3135
. Wind	625	800	1050	1200	1200	555	5430
. Geothermal	365	650	1635	1500	2000	550	6700
. Solar	215	285	270	205	0	0	975
. Small Scale Hydroelectric	40	100	245	270	230	40	925
. DNRC: Human Services Incentives, Standards and Management	355	510	955	1075	1275	1055	5225
TOTAL COST	3600	5500	7900	9000	10800	10000	46800
Proposed State Share	900	1100	1300	1500	1800	2000	8600
Proposed Federal Share	2700	4400	6500	7500	9000	8000	38200
Cost Sharing Ratio	3:1	4:1	5:1	5:1	5:1	4:1	4.43:1

The budgets are expressed in terms of 1979 dollars, and no adjustment has been made for inflation. The federal contribution increases in the first years as the program effectiveness is demonstrated. The federal contribution is reduced in the last year because the funds required to complete the program do not require a 5:1 federal match with the projected coal tax revenue.

The program assumes a February 1979 start but can be operated with a six month slip if the state funds become available in June and the federal funds become available in October of each year.

PLEASE NOTE: THE FOLLOWING PAGES WERE TREATED AS A UNIT IN THE ORIGINAL DOCUMENT.

October 15, 1979

Dear Mr. Wittow:

I am enclosing the Montana Energy Conservation plan for your information.

If you have any questions or wish to discuss this, please contact our office at your convenience.

Pat Forsell

for J. D. Plunkett

THE MONTANA ENERGY CONSERVATION PLAN

Draft Final Report

January 31, 1977

Submitted to the

Montana Energy Advisory Council

by

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PREFACE

Governor Thomas Judge set the tone for the Montana Energy Conservation Plan in his energy message to the 45th Legislative Assembly on January 18, 1977. In that message, Governor Judge made the following statement:

> "During the last four years, Montana has become the nation's leader in design and enforcement of environmental safeguards. During the next four years, Montana should become the nation's leader in conservation of its energy resources and elimination of waste in their usage.
>
> At this point in our history, government must demonstrate its determination to reduce consumption of all resources--fiscal as well as natural. The number one priority and the basic cornerstone of our energy policy must be reduction of energy demand; any other course is ultimately suicidal."

Simply stated, the intent of this project is to follow the lead of the Governor and create a plan which will make energy conservation the keystone of Montana's energy policy.

CAUTION

It must be noted at the outset that both energy savings and cost data for some of the program measures included in this plan are difficult to quantify. For some measures, accurate energy savings simply could not be calculated because specific data do not exist. Data on projected behavior modification due to education or incentives particularly is tenuous. In all cases when assumptions were made, we have attempted to be conservative and likely have underestimated actual energy savings in many cases. Program measure costs are speculative in some cases since the actual program scope and contents must be determined by the legislature. The program measure costs reported here include funding from all sources: state, local, and federal. Specific legislative appropriations for some program measures are not required.

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A. PLAN INTENT

INTRODUCTION

The constraints of increasingly scarce energy affect all parts of the United States. Montana, like other states with a relative abundance of energy resources, is no exception and today must face critical questions regarding future supply. The presence of vast reserves of coal in Montana creates an illusion that somehow we are exempt from the need to ponder the consequences of future energy shortfalls. Coal currently cannot be used in many sectors of Montana's energy economy, and its massive long-range development may have important negative consequences. Meanwhile, two major current sources of energy--natural gas and crude oil imports from Canada will be curtailed within a few short years. A sober assessment of this situation leads to the endorsement of conservation as immediately necessary if we are to attain energy self-efficiency and are able to bridge the gap to a non-fossil fueled energy future. Under strong executive leadership and with the broad support of the Montana legislature, the state intends to implement the strongest possible plan of energy conservation realizing that the example must come from a state whose non-renewable energy sources are in great demand.

This report focuses on specific methods of achieving an immediate reduction of energy use as a partial answer to a dwindling supply. It also recognizes the importance of building a long-range commitment to reliance upon renewable energy through acceptance of an ethic of energy conservation as a way of life for all Montanans. Thus, great emphasis is placed upon creating a comprehensive and coordinated plan for involving all elements of Montana society in saving energy in every sector of current use. When implemented, the elements of the energy conservation plan outlined in this document will far exceed the requirements imposed in the Energy Conservation Policy Act (P.L. 94-163) which addresses energy conservation in five areas: lighting efficiency standards for public buildings; car pools, van pools, and public transportation; standards and policies for improving the energy efficiency of the procurement practices of the state and its political subdivisions; thermal efficiency standards for new and renovated buildings; and a traffic law which permits right turns on red after stop. The goal of the program is a 5 percent reduction in each state's projected 1980 energy consumption.

In Montana, the state's Energy Advisory Council is responsible for developing the state plan. The Montana Energy Advisory Council (MEAC) has decided to move well beyond FEA's five mandatory areas and study the possibilities for energy conservation in all sectors of Montana's economy--both in the immediate and the long-term future. Montana's plan also will focus on replacing non-renewable with renewable energy sources to the maximum extent possible.

Since all Montana citizens will have to live with the energy conservation plan, public meetings were held throughout the state to review the plan as it was being developed. This report constitutes the Montana Energy Conservation Plan, based both on research and public involvement.

The methodology approach used in this study is similar to that developed by Amory Lovins (see Foreign Affairs, October 1976). We do not assume that Montana needs electricity, oil, or natural gas. Rather, we believe that Montanans want lights, warm homes, efficient and economical transportation, and other tangible things.

Once we have established what these real energy based needs are, we can ask the question "How do we best meet the needs?" Our first step was to analyze the waste associated with various energy uses. Eliminating this waste requires various kinds of conservation in our homes, businesses, cars, and factories which will allow us to perform functions better, more efficiently, and with less energy. The next step is to review our current and future energy needs. These can be divided into several categories:

a. Low grade heat (under the boiling point of water) for space and water heating.

b. Medium grade heat (<250°C) for process steam and industry.

c. High grade heat for industrial applications and electricity.

d. Electricity for motors and lights.

e. Liquid fuel for transportation.

When stated this way, it is easy to see exactly what needs must be met by what technologies. Space heating, for example, can be accomplished by using low grade heat from solar collectors or rejected heat from some industrial process. It does not make thermodynamic sense to burn valuable liquid fuel (vital for transportation) to provide heat with such low temperature requirements. This matching of energy quality to appropriate end use requirements utilizes the laws of thermodynamics. Maximizing thermodynamic efficiencies assures the best matching possible.

Initially, it is necessary to define energy conservation and the methodological framework used to develop our preliminary analysis. We define energy conservation as the efficient utilization of energy. Energy conservation does not necessarily imply curtailment. We do not propose to conserve energy by closing Montana's industries or not heating Montana homes.

Instead, we propose to conserve energy by making equivalent amounts of energy do much more for us. This can be done by substituting another resource (capital, skilled labor, time, careful workmanship) for energy; it also can be accomplished either by consuming less of or a different mix of the goods and services requiring energy. We do not view energy conservation and renewable energy development as being counter to Montana's economic development plans. Energy conservation will create jobs. Both energy conservation and renewable energy development are labor intensive rather than capital intensive since their application primarily is in decentralized small-scale and individual use. Most of Montana's homes and businesses need more insulation and should be weatherized more fully. The state's industries can purchase more energy efficient equipment. Solar heating devices can be manufactured and sold in Montana. Energy conservation and renewable energy development present excellent opportunities for both Montana business and labor.

A sincere commitment to these principles will guarantee a marked reduction in total energy consumption within the state, while actually enhancing other goals such as economic development, employment, and environmental protection.

A fundamental assumption of this study is that energy conservation will be successful only if Montanans embrace the principle voluntarily and enthusiastically. To this end, major emphasis is placed upon programs of education and economic incentive. A significant responsibility ultimately is left with the private sector, under the assumption that Montanans will realize and will pursue energy conservation measures which assist them as individuals while contributing to the welfare of the entire state. Mandated measures are limited and are extended principally to activities of governments within the state on the grounds that leadership by example is the best method of promoting compliance.

The basically easy availability and low cost of energy in Montana has allowed us to defer important decisions regarding energy production and utilization. Government, business, and citizens share this blinder vision. Now it is time to refocus together on the hard choices which confront us. We have vast quantities of coal but also unlimited supplies of wind and sun. Shall we choose to spend the energy principal of non-renewable resources or live off the energy interest of renewable resources? A commitment to intensive energy conservation practices today will provide us with a larger margin of error for reaching a decision on future alternative energy tracks. To this end, the following report details the components of Montana's energy conservation plan.

MONTANA'S ENERGY CONSUMPTION PATTERNS

According to the Federal Energy Administration (FEA), Montana consumed 340 trillion Btu's of energy in 1975. FEA projects that Montana's energy consumption will reach 370.5 trillion Btu's by 1980.

In 1974, Montana's gross per capita energy consumption was 440 million Btu's. This compares to a national per capita average of 340 million Btu's. Montana's high per capita consumption results both from the concentration of resource extractive industries within the state and Montana's large land mass and dispersed population. Per capita energy consumption in Montana grew at a rate of almost 3 percent per year in the 1960's. Between 1970 and 1973, Montana's per capita energy consumption grew at a 2 percent annual rate, and since 1973, energy growth has slowed to less than 1 percent per year. Following is a sectorial breakdown of the energy consumption patterns within Montana.

Residential

The residential sector consumes about 15 percent of the energy used in Montana. Eighty-eight percent of this energy is used for space and water heating. The remaining energy is used to power lights and electricity. Two thirds of the energy used in the residential sector comes from natural gas. The remaining energy use is broken down almost evenly between electricity and other sources such as propane and fuel oil.

Commercial

The commercial sector also accounts for about 15 percent of the energy used in Montana. Of this, only about 75 percent is used directly in commercial buildings. In commercial buildings, about 62 percent of the energy used is for space heating and air conditioning. An additional 28 percent is used for lighting. Natural gas accounts for about 50 percent of the energy used in commercial buildings, electricity accounts for 35 percent, and the remaining energy is divided between fuel oil, coal, and propane.

Industrial

Over the past decade, energy consumption in Montana industry has grown faster than the energy consumption of any other sector. Montana industries currently consume 35 percent of the total energy used in the state. Montana industry consumes over 40 percent of all natural gas sold within the state as well as over 60 percent of all electricity. In 1974, Montana industry consumed over 36 billion cubic feet of natural gas. This energy use is concentrated in a few basic industries (mineral mining and processing, wood products and paper, oil refining, food products, and cement). For example, in 1974, the Anaconda Company and Hoerner Waldorf together consumed over 40 percent of all the natural gas distributed to industry.

Agriculture

The agriculture sector accounts for 4.4 percent of Montana's fuel and electric usage, including the natural gas and oil required to produce needed fertilizer and pesticides. The production of crops in Montana accounts for 95 percent of the energy used in agriculture, while livestock production requires 5 percent. Fertilizer and pesticides manufacturing consumes 44 percent of the total energy used in crop production, and field operations and farm vehicles account for 56 percent.

Transportation

Transportation presently accounts for about 25 percent of the nation's direct fuel consumption. An additional 18 percent of the U.S. energy budget is used indirectly to build and maintain vehicles, construct roads, etc.

In contrast, Montana's transportation sector directly used 31 percent of the total energy consumed in the state in 1974. The use of motor gasoline in Montana has grown fairly steadily at an average annual growth rate of about 3 percent since 1950. The majority of the gasoline consumed in Montana in 1974 was produced at in-state refineries. Only 16 percent of the feedstock for Montana refineries was produced in Montana. Forty percent of the feedstock for Montana refineries currently is imported from Canada. This feedstock is scheduled to be eliminated in the 1980's, and replacement feedstocks have not been located yet. Gasoline consumption accounts for 73 percent of the energy used in the transportation sector, highway diesel fuel accounts for another 9 percent, and the remaining 18 percent is used by railroads.

Government

The final energy consuming sector in Montana is state and local government. Government operations generally are included within the commercial and transportation sectors; but since Montana government has total control over its own energy consumption, we decided to address government operations separately.

Energy consumption in Montana government operations is substantial. For instance, in fiscal year 1975, eleven Montana state government building complexes consumed over 1.7 billion cubic feet of natural gas. Warm Springs State Hospital, where natural geothermal waters flow to the surface, consumed 212 million cubic feet of this total. Montana state and local governments also operate several thousand motor vehicles. Each year, the various Montana political subdivisions spend millions of dollars in various energy consuming procurements.

Montana governments have authority in the area of solid waste management. In the state of Montana, the energy equivalent of 50×10^{12} Btu's is processed as solid waste and used for land fill annually. This resource includes paper, glass, metals, and plastics. In addition, another 1.7×10^{12} Btu's of fuel in the form of organic burnable wastes (food, grass clippings, etc.) is thrown away.

Montana state and local governments also are responsible for sewage treatment. The present system for sewage treatment considers sewage an undesirable waste product rather than a resource. In actual fact, the energy content of the sewage treated in Montana is about 1×10^{12} Btu's per year. This resource also has a fertilizer value in some applications.

The handling and purifying of these wastes require about 1.5 million Btu's per million gallons of sewage. For residential uses alone, the state of Montana consumes 3.2×10^{10} Btu's for sewage treatment. When industrial and commercial uses are considered, this figure triples. In addition, the technologies involved require great quantities of water which is in itself a scarce and valuable resource.

ENERGY CONSERVATION GOAL

The Federal Energy Administration (FEA) estimates that Montana will consume 370.5 trillion Btu's of energy during the calendar year 1980. The goal of the FEA energy conservation program is a 5 percent reduction in this projected consumption level. Thus, to participate in the FEA program, Montana should propose projected 1980 energy savings of at least 18.53 trillion Btu's. As was noted in the introduction, Montana has chosen to move well beyond the five FEA mandatory areas and investigate energy conservation and renewable energy measures applicable to all sectors of Montana's economy. While Montana's plan focuses on both short and long term measures, particular emphasis was given to those measures which would have a significant and fundamental long term impact. This plan was developed to make energy conservation and renewable energy a major long term energy supply technology, not specifically to save 5 percent of Montana's 1980 energy consumption. Even so, this plan will exceed FEA's 5 percent goal and save a projected 19.62 trillion Btu's in calendar year 1980.

has Alaska adopted the FEA plan?

B. PLAN SUMMARY

Table B1.--Continued

	Program Measures	1980 Estimated Energy Savings (in trillion Btu's)	Estimated Cost of Implementation (in $000's) 1977	1978	1979	1980
7.	Conservation Loan Programs	1.8	50	50	55	55
8.	Renewable Energy Tax Credit	.249	0	0	0	0
9.	Public Utility Measures	1.14	100	50	100	100
10.	Energy Conservation Education	5.83	204	172	230	230
	Crude Oil Saving	.47				
	TOTAL.	19.62	2,719.76	1,681.96	1,369.46	1,369.46

Table B1.--Plan Summary

	Program Measures	1980 Estimated Energy Savings (in trillion Btu's)	Estimated Cost of Implementation (in $000's) 1977	1978	1979	1980
1.	State Building Code and Thermal Efficiency Standards	3.63	90	20	20	20
2.	Lighting Standards for Public Buildings	1.36	costs of implementation are included in program measure 1.			
3.	Procurement: Life Cycle Cost Analysis and Vehicle Fuel Efficiency Standards	.32	35	0	0	0
3a.	Energy Managing, Auditing, and Retrofitting State Buildings	.753	200	500	250	250
3b.	Renewable Energy Demonstration Project	Uncertain	-------------Uncertain-----------------			
4.	Right Turn on Red	Already in force no savings	0	0	0	0
5.	Car Pool/Van Pool: Increase in Transit Level of Service	.048	1,226	206	6	6
5a.	Public Transportation and Railroad Assistance Fund	.15	12.5	25.5	50	50
5b.	Bikeway Construction	.003	202.26	58.46	58.46	58.46
5c.	Enforcement of 55 M.P.H. Speed Limit	2.23	0	0	0	0
6.	Weatherization	.29	600	600	600	600

C. DESCRIPTION OF PROGRAM MEASURES

Energy conservation will become an integral part of Montanans' daily lives only when its benefits are perceived clearly. Individuals must be made aware of the significant economic and environmental advantages of saving energy from traditional sources in the short run and of shifting to alternative energy supplies in the long term. Energy consumption patterns can be changed in three basic ways:

1. government can force compliance with standards, as in the case of fuel quotas, taxation for excessive use, or financial penalties;
2. incentives can be provided to alter use patterns, as in the case of low interest loans for insulation or tax credits for industrial retrofitting; and
3. educational programs can address the multitude of energy saving techniques in virtually every category of energy end use in Montana.

Most of the specific implementation strategies involve either mandated or incentive programs or a combination of the two approaches. The following discussion provides definitions, examples, and rationales for the two basic categories.

<u>Mandatory Programs</u>

Fuel allocation programs, rationing, and forced reduction of energy consumption are effective in saving energy under conditions of crisis. Mandatory programs like these sometimes are required, but they should be used sparingly and in the proper circumstances. Mandatory programs may include direct compliance measures or severe tax sanctions, as in the case of greatly escalated gasoline taxes which could produce a shift to smaller automobiles. In either case, they run the risk of possible public antagonism and resistance which could damage the broader energy conservation program. For the most part, mandated measures have been confined to areas specifically required by the FEA and to other areas of government activity brought under direct control more easily.

Incentive Programs

Examples of incentive programs include tax subsidy measures, direct assistance such as weatherization, low interest loans, state assistance for energy audits, permissive legislation which could allow communities to experiment with alternative energy systems, and provision of matching funds for acquisition of federal monies. Incentive programs are appropriate when they stimulate the self-interest economic motive on the part of individuals. They are advantageous when they have an economic multiplier effect, as in the stimulation of jobs with the weatherization program. This approach should be maximized where short term energy savings can be realized appreciably, as in the case of weatherization. Since public resources are involved, programs should be chosen which have minimal bureaucratic costs for compliance and have the greatest potential for private sector economic ripple effect.

For both mandatory and incentive programs, there are associated important educational effects. The full range of educational programs are discussed as one implementation strategy. The following summary identifies the discrete program measures according to their primary nature as mandatory, incentive, or educational.

Table C1.--Summary of Program Measures by Type of Program

Mandatory Programs

No. 1	State Building Code and Thermal Efficiency Standards
No. 2	Lighting Standards for Public Buildings
No. 3	Procurement: Life Cycle Cost Analysis and Vehicle Fuel Efficiency Standards
No. 3a	Energy Managing, Auditing, and Retrofitting State Buildings
No. 3b	Renewable Energy Demonstration Project
No. 4	Right Turn on Red
No. 5	Car Pool/Van Pool: Increase in Transit Level of Service
No. 5c	Enforcement of 55 m.p.h. Speed Limit
No. 9	Public Utility Measures

Incentive Programs

No. 5a	Public Transportation and Railroad Assistance Fund
No. 5b	Bikeway Construction
No. 6	Weatherization
No. 7	Conservation Loan Programs
No. 8	Renewable Energy Tax Credit

Educational Programs

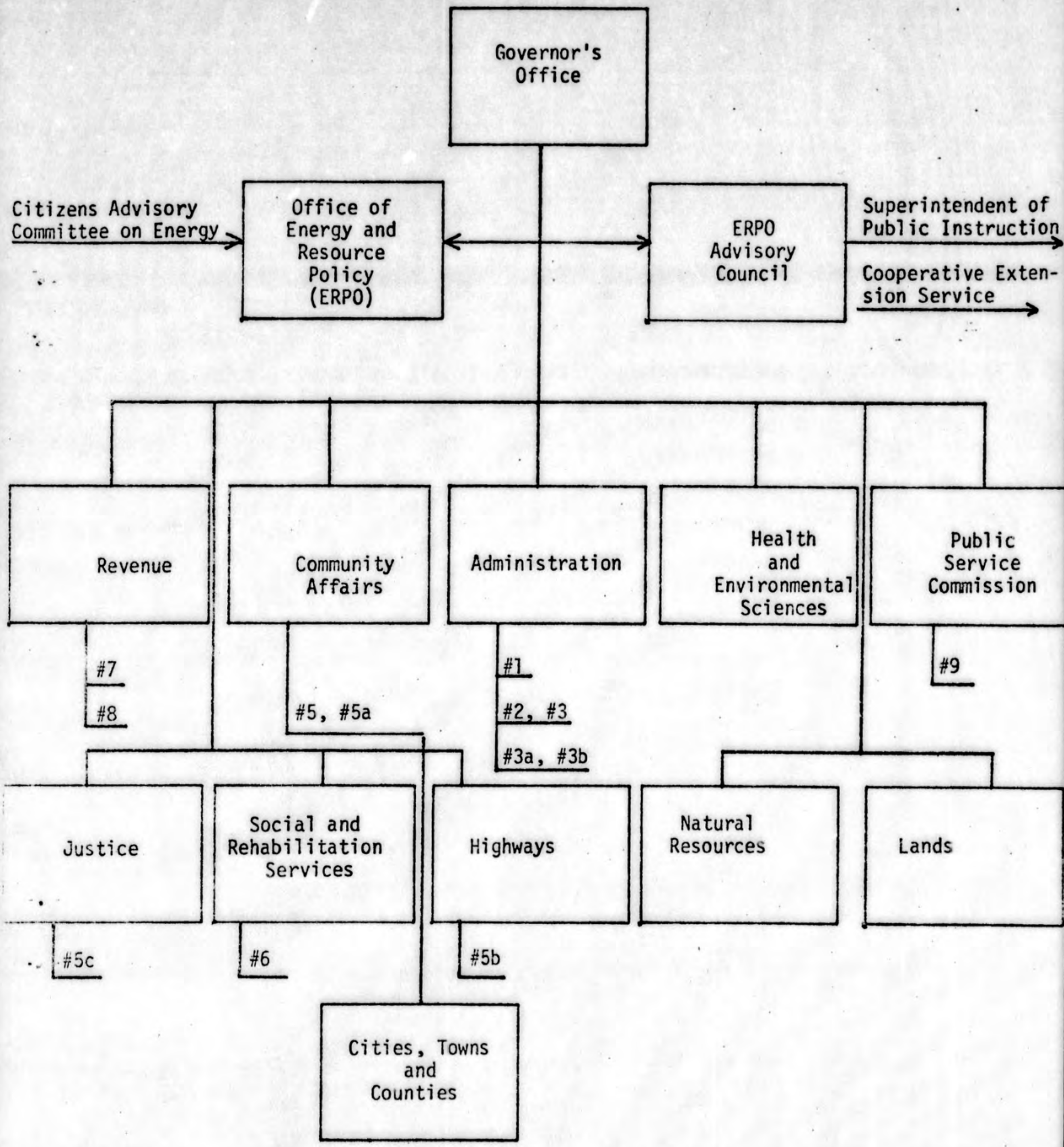
No. 10	Energy Conservation Education

It also is useful to identify program measures according to the principal energy use sectors which they address (see next page for a summary of program measures by sector).

Table C2.--Summary of Program Measures by Type of Program

Sector	Program Measure No.
(1) residential	1, 6, 7, 8, 9, 10
(2) commercial	1, 2, 7, 8, 9, 10
(3) industrial	9, 10
(4) agricultural	9, 10
(5) transportation	4, 5, 5a, 5b, 5c, 5d, 10
(6) government	3, 10

Figure C1.--Agency Responsibility Interactions: By Program Measure



PROGRAM MEASURE NO. 1--STATEWIDE BUILDING CODE AND THERMAL EFFICIENCY STANDARDS

Narrative Statement

Montana already has in place the necessary authority to comply with the objective of energy savings through elimination of excessive heat loss in new and renovated buildings. State law contains building code requirements which call for building designs to take into account the efficient utilization of energy. An administrative mandate has been extended to the Department of Administration to adopt all or part of a nationally recognized building code. In compliance with FEA requirements, a 1977 legislative mandate will call for the immediate implementation of standards, at least as stringent as ASHRAE 90-75, to be in place in advance of the January 1, 1978 deadline. The building code council will be mandated to conduct a technical evaluation of appropriate revisions of ASHRAE 90-75 and other code models. These revisions should include consideration of upgraded insulation standards, thermal shutters, and direct solar gains as a minimum. Public hearings will be required for citizen input into the selection of standards and adoption of procedures for certification and enforcement. The Department of Administration is charged with fulfilling this and subsequent phases of the full implementation strategy.

Within four months of the passage of legislation, the Department of Administration will have drafted a code meeting the minimum standards but suited to Montana's particular weather conditions. Consultation with the Department of Health and Environmental Sciences is mandated to insure consideration of environmental and health consequences of materials used for insulation. Following adoption of the code, the Department of Administration will develop a program of training and information for local building code officials prior to January 1, 1978. Consultation with the Department of Community Affairs in encouraged to utilize existing channels of interaction with local officials.

Estimated Energy Savings for Calendar Year 1980

Using FEA supplied methodology and regional data, we calculate that 1980 energy savings from implementing thermal efficiency standards equivalent to ASHRAE 90-75 for new and renovated buildings in the residential and commercial sector amounts to 2.44 trillion Btu's. We assume that the building code will have been in effect for 3.25 years by the end of 1980, and then it will apply to 25 percent of the residential renovations and 50 percent of the commercial renovations.

The Ecotope Group of Seattle, Washington, in calculations developed for this study, has determined that the implementation of ASHRAE 90-75 likely will save on the order of 0.8 trillion Btu's in 1980 in the residential sector and that the combined lighting and building code standards for the commercial sector will save 2.6 trillion Btu's in 1980. They indicate that a more stringent standard in the residential sector (1" to 2" additional insulation in walls, 8" additional ceiling insulation, 6" floor insulation, storm window caulking,and weatherstripping) could save approximately 1.2 trillion Btu's of additional energy. The major reasons for the slight discrepancy in results of the ASHRAE calculations is due to the fact that Ecotope has determined that new residential construction in Montana already nearly meets ASHRAE 90-75 and that Montana in general is not growing as rapidly as the rest of the western United States.

To be internally consistent, we are attributing the energy savings calculated to this program measure using the FEA methodology. We note that an

Table C3

MILESTONE CHART

FY77 FY78 FY79 FY80

Milestones	J A S O N D | J F M A M J J A S O N D | J F M A M J J A S O N D | J F M A M J J A S O N
Legislative enactment of deadline for building code revision. -	
Administrative adoption of building codes containing a minimum of ASHRAE 90-75 standards.	
Completion of training and information for local building code inspectors.	
Ongoing revision, monitoring, and upgrading of energy conservation aspects of the building code.	
Ongoing revision, monitoring, and upgrading of energy conservation aspects of the building code.	

additional 1.19 trillion Btu's of energy will be saved in 1980 by adopting more stringent standards in the residential sector.

Table C4.--Costs of Implementation
(includes costs for program measure No. 2)

1977	$20,000	Draft code
	$70,000	Training of Code inspectors
1978	$20,000	Monitor code
1979	$20,000	Monitor code
1980	$20,000	Study code for possible revision

PROGRAM MEASURE NO. 2--LIGHTING STANDARDS FOR PUBLIC BUILDINGS

Narrative Statement

Lighting efficiency standards will be included within the building code program described under program measure No. 1. The same implementation strategies and target deadlines apply. The state will use a standard no less efficient than in Section 9 of ASHRAE 90-75 as the minimum standards for lighting efficiency, and the Department of Administration shall designate the category of public buildings to which the standards are applicable.

The milestone chart (see Table C3) for program measure No. 1 also applies to program measure No. 2.

Estimated Energy Savings for Calendar Year 1980

Using FEA methodology and regional data supplied by FEA, we calculate that 1.36 trillion Btu's of energy will be saved in calendar year 1980 by implementing this program measure. We assume that the standard will have been in effect for 3.25 years and that all the floor space of new buildings will be affected, along with half the floor space of existing buildings.

Costs of implementation are included in the costs for program measure No. 1 (see Table C4).

PROGRAM MEASURE NO. 3.--PROCUREMENT: LIFE CYCLE COST ANALYSIS AND VEHICLE FUEL EFFICIENCY STANDARDS

Narrative Statement

The public sector provides broad opportunity for substantial energy savings. State and local governments utilize large amounts of energy, directly in operations and indirectly through the purchase of buildings, equipment, and materials. Governments, like private citizens, have not been inspired by the need to eliminate wasteful energy use until quite recently. This program measure will make energy conservation a salient principle of daily government activities and will produce significant direct savings. In addition, the example set by government should serve indirectly to promote savings in the private sector by providing exemplary patterns for emulation by businesses.

The state is in a current stage of physical plant growth. The capitol building complex is under expansion, and additions or renovations are being made to numerous public facilities including university campus buildings, state hospitals, and detention facilities. This period of new construction should be made to symbolize a state policy of long term investment in energy conservation and renewable energy. Under provisions of proposed legislation, the Department of Administration is charged with adopting a uniform design and procurement procedure which includes life cycle cost analysis and analysis of payback periods for energy conservation over the effective life of buildings and equipment. The state's financial commitment to the operation and maintenance of public owned facilities for the duration of their useful lives permits the adoption of construction options which require ten or more years of fuel savings before net economic savings are realized. Accordingly, the state is best situated to consider longer life cycle cost periods.

The Department of Administration will create an inventory of all classes of equipment and materials to be covered under the life cycle cost procedure, but the categories must include (at a minimum) all new buildings, motor vehicles, computers, and print reproduction equipment. The Department of Administration is required to adopt the most recent standards produced by efforts such as those of the General Services Administration and the National Bureau of Standards. At a minimum, however, the following considerations are required of the life cycle cost standards for buildings:

a. fuel cost escalation and total fuel cost inflation rate, interest rate, and discount rate over the life of the equipment or building;

b. cost of maintenance (including labor and materials) and operation over the life of the equipment or building;

c. the orientation and integration of the facility with respect to its physical site;

d. the amount and type of glass employed in the facility and the directions of exposure;

e. the effect of insulation incorporated into the facility design and the effect on solar utilization of the properties of external surfaces;

f. the variable occupancy and operating conditions of the facility and subportions of the facility; and

g. an energy consumption analysis of the major equipment of the facility's heating, ventilating, and cooling system, lighting system, hot water system, and all other major energy consuming equipment and systems as appropriate. This analysis shall include 1) the comparison of alternative systems; 2) a projection of the annual energy consumption of major energy consuming equipment and systems for a range of operation of the facility over the life of the facility; and 3) the evaluation of the energy consumption of component equipment in each system, considering the operation of such components at other than full or rated outputs.

The Department of Administration will be provided resources for preparing the life cycle cost analytical procedure including costs of programming computer software necessary for the analysis and supporting personnel and computer time required in the evaluation process. The Department of Administration will have the evaluation procedure in place by January 1, 1978 and will supervise its application to relevant state agencies thereafter. Application to local governments will not be mandatory, except in cases where state funds are used for public building construction. Rather, the Department of Administration will work with the Department of Community Affairs to promote mechanisms through which local governments can avail themselves of the life cycle cost procurement procedure and can enter joint purchase agreements with the state to maximize cost savings. The Department of Administration will promote communication of all energy saving procurement techniques both within state government agencies and between state and local governments.

The Department of Administration also will be given explicit authority to require the purchase of state vehicles with average fuel efficiency levels in the upper one third of the U.S. Environmental Protection Agency's city/highway rating scale. This mandate will apply to all passenger vehicles purchased by any state agency (except Montana Highway Patrol purchases of law enforcement vehicles) beginning July 1, 1977.

In addition, the Department of Administration will conduct the purchase inventory studies necessary to comply with all other FEA procurement requirements.

Estimated Energy Savings for Calendar Year 1980

The major energy savings which will occur under this program measure will be in the area of new state building construction. Ecotope projects that 2 million square feet of new construction will occur in the government and institutional sector by 1980. For this analysis, we will assume that 25 percent of this construction will occur each year between 1977 and 1980. We again will assume that design contracts for construction in 1977 and 1978 already have been let and no design changes are possible. We will assume that 50 percent of the construction that is projected to occur in 1979 and 1980 will fall under the life cycle cost analysis program (500,000 square feet). We will again assume that a life cycle cost purchasing decision could save 25 percent of the energy consumed in a new building (split equally between fossil fuels and electricity) or 62,500 Btu's per square feet. Thus, we project total energy savings of approximately .07 trillion Btu's in 1980 for building procurement alone.

The state motor vehicle fuel efficiency procurement policy also will save energy. Although exact records have not yet been compiled, it appears that over ten million vehicle miles are traveled annually by state owned passenger vehicles. The state fuel economy standard requires that American made vehicles be purchased which are in the top one third of the combined EPA city/highway mileage standard. Since all motor vehicles will meet a 20 mile per gallon standard by 1980 under federal regulations, only those fuel economy gains above 20 miles per gallon can be credited to this program. If we assume that under this program measure the state passenger car fleet will have an average fuel economy of 25 miles per gallon, a total of .25 trillion Btu's of gasoline will be saved in 1980.

Energy saving through life cycle cost procurement will occur in many other areas; however, insufficient data exist to quantify the savings.

Table C5

MILESTONE CHART

Milestones	FY77 J A S O N D	FY78 J F M A M J J A S O N D	FY79 J F M A M J J A S O N D	FY80 J F M A M J J A S O N D
Motor vehicle efficiency standards adopted and in place				
Life cycle procurement procedure in place and applicable to state agencies. Procurement procedures available to local governments; joint purchase agreements available				

Table C6.--Costs of Implementation

1977	$35,000	Computer Programming Software
1978		
1979		
1980		

PROGRAM MEASURE NO. 3a--ENERGY MANAGING, AUDITING, AND RETROFITTING STATE BUILDINGS

Narrative Statement

The commitment to life cycle cost analysis in designing and constructing new state buildings is a symbolic beginning in the public sector with far-reaching results. Other measures must be instituted to achieve present direct savings in the operation of state government buildings. Some programs can be implemented immediately to eradicate fuel wastage. A number of these will be included under the broad program title of energy management in state buildings. The components of this program include the following:

a. energy auditing in existing state buildings for determination of significant energy savings potential;

b. implementing energy management practices with the existing network of buildings; and

c. implementing conservation retrofitting in state buildings on a priority basis as established by the audit program.

Under the energy audit program, from 250 to 300 state buildings would be selected to identify operational and structural modifications capable of reducing energy demands with a minimum disruption of on-going functions. The energy audit program will develop a standard evaluation methodology which can be utilized by administrators of state and local buildings not selected for the audit sample which, nevertheless, could benefit from analysis. Efforts should be made to encourage the participation of the private sector for the purposes of assisting in designing the audit procedures and promoting widespread use of the completed audit procedure in the private sector. Under the terms of proposed legislation, an appropriation of $200,000 would be made to conduct the energy audit.

While it is expected that the energy audit program will provide valuable suggestions for both structural and operational modifications of buildings, a program of energy management does not need to await results of the audit. Immediate savings can result from implementing known techniques which require little additional resource outlay. Simply educating maintenance personnel and building users in the efficient management of thermostat settings, illumination levels, hot water control, equipment maintenance, and ventilation can achieve short run savings. More significant savings can accrue from small expenditures for minor retrofitting devices such as flow reduction water faucets, double door entrances, and added insulation and weatherstripping. Many of these changes can be made in the absence of the energy audit and should be encouraged in all state buildings.

To accomplish these energy savings, Governor Judge has issued an executive order requiring the Department of Administration to specify and put into effect more efficient management practices in the operation of existing state buildings. Such measures could save on the order of 15-30 percent of the energy use in existing buildings.

Major retrofitting will occur in those buildings discovered by the energy audit to be in greatest need and capable of producing the most savings at the lowest cost of retrofitting. As in the case of life cycle cost procurement, the state is in a good position to make important leadership contributions since the state owns its buildings and can afford the years necessary to recapture the investment cost. As a large fuel consumer, the state must adopt this hedge against the inflation of fuel costs and must show private citizens the advantages of doing so themselves. Under the terms of proposed legislation, an appropriation of $500,000 would be made for the acquisition and installation of conservation materials. A portion of this funding would be set aside for the program of energy operations management, including informational and educational materials as well as minor retrofitting equipment and supplies.

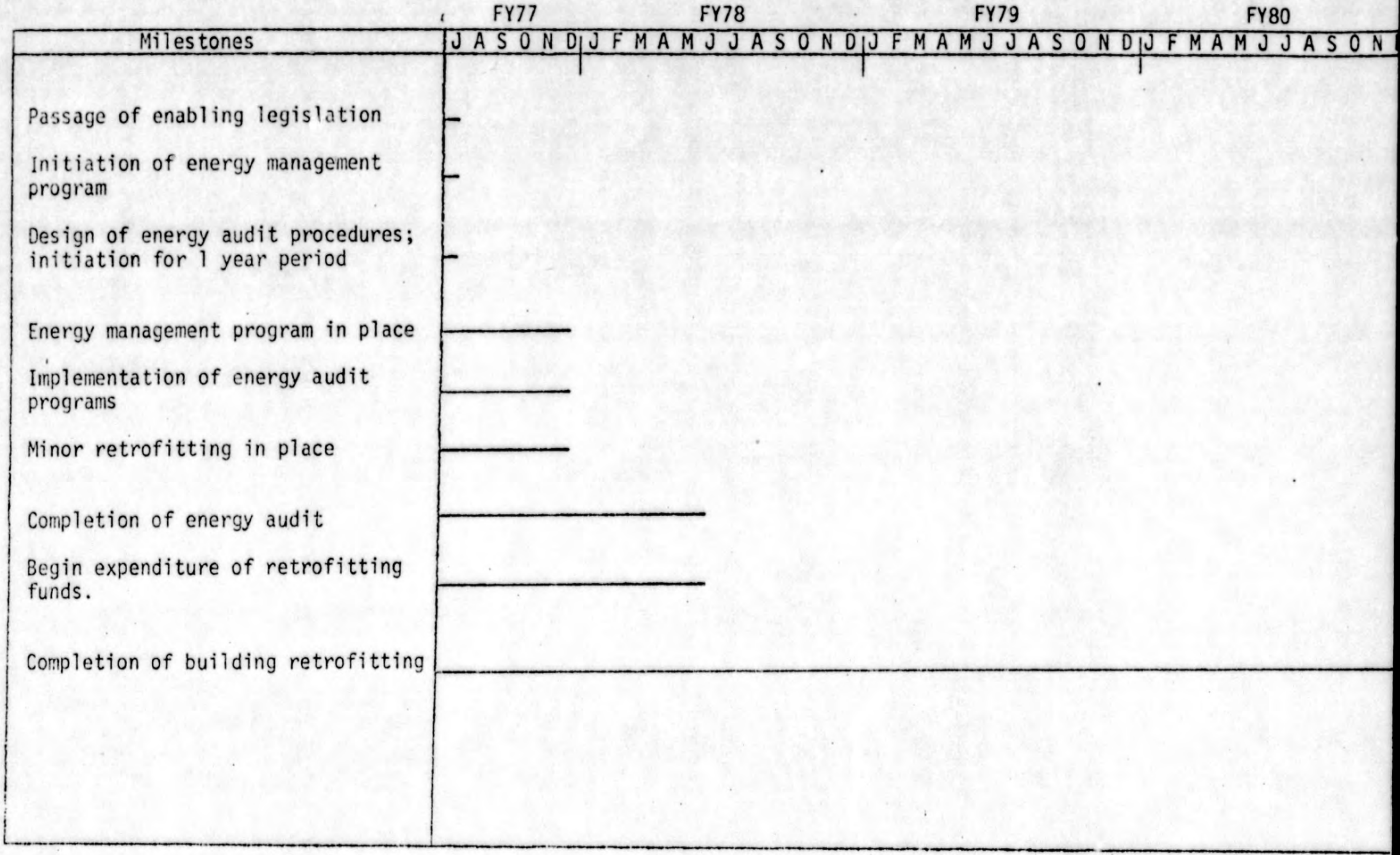
Estimated Energy Savings for Calendar Year 1980

Both the energy auditing program with its accompanying retrofit appropriation and the energy management program will produce almost immediate energy savings in government operations. Ecotope projects that 1.7×10^7 square feet of government floor space will be in existence in 1980. The average energy consumption of government buildings in Montana works out to be 250,000 Btu's per square feet per year. Thus, energy consumption in government buildings in 1980 is projected to be 4.25 trillion Btu's. If 60 percent of the buildings (floor space) in the government sector are audited and implement the governor's executive order and each save a projected 20 percent of their energy consumption due to implementing energy conserving operating procedures, a total of .51 trillion Btu's of end use energy will be saved in 1980. If we assume that 80 percent of these savings will be fossil fuels and 20 percent electricity, actual energy savings from implementing this measure will be .748 trillion Btu's using FEA methodology. These savings will be accomplished with a capital investment of less than $100,000.

The energy auditing and retrofit program will produce energy savings in addition to those calculated above. It is projected that approximately $900,000 in state funds will be available for implementing energy conservation procedures disclosed through the auditing procedures. Ecotope estimates that energy savings on the order of 50 percent can be accomplished for (at most) approximately $3.00 per square feet in existing buildings.

Table C7

MILESTONE CHART



Thus, $900,000 will retrofit approximately 300,000 square feet, and retrofitting existing state buildings will save approximately .045 trillion Btu's in 1980. This assumes that the retrofitting will be applied to the worst energy consuming buildings and will save 150,000 Btu's per square foot. Total savings in state government building operations thus are projected to be approximately .753 trillion Btu's in 1980.

Table C8.--Costs of Implementation

1977	$100,000	Energy audit
	$100,000	Energy management and minor retrofitting
1978	$100,000	Energy audit
	$400,000	Retrofitting
1979	$250,000	Retrofitting
1980	$250,000	Retrofitting

PROGRAM MEASURE NO. 3b.--RENEWABLE ENERGY DEMONSTRATION PROJECT

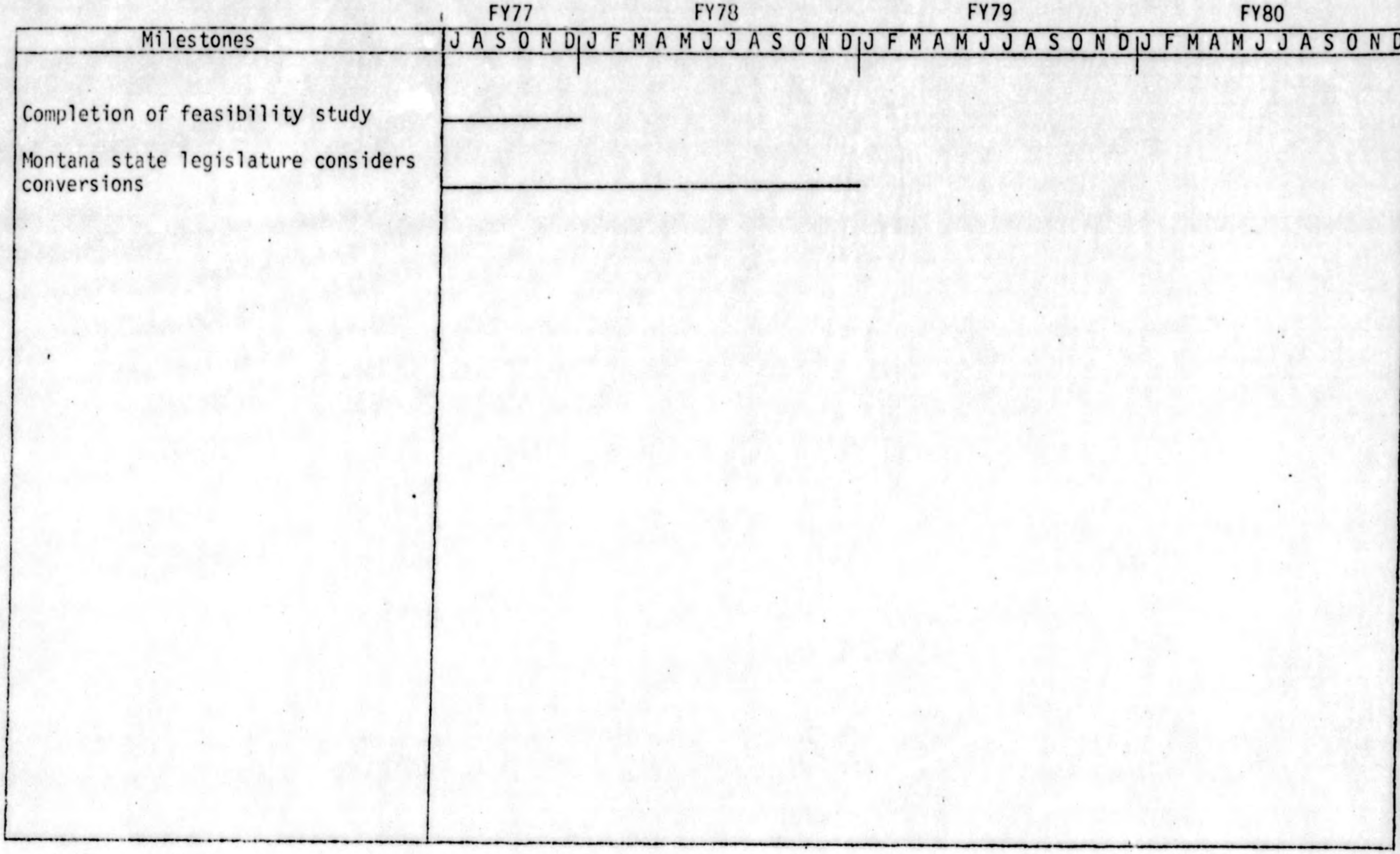
Narrative Statement

In addition to the direct savings resulting from changes in energy use patterns of the state government, the potential demonstration effect of state activities for private behavior is quite large. Because of the great diversity of both renewable and non-renewable energy sources in the state, a number of projects could be undertaken to illustrate the fact that Montana is, by no means, locked into traditional energy use patterns. Even though certain projects might not be cost effective in the short term themselves, they are worth supporting for their value in stimulating public awareness of the wide range of innovative energy sources that currently are possible both in technological and economic terms.

Serious consideration has to be given to creating model projects in more than one energy use sector. Solar heating of a highly visible state building is one possibility. Another realistic project might be the conversion of the Warm Springs State Hospital to geothermal heat as part of a renovation of that facility. Therefore, it is recommended that the state undertake a research and development effort to consider the geothermal adequacy as well as the costs, practicability, and possible environmental impacts of a geothermal project at Warm Springs. If found to be advantageous, the state should accomplish the conversion task immediately. If Warm Springs State Hospital were converted to geothermal energy, at least .25 billion cubic feet of natural gas would be conserved. The state of Montana also has an opportunity (some would argue "obligation") to convert its other building complexes from natural gas to some other energy source. In many cases, coal would be the most economic choice; however, coal's polluting characteristics must be considered fully before any

Table C9

MILESTONE CHART



conversions are undertaken. The state of Montana has a tremendous reservoir of talent within the university system. The universities should take the lead in developing innovative solutions to natural gas supply problems. Many state building complexes are in areas with sizable potential for the implementation of renewable energy resources. This potential should not be ignored.

Estimated Energy Savings for Calendar Year 1980

The extent of energy savings from this program measure obviously depends on the degree to which conversions are effected. Feasibility studies alone will save no energy. Because we cannot recommend a specific appropriation for conversion at this time (the 1979 legislature must address this), we presently cannot attribute any direct energy savings to this program measure.

Costs of Implementation

The costs of implementation are uncertain. The state may be able to conduct these evaluations by redirecting existing resources. Long term savings may be the actual result.

PROGRAM MEASURE NO. 4--RIGHT TURN ON RED

Narrative Statement

Montana has a "right-turn-on-red" traffic law (RCM 32-2137):

> "Vehicular traffic facing the signal shall stop before entering the crosswalk on the near side of the intersection or, if none, then before entering the intersection and shall remain standing until green or "Go" is shown alone or until a right turn can safely be made and in making such turn vehicular traffic must yield the right-of-way to pedestrians lawfully within the crosswalk and to other traffic lawfully using the intersection. If a traffic sign legend indicating that no right turn on red may be made after a stop is posted at said intersection, such movement cannot be made until green or "Go" is shown alone."

Because Montana has a "right turn on red" traffic law, estimates of milestones, energy savings, and implementation cost are not applicable.

PROGRAM MEASURE NO. 5--CAR POOL/VAN POOL: INCREASE IN TRANSIT LEVEL OF SERVICE

Narrative Statement

The transportation sector in Montana offers considerable prospect for energy savings because of the high percentage of total energy use it constitutes. At the same time, it must be remembered that reduction in fuel use is quite difficult in a highly rural state where transportation is a critical link between dispersed pockets of population. The greatest opportunity for savings in the mandated program measures in transportation lies in the more urbanized areas where incentives are necessary to increase the number of persons per vehicle. In response to FEA requirements, two Montana cities with urban area populations of between 50,000 and 100,000 have been selected for car pool/van pool matching campaigns (Billings) and increased levels of transit service (Billings and Missoula).

Both carpooling and increased levels of transit service can produce direct energy savings and the residual benefits of reduced peak hour traffic congestion, air pollution, and transportation for the aged or disabled. But habits associated with the use of private automobiles are difficult to break and may require time to alter. The program measures described here would be most effective under conditions in which complementary measures (such as increased motor fuel taxes or increased parking fees) were imposed. Nonetheless, it is possible to show net energy savings from car pooling and mass transit if imaginative and aggressive promotional programs are implemented. Four additional Montana urban areas have submitted demonstration project responses to the Federal Urban Mass Transit Act (UMTA), and other communities have initiated voluntary car pooling projects, which are indications of the potential for energy gains from broadening these programs.

A plan exists for implementing a car pool system for Billings and only requires sufficient funding to be in place by January 1, 1978. Funds to support the program have been proposed in the Emergency Highway Energy Conservation Act, available initially to the communities on a 90/10 federal/state match basis.

The plan for increasing the transit level of service in Billings calls for significant increases in service and ridership based on a reduction of headway time from 45 minutes to 20 minutes. The increased level of service is dependent upon the purchase of new buses. A bill in the current legislative session would provide state matching of capital grant funds under UMTA for purchase of equipment by local governments. Upon receipt of funding, this program could be in operation within one year and fully implemented by 1980.

Voters in Missoula approved creation of a metropolitan transit district to provide service within the incorporated area. The plan provides for establishment of a core system in 1977 and expansion in subsequent years (through 1980). The savings attributable to this initiation of transit service are comparable to the increase expected in the upgrading of the Billings program. Both the Billings and Missoula expanded transit level of service programs are coordinated through their respective local metropolitan planning organizations.

Estimated Energy Savings for Calendar Year 1980

Billings Car Pool

Assuming that 10 percent of the working force participates, it would result in a reduction of 12, 836 vehicle miles of travel per day in Billings which amounts to 237,120 gal/yr or .02964 x 10^{12} Btu/yr. Applying the annual growth rate in gasoline consumption of 3 percent (reflecting both the increased numbers of miles driven and participation in the car pool program) would give a total savings of .0353 x 10^{12} Btu. Because of the estimated small savings, the "Guidelines for Travel Demand Analysis of Program Measures to Promote Carpools, Vanpools, and Public Transportation," prepared for the Federal Energy Administration by Cambridge Systematics, Incorporated, was not used to calculate the potential energy savings. The city of Billings conducted a comprehensive car pooling analysis which is used for this analysis.

Billings chose to use the FHWA Computer Matching Program to match travel data and participant requests. There are approximately 42,800 employees in the Billings urban area. The average roundtrip to work is 6 miles. The following assumptions were used to calculate the energy savings:

a. 1.2 commuters per vehicle in rush hours;
b. 10 percent of total employees join car pool;
c. 13 miles per gallon of fuel consumed;
d. 3 commuters per vehicle in car pool; and
e. 98 percent of the employees in cars.

Billings Mass Transit

Two methods were used to project the possible energy savings of this program measure: "Guidelines for Travel Demand Analysis of Program Measures to Promote Carpools, Vanpools, and Public Transportation" and Btu analysis from data provided by the Billings transportation planners. The first procedure would yield a savings of .061 x 10^{12} Btu/yr, whereas the latter projects a savings of .00673 x 10^{12} Btu/yr. The latter number is in the same magnitude as that calculated for the Missoula bus system and is the more conservative figure. Thus, the remaining analysis is based on this projection.

Only the persons served by the bus route were included in the analysis. This included 87,000 persons served with an average of 2.7 persons per household. Assume that 1.1 workers per household yields 35,444 potentially affected workers. The remaining assumptions were used in calculating with FEA guidelines:

a) 1.2 persons per car;

b) 6 mile roundtrip;

c) 13 miles per gallon per auto;

d) 8 miles per gallon per diesel bus;

e) 40 persons per bus and 20 percent occupancy; and

f) base modal shares (see appendix).

Methodology used to calculate savings from information provided by the Billings city transportation planner included the following:

a) total ridership per day would increase from 1500 in 1975 to 2100 in 1980;

b) the number of bus miles traveled per day to decrease headway would increase from 1500 miles per day in 1975 to 2000 miles per day in 1980;

c) 6 mile roundtrip;

d) 13 miles per gallon per auto; and

e) 8 miles per gallon per diesel bus.

Missoula Mass Transit

Based on data provided by the Missoula City Planning Office, the bus system implemented by 1980 would have an energy savings of $.0065 \times 10^{12}$ Btu/yr. Translated into gallons of gasoline, the system would yield a savings of 51,864 gallons of gasoline.

Table C10

MILESTONE CHART

Milestones	FY77: J A S O N D	FY78: J F M A M J J A S O N D	FY79: J F M A M J J A S O N D	FY80: J F M A M J J A S O N
Billings car pool system in place, renewable on a yearly basis				
Missoula mass transit system initiated				
Billings mass transit system partially expanded				
Billings car pool system established on a renewable basis				
Missoula mass transit system at full level of operation				
Billings mass transit system at full expanded level of operation				

Based on the number of miles traveled per year by the bus system and the number of persons riding provided by the Missoula City Planning Office, the energy savings was computed. Assumptions included the following:

a) 447,668 miles traveled per year by bus in 1977;

b) 24,700 persons used the bus per year in 1977;

c) the ridership and bus mileage remained constant through 1980;

d) 13 miles per gallon per auto; and

e) 8 miles per gallon per diesel bus.

Note the total savings is .048 trillion Btu's in 1980.

Table C11.--Costs of Implementation
(includes costs for program measure No. 2)

	Billings Car Pool	Billings Mass Transit	Missoula Mass Transit
1977	$26,000		$1.2 million (capital costs only)
1978	6,000	$200,000	
1979	6,000		
1980	6,000		

PROGRAM MEASURE NO. 5a--PUBLIC TRANSPORTATION AND RAILROAD ASSISTANCE FUND

Narrative Statement

The energy efficiency of well utilized public transportation and railroad passenger and freight service offers prospects of substantial energy savings if a significant portion of transit needs now met by private automobiles and motor freight carriers could be assumed by the urban public and railroad transportation modes. Large shifts to these efficient alternatives to the private internal combustion vehicle are unlikely in view of the totally inadequate level of service and convenience currently offered by these transportation systems.

Years of neglect and under utilization of these systems have been aggravated and abetted by the enormous public subsidy of the interstate, state, and local highway system and related services such as police patrol, traffic control systems, and public parking facilities. There has been a pervasive presumption that the public interest is best served by government actions which increase the speed, accessibility, geographic range, and convenience of private automobile and truck transportation. This preoccupation with private on-demand mobility has seriously impaired the capability of other transit modes to support Montana's transportation requirements. Because of the single focus policy, Montana's economic health and social diversity lean upon an energy supply which is extremely vulnerable to curtailments and disruptions over which the state has little or no control.

If Montana hopes to reestablish a balanced and diverse transportation system necessary for future prosperity and viable communities, it must be willing to invest significant capital and operational expenses to gradually resuscitate a severely atrophied rail system and also be willing to initiate and support urban transit systems for short-distance, high-volume passenger trips. Public response to these transportation improvements are likely to be slow as engrained attitudes regarding cars, convenience, and speed adjust to emerging fuel constraints and price inflation. Deficit operation of many public transit and rail services is to be expected during the beginning years of establishing public confidence in, and use of, these systems. Without assuming the responsibility for providing energy efficient transportation alternatives now, Montana cannot expect to be spared the consequences which will beset a society whose mobility is almost totally dependent on the fluctuations of foreign suppliers of petroleum.

In view of this need for immediate preparation of a multipurpose transportation system, we recommend that the Gasoline Distributor's License Tax (levied at 7 3/4¢/gallon effective July 1, 1977) be increased by 2 1/4¢/gallon, with the revenues being deposited to the account of a Public Transportation and Railroad Assistance Trust Fund. The monies in this fund would be administered by the state's Department of Community Affairs, which currently has authority for public transit programs and is to be designated the lead agency for Montana's railroad planning and assistance program. Eligible appropriations from this trust fund would be for 1) state grants to local governments for public transit planning; 2) state capital grants to local governments to match federal Urban Mass Transportation Act funds (80/20 federal to state and local matching ratio) for public transit vehicles, equipment, and facilities; 3) state subsidies for up to half of a local public transportation program's operational deficits (as currently authorized by 11-4513 RCM); 4) state planning, subsidization, and capitalized implementation of a statewide rail service program as developed in compliance with the federal Railroad Revitalization and Regulatory Reform Act; 5) state grants for planning, capitalized implementation, and operational support of innovative, energy efficient transportation demonstration projects; and 6) expenses incurred by the department for planning, implementing, and evaluating the statewide public and railroad transportation programs.

The fund would receive approximately 19 million dollars (2 1/4¢/gal x 422,233,150 gals/yr) from revenue generated in the 1978-1979 biennium if the tax were to go into effect by July 1, 1977. While these are not insignificant sums of money, they are a modest proportion of the funds allocated to the Highway Trust Fund (approximately $65,446,200). It also must be recognized that there is a pressing need for state financial assistance to public transit and railroad service maintenance at this very moment.

Perhaps more than one hundred miles of railroad lines within Montana have been abandoned in the last few years. There is strong speculation that a forty three mile stretch of rail service between Vaughn and Augusta (Lewis and Clark and Cascade counties) may be discontinued within the year. There also is the prospect of the Milwaukee Railroad Company merging with Burlington Northern (Milwaukee's petition for permission to merge currently is before the Interstate Commerce Commission). Under federal railroad reorganization rules, merged railroad companies can discontinue rail service along one of their combined lines whenever they are roughly parallel. Since most, if not all, of Milwaukee's rail lines are in this parallel category with Burlington Northern's service, the potential impact of discontinued rail service throughout the southern portion of Montana is severe.

A large portion of rail freight demand comes from Montana farmers who must move millions of bushels of grain and other products to markets each year. When rail haulage of this harvest is curtailed or discontinued, farmers have little option but to switch to motor freight carriers. Not only are motor carriers less energetically efficient than rail freight, the increased requirements and wear and tear of rural road systems would require substantial expenditures of state highway trust funds to upgrade roadways for this increased motor carrier use.

Maintenance and eventual expansion of rail freight service in eastern Montana is particularly significant if the state is to pursue a policy of exporting coal for out-of-state energy demands. Sustaining and extending local rail service may be desirable if Montana chooses to encourage in-state small scale load center coal conversion to electricity, district heating, and residential heating. Transporting coal for industrial co-generation and local utility service would be assisted greatly by a functional rail system.

The case for assistance to urban public transit programs also is strong for the 1978-1979 biennium. The city of Missoula recently established an urban transit district and now is purchasing buses to begin implementing its public transportation plan. The consolidated local government of Butte-Silver Bow is considering seriously the establishment of an urban transit district, and Billings needs to improve upon its public bus service. Currently, all capital expenditures necessary to begin such public transit programs (and to acquire 4 to 1 federal UMTA matching funds) must come from the local governments. With the full weight of capitalized expenditure upon local communities, the capability of beginning with an adequate level of public transit service is weakened.

Furthermore, while the state is authorized to subsidize up to one half the local public transit operational deficits, the actual assistance levels have been substantially less than this upper limit. There also is a problem of state payments coming at the end of the year in which the deficits occurred, while the local government must cover the costs on a continuing basis. We endorse the Department of Community Affairs' recommendation that the state provide operational funding assistance at the beginning of the year based on estimated deficits or during the year as deficits are incurred (perhaps on a quarterly basis).

Estimated Energy Savings for Calendar Year 1980

Energy savings under this program measure will occur from both reduced demand due to increased gasoline prices and from the direct energy savings from increased levels of public transportation and other innovative transportation measures.

It has been documented that an increase in the price of gasoline will cause a decrease in its demand. Assuming a "best case" estimate, a 1 cent increase in gasoline price would give a 1 percent fuel savings in 1980. Using a 3 percent annual growth rate in gasoline consumption, 1980 gasoline consumption is projected to be 66.8 trillion Btu's. Thus, it is estimated that 1.5×10^{12} Btu's would be saved in 1980 by the enactment of this indirect measure.

The direct energy savings accompanying this measure cannot be quantified at this time. All the specific programs that would be adopted have not been enumerated yet.

As one specific example of the potential direct energy savings from this program, we shall consider the Vaughn to Augusta rail line.

Table C12

MILESTONE CHART

Milestones	FY77 J A S O N D	FY78 J F M A M J J A S O N D	FY79 J F M A M J J A S O N D	FY80 J F M A M J J A S O N D
2 1/4 gasoline tax increase goes into effect	—			
Public Transportation and Railroad Assistance Fund implemented	—			

Approximately 2,557 tons of agricultural or livestock products were hauled over this line in 1972. If this transportation is done by truck with an energy use of 2400 Btu/ton mile, the energy usage would be 2.639×10^8 Btu. Whereas, if the same load was hauled by train with an energy use of 750 Btu/ton mile, the energy demand would be 8.246×10^7 Btu. Assuming the same level of production in 1980 would yield the projected savings of .00018 x trillion Btu.

Table C13.--Costs of Implementation

	Administrative Costs	Additional Tax
1977	$12,500	$4.75 million
1978	25,500	9.5 million
1979	50,000	9.5 million
1980	50,000	9.5 million

PROGRAM MEASURE NO. 5b--BIKEWAY CONSTRUCTION

Narrative Statement

As with many other energy conservation program measures, the promotion of bikeways has a dual set of benefits. Not only is bicycling an energy efficient mode of transportation, it is a package of positive externalities. It is less expensive, often more convenient, usually more healthful, and certainly more compatible environmentally than its chief rival--automobiling. And based on testimony in public hearings throughout Montana's urban areas, it appears that a significantly greater incidence of bicycling would occur if bicycle paths were established to help reduce the hazards of competing with other traffic. Immediate goals in Montana are to develop the bikeways in four of the larger urban areas: Miles City, Missoula, Billings, and Great Falls. Funding would come from state highway construction funds if the legislature clarifies previous legislation providing that 3/4 of 1 percent of the funds be spent for creation of footpaths and bicycle trails.

Estimated Energy Savings for Calendar Year 1980

Extensive local energy saving calculations have been performed for potential bikeways in Miles City, Billings, Great Falls, and Missoula. The combined plans are projected to result in over 163,000 fewer vehicle miles per day traveled in these cities. The total savings from implementing bikeways in these four cities is .0032 trillion Btu's.

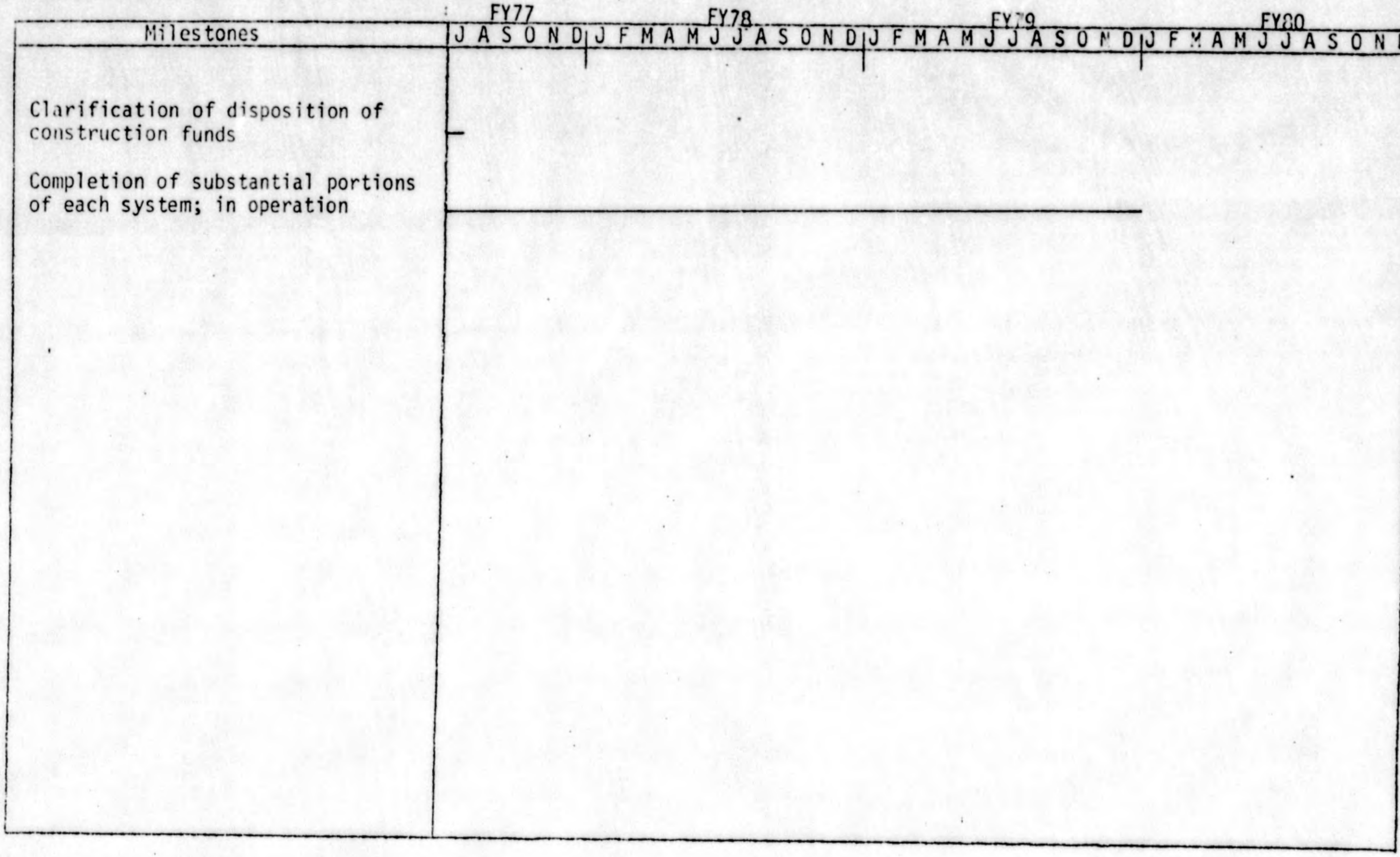
Table C14--Costs of Implementation*

	Miles City	Missoula	Billings	Great Falls
1977-1980	$26,800	$117,000 (in hand)	$166,400	$67,440

*To be funded from a combination of gasoline tax, bicycle license fees, sale of maps, federal grants from Bureau of Outdoor Recreation, and Highway Safety funds.

Table C15

MILESTONE CHART



PROGRAM MEASURE NO. 5c — ENFORCEMENT OF 55 M.P.H. SPEED LIMIT

Narrative Statement

Numerous studies have documented well the two-fold advantage of the nationwide 55 mile per hour speed limit: overall fuel savings and reduction of fatal accidents. Nonetheless, it remains true that penalties for violation have failed to produce uniform compliance with the speed standard. In Montana, a combination of extensive open road and inconsequential fines has produced a substantial percentage of violators. Based on 1976 Montana Highway Department data, more than 60 percent of drivers on state highways exceeded the limit (broken down as follows):

31.8 percent	55-60 m.p.h.
19.0 percent	61-65 m.p.h.
7.7 percent	66-70 m.p.h.
3.8 percent	70+ m.p.h.

Strict conformance to the 55 m.p.h. limit could produce significant savings by 1980. It has been shown that automobiles traveling at 60 m.p.h. consume 5 percent more fuel per mile than those traveling at 55 m.p.h. The corresponding figures for reductions back to 55 m.p.h. are 13 percent for 65 m.p.h. and 20 percent for 70 m.p.h. Thus, immediate savings are likely since more than half of Montana's drivers would be affected. It should be noted that stricter enforcement of the limit may alter the behavioral pattern of only a portion of the drivers (perhaps two-thirds) and that resentment to the imposition may produce some non-quantifiable costs of compliance. A public information program should focus first upon greater voluntary compliance, especially during the portion of the year when the nation's fuel shortages are dramatized by the winter's coal. However, enforcement <u>can</u> change behavior (i.e., perception of risk in being caught).

Immediate enforcement with stricter fines will not require any additional manpower, vehicles, or radar costs on the part of the Montana

Table C16
MILESTONE CHART

Milestones	FY77 J A S O N D	FY78 J F M A M J J A S O N D	FY79 J F M A M J J A S O N D	FY80 J F M A M J J A S O N D
Immediate Implementation	—			
Strict enforcement with stiffer fines policy in place	—			

Highway Patrol. The exact fine mechanism and structure will be determined by the 1977 Montana State Legislature.

Estimated Energy Savings for Calendar Year 1980

Approximately 75 percent of the vehicle miles traveled in Montana are on roads with a posted 55 m.p.h. speed limit. Using data supplied by the Montana Highway Department and the Montana Highway Patrol, we calculate that if everyone in the state obeyed the 55 m.p.h. speed limit, 2.83 percent of the energy used in transportation could be saved. In our analysis, we assume that strict enforcement of the 55 m.p.h. speed limit would cause two thirds of the drivers in Montana to change their behavior and obey the speed limit. This would result in a 1980 projected energy savings of 2.23 trillion Btu's.

Table C17. --Costs of Implementation

1977	0
1978	0
1979	0
1980	0

Supplemental Discussion: 55 Mile Per Hour Speed Limit

The 55 mile per hour speed limit saves both energy and lives. It also is mandated by the Federal Government, and no state may have a speed limit greater than 55 m.p.h. As was shown previously, it is disobeyed routinely in Montana. With wide expanses of land to traverse in Montana, travel time often is important. The 55 m.p.h. mandatory speed limit has been ill-received, particularly in the disperse eastern portion of the state. For this reason, a resolution has been introduced into the Montana legislature calling for the Federal Government to raise the maximum speed limit to 65 m.p.h. We submit that there is an alternative method to both conserve energy and raise the speed limit. We suggest that the legislative resolution be amended to propose that the Federal Government consider a variable speed limit in Montana as an experiment.

Particularly with passenger automobiles, there are significant variations of fuel efficiencies that should be recognized in governmental efforts to reduce energy consumption. Rather than imposing a uniform maximum speed for all cars, highway laws could be applied so that encouragement is given to the purchase of smaller more fuel efficient vehicles by strictly enforcing a graduated maximum speed limit based on vehicular fuel efficiency. Each driver then is permitted to burn up a similar amount of energy. For example, a vehicle which obtained a 30 mile per gallon average might be permitted to travel 60 miles per hour, while a vehicle that only obtained 15 miles per gallon would be constrained to travel at 50 miles per hour. The significant difference in speed then is perceived as a trade off between elapsed travel time and larger, heavier vehicle amenities. Such a policy would create a strong incentive among consumers to purchase lighter weight, higher fuel efficiency vehicles, thus significantly reducing the enormous demand for non-renewable resources (oil, iron, aluminum) represented by the automobile industry. A government energy policy should not merely penalize all forms of energy consumption, rather it should consciously encourage actions which improve end use efficiencies in those necessary areas when transitions to renewable energy forms or generically different modes of service require substantial load times and capital investment.

As a final note, the safety aspects of the graduated speed limit with increased speeds for smaller light weight cars should be explored thoroughly. The requirement of air bags and other safety engineering features for new cars permitted to exceed 55 miles per hour may be reasonable.

PROGRAM MEASURE NO. 6.--WEATHERIZATION

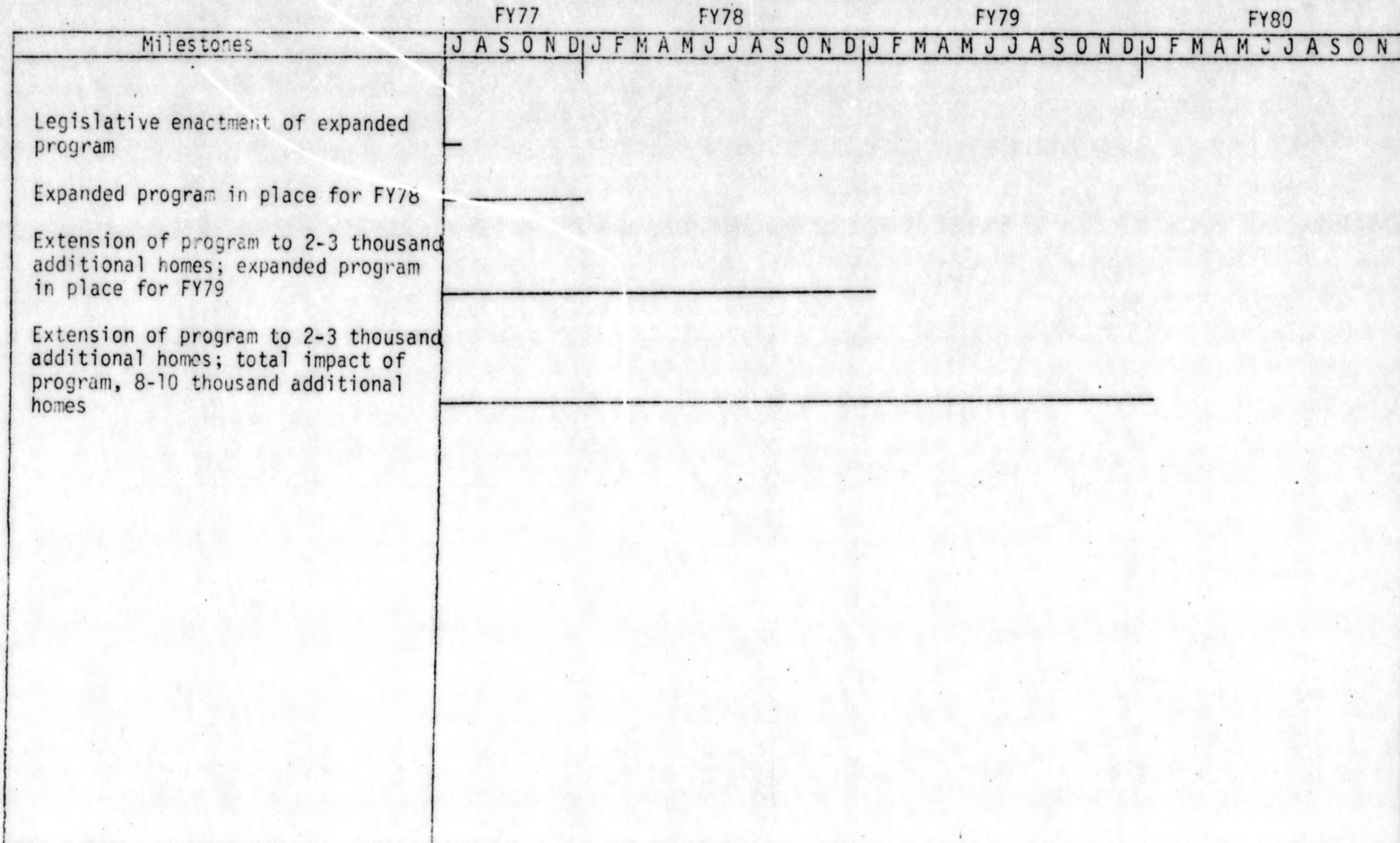
Narrative Statement

The federal government's cooperative weatherization program already has proved to be an effective method of reducing heat loss in Montana homes. Approximately two thousand homes have been upgraded with demonstrated energy savings ranging from 15 to sometimes more than 40 percent of previous energy consumption levels (depending on the quality of the existing construction). Still, nearly 30,000 additional low income households in the state are eligible for energy conservation renovations through the program. The state is committed to a significant expansion of the weatherization program in order to reach a substantial number of these homes. The results will be an immediate documentable energy savings together with a needed reduction of the burden of rapidly rising heating costs upon those in Montana who are least able to afford them. The extensive state commitment is justified further by the availability of federal weatherization funds from the Community Services Administration at a sixty-to-forty match ratio and under Title 20 of the Social Security Act, a three-to-one match ratio.

The state will utilize $150,000 per year for FY78 and FY79 to generate an approximate additional $450,000 per year in federal funds. This commitment amounts to an approximate tripling of the resources of the existing program. Implementation of the program will be done within the existing framework of joint administration by the Department of Community Affairs and the Department of Social and Rehabilitation Services. The combined federal and state weatherization funds will be allocated to local weatherization programs on both a formula and project basis. One half of the funds will be disbursed to local programs according to the incidence of eligible households, and the remaining one half will be allocated on the basis of

Table C18

MILESTONE CHART



PROGRAM MEASURE NO. 7--CONSERVATION LOAN PROGRAMS

Narrative Statement

Two basic economic factors tend to reduce consumer interest in energy conservation: 1) the costs of correcting inefficient uses of energy generally are greater than original construction or installation costs of appropriate conservation measures; and 2) a discrepancy exists between the average and marginal costs of energy supplied to the consumer on the one hand and the marginal cost to the energy supplier for providing additional units of energy to meet growing consumer demand on the other hand. This second factor is the most serious impediment to rational allocation of capital for conservation. The formulas for determining retail cost of energy to consumers aggregates the more expensive new conversion plants and fuel reserves with the less expensive existing plants and fuel resources. This averaging of old and new costs underestimates the true economic value of end use energy conservation relative to the economic costs of increasing energy supplies and delivery capacity.

Clearly, a need exists to achieve an equilibrium between the marginal life cycle costs of saving a unit of energy through demand reduction and the marginal life cycle cost of converting and delivering an additional unit of energy through supply expansion. The energy conservation loan program promotes this objective through state government encouragement of life cycle energy investment decisions.

Historically, Montana has been a captial-poor state. Most of the wealth generated by the resource extraction and processing industries has accrued to out-of-state investors. This primary flow of capital out of Montana severely restricts the ability to finance in-state economic development, particularly that of small businesses with limited credit ratings. With the 1975 enactment of the state tax on coal extraction levied at thirty percent of the mine-mouth market value, an opportunity exists to build in-state capital. This coal tax revenue exceeded sixty-one million dollars in the 1976-1977 biennium and is forecasted to approach one hundred million dollars for the 1978-1979 biennium. These state revenues will continue to escalate as the market value of Montana coal increases and as extraction rate expands to meet rational demands for low-sulfur coal.

The people of Montana recognized the fiscal danger of a situation in which large sums of coal tax revenue could be spent unwisely for short term governmental projects and services which do not contribute to the future strength of the economy. In 1976, the Montana constitution was amended to create a coal tax trust fund in which twenty-five percent (rising to fifty percent in 1980) of the coal tax revenue would be earmarked as principal to be invested by the state. This investment insures economic benefits to future generations of Montanans when the coal resources have been exhausted.

The central issue regarding this coal tax trust is the legislature's determination of how these funds will be invested. Currently, the state manages an investment program with 627 million dollars of public funds (surplus treasury funds, public employer pension funds, trust funds for schools and universities, etc.). Of these funds, less than 14 percent ($87,166,00) is invested within the state. The small proportion of public funds invested in Montana is a direct result of statutes which govern how the state board of investments must manage the investment program. Operating under the "prudent man rule" (70-309(1) RCM), the board must administer the state's investments as if the public funds were the board members' own personal wealth. The effect of this management policy is an institutional inability to consider the many indirect economic benefits which accrue to the state government as a result of in-state investment of public capital.

Since the potential positive impacts on Montana's employment, property values, taxable corporate and personal income, and other economic factors cannot be considered in the board's investment decisions, the only criterion of concern is maximizing the rate of return on the investment instrument itself. This narrow view of the public interest served through the state's investment policy perpetuates the flow of public capital to out-of-state investments which offer higher yields and perhaps lesser risk in some cases than are available from in-state investment opportunities. While it is recognized that there are certain additional investment rules for managing many of these public funds (i.e., trust and legacy funds, public employee retirement funds) which compel maximum interest rates of return, there is no specific requirement that the newly created Coal Tax Trust Fund be restricted to those same single-focus investment principles.

We recommend that the Coal Tax Trust Fund be created as a separate account of the state's unified investment program to be managed by the Board of Investments according to rules and objectives specifically established for this trust. The primary requirement of this fund is that investments of coal trust monies must be made within Montana. These investments can be in the form of time deposits of trust funds with banks, savings and loan associations, and credit unions throughout Montana which then can be issued as loans to Montana citizens, purchases of local government bonds, and purchases of revenue bonds issued by in-state businesses.

It is recommended further that loans of state coal trust funds on deposit at in-state financial institutions should be prioritized to promote, through power interest rates, investments which conserve energy in homes, farms, public institutions, businesses, and industry. The scope of eligible conservation investments should be sufficiently broad to include building improvement measures (such as insulation, thermal windows, more efficient furnaces, electric load management devices, flow reduction water faucets, etc.), consumer loans (such as purchases of energy efficient automobiles, refrigerators, etc.), and large commercial loans for investments in total energy systems, industrial co-generation of process steam and electricity, waste heat recovery systems, and other energy conserving equipment or processes.

In addition to loans for investments which conserve our non-renewable resources, the trust fund also should promote investments in systems which convert renewable energy sources (sunlight, winds, biomass, and small scale hydro-electric generation) into useful energy supplies. Such investments should be made only in those renewable energy technologies demonstrated to be technically feasible and cost-effective on a life-cycle cost basis. Montana's current alternative energy grant program should be utilized in substantiating the eligibility parameters for renewable energy investments covered by this coal trust loan program.

<u>Estimated Energy Savings for Calendar Year 1980</u>

It is estimated conservatively that fifty million dollars will be available under this program by the end of calendar year 1980. We then will assume that twenty million dollars of this fund actually is loaned for conservation retrofitting in existing residences and businesses and that an additional ten million dollars in local government revenue bonds for local government conservation retrofit programs are issued. Thus, we assume that fifteen million dollars in residential retrofitting takes place by 1980 along with fifteen million dollars in commercial and government retrofitting. For approximately fifteen hundred dollars, an average existing Montana residence can reduce its fuel consumption by 50 percent or 75 million Btu's per year. Thus, fifteen million dollars will retrofit over 9900 residences for an end use energy savings of .75 trillion Btu's. If 80 percent of this savings is in fossil fuel and 20 percent is in electricity, the total energy savings (according to the FEA methodology) will be 1.08 trillion Btu's. In commercial and government retrofit, fifteen million dollars is assumed to save 100,000 Btu's per square foot per year for $3 per square foot. Thus, the end use energy savings in the government and commercial sectors in 1980 is .5 trillion Btu's. Again, assuming that 80 percent of the energy savings is fossil fuel and 20 percent is electricity, the total commercial and government 1980 energy savings using FEA methodology would be .73 trillion Btu's.

The total 1980 energy savings from implementing this program measure thus are calculated conservatively to be approximately 1.8 trillion Btu's. This calculation assumes that only 60 percent of the available trust fund money actually is invested in conservation retrofit. Potential savings may be twice our reported figure.

Table C20

MILESTONE CHART

Milestones	FY77						FY78												FY79												FY80											
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Program is enacted by the legislature and goes into effect	—																																									
Administrative procedures arepromulgated	—	—	—																																							
Loan interest loans become available	—	—	—	—	—	—																																				
State begins to purchase revenue bonds																																										

Table C21.--Costs of Implementation

1977	$50,000
1978	$50,000
1979	$55,000
1980	$55,000

The estimated costs of implementation reported here are strictly administrative costs. In addition, the state will lose income due to the preferentially low interest rates that it accepts on in-state investments. This could amount to $150,000 for the year 1980 alone. The state also would receive additional income from the multiplier effect of investing its funds within the state. This additional income cannot be quantified at this time.

PROGRAM MEASURE NO. 8--RENEWABLE ENERGY TAX CREDIT

Narrative Statement

In recent years, public interest in renewable energy conversion systems has risen dramatically from an attitude of curious amusement to a growing consensus that solar and wind energies will be major energy sources in the future. While belatedly gaining recognition as the long term solution to our crisis of non-renewable energy dependency, solar energies have not been widely perceived yet as near term energy supply options. This reluctance to accept one of the next century's primary energy supplies as the decade's reasonable energy option stems from many factors.

The rapid escalation of fossil fuel prices has been in effect for only the last few years, and there remains much confusion over whether these inflationary pressures will persist indefinitely. This same short period of fossil fuel supply constraints and price rises also marks the beginning of serious consideration of renewable energy alternatives. Hence a widespread unfamiliarity with the technology of their conversion and use exists. There is also the economic condition of the average cost of conventional energy supplies to the consumer being substantially less than the marginal cost to the supplier for providing new units of depletable energy. This dilution of the new cost of energy among the lower priced, on-line supplies delays the impact on the consumer; and it also reduces the apparent cost effectiveness of renewable energy systems which displace the need for depletable energy consumption. Of no small significance is the immature status of this fledgling industry. Cost reductions through larger scales of production and innovative materials and designs have not yet reached the marketplace. And finally, our tax system biases the flow of capital by offering investment tax credits, amortized depreciation, depletion allowances, etc. for large scale corporate efforts to extract, convert, and deliver more non-renewable energy, while individual or family investments in durable, value-producing goods (like a solar water heater or wind generator) are ignored as frivolous consumer purchases.

To compensate for these conditions which artificially depress the market for renewable energy systems, we recommend that Montana enact a six year tax credit for investments in purchasing or constructing and installing such systems. This credit would be against a taxpayer's state income tax liability and would be offered on two different schedules. For installations on a principal dwelling unit, a credit of 40 percent of the first $1,000 cost and 20 percent of the next $3,000 cost of the system is available. For installations on real property used in business or trade, the credit would be 40 percent of the first $3,000 and 20 percent of the next $9,000 cost of the system. If the federal government were to enact similar tax credits, the state credit would be reduced, but not eliminated, in order to complement the federal incentive. Renewable energy systems purchased and installed after the six year period would not be eligible for the state's tax credit because we believe the market stimulating purpose of the incentive will have been accomplished.

We further recommend that for this same six year period, a taxpayer who installs a renewable energy system may choose to amortize the full value of that system over a sixty month period. Such amortization would be allowed as a deduction from that taxpayer's adjusted gross income computed for state income tax purposes.

Table C22

MILESTONE CHART

	FY77						FY78												FY79												FY80											
Milestones	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Renewable energy tax credit adopted by the legislature and enacted into law																																										

Estimated Energy Savings for Calendar Year 1980

The tax credit definitely will encourage solar hot water heaters. For the purposes of this analysis, we will assume that the average Montana home hot water heater requires 28.7 x 10^6 Btu's per year. Solar hot water heaters can provide up to 80 percent of the average Montana domestic hot water heating needs at a reasonable cost of about $1,000 per heater. This cost is reduced to $600 per heater by the tax credit. The life cycle cost of the solar energy used is decreased from $2.96/mm Btu's to $1.77/mm Btu's (about the cost of natural gas now). If we assume a 1 percent per year remodeling rate, 6,400 Montana homes in 1980 will have solar water heaters. This would represent a savings in fossil fuels and electricity of .249 trillion Btu's in 1980 (70 percent fossil fuels, 30 percent electricity + electricity conversion factor).

It is very likely that many other renewable energy systems will be purchased under this program; however, it is impossible to project exactly what they might be or what energy savings might occur.

Table C23.--Costs of Implementation

1977	Adminis[illegible]ative costs will be assumed by the De[illegible]tment of Revenue	
1978	$800,000	Tax credit
1979	$800,000	Tax credit
1980	$800,000	Tax credit

PROGRAM MEASURE NO. 9--PUBLIC UTILITY MEASURES

Narrative Statement

Utility Rate Structure Study

With the exception of fuel used in transportation, the vast majority of energy consumed in Montana is marketed through the fixed utilities which distribute natural gas and electricity. The signals which stimulate consumer decisions on the use of these energy forms are the prices which depend on the rate structure that is approved by the Public Service Commission. It is imperative that the impact of rate schedules on electricity and gas demand be analyzed thoroughly to identify whether the efficient use of energy is encouraged through the regulatory policies of the commission.

Consumer demand for energy primarily is a function of price; but the effect of price on demand varies with the degree to which a particular demand exceeds those basic energy requirements that must be satisfied irrespective of costs. This variable effect of price on levels of consumption is referred to as the elasticity of demand. Energy needs for physical comfort, hot water, cooking, and power for refrigeration and lights are less susceptible to reduction because of price than energy needs would be for additional space heating, illumination, convenience appliances, and other energy consuming goods and services which exceed that irreducible level of minimum energy requirements. The reduction of energy consumption is most likely to occur in those marginal end use categories, particularly if state policy intends to maintain equitable minimum energy supplies for all citizens.

Current utility rates for natural gas and electricity are charged on a declining block schedule in which the per unit price decreases as the level of consumption increases. Historically, as the demands on utilities grew, the costs of supplying electricity or natural gas decreased with larger scale production and distribution facilities. This trend has been reversed in recent years, and it is clear that increased energy supplies will cost substantially more at the margin than the costs of on-line supplies. In Montana, this escalation of new energy supply prices is particularly apparent since the predominant role of hydroelectric generation is being superseded by coal-fired generation capacity; and new natural gas prices continue their steep rise above cost levels that were in effect only two years ago.

With the costs of supplying consumer demands for natural gas and electricity escalating, the appropriateness of declining block rates which promote additional consumption must be evaluated as to their implications for conserving energy and equitably allocating costs among customers according to the utility costs of serving their particular needs. The Montana Consumer Counsel recently granted funds to assist the Montana Power Company in conducting a load characteristic study of randomly selected residential, commercial, and industrial customers. By monitoring these customers' demands for electricity as a function of time, the utility company will be able to identify the contributions each customer class makes to the system's energy supply and demand capacity requirements.

It is recommended that this study be augmented with a simultaneous one year analysis of the operations of the Montana Power Company (and other major utilities if funds permit) to determine the utility's real costs of providing electric power to all customer classes. Without an accurate assessment of capital and operational costs of providing electric power, the validity of the current rate structure in relation to customer load characteristics cannot be determined fully.

The significant issue of integrating renewable energy conversion systems (solar heating equipment or wind electric generators) with utility networks also should be addressed by this customer load study. There are a limited but growing number of buildings in Montana that are solar heated. We recommend that a selected number of these buildings be incorporated into the load study to identify the characteristics of their auxiliary energy demands and to determine how their heat storage capabilities can be used for electric load management purposes.

After one full year's analysis of utility costs of service and customer class load characteristics, the Consumer Counsel and the Public Service Commission should determine whether the existing rate schedules accurately charge just and reasonable rates to customers according to their responsibility for electric service costs incurred for their benefit. This assessment also should consider the long run marginal cost of service for continued expansion of the utility system. With the completion of this review, the Public Service Commission should recommend an electric utility rate schedule which may reflect more accurately the true costs of service and which will support the conservation of depletable energy resources.

Encouraging Industrial Co-generation of Process Heat and Electricity

Many of Montana's energy intensive industries consume huge quantities of natural gas for producing process heat and steam necessary for their operations. There are promising opportunities for this process steam to be applied to generate electric power in addition to supplying heat and mechanical power. A National Science Foundation study estimates that current industrial co-generation represents only five percent of the total capability for implementing this dual purpose energy use in the United States. That same study estimated that the Hoerner-Waldorf paper mill in Missoula has a capability to generate 35 megawatts of electricity in conjunction with its on-going operations; and the oil refinery complex in Billings represents another major prospect for co-generated electricity.

Since the mechanical and thermal energy of the steam used for industrial generation of electricity is applied subsequently to other industrial processes, the total end use efficiency of the raw source energy is substantially higher than those conversion efficiencies characteristic of central electric generating stations. By implementing conversion technologies which increase end use efficiencies, industrial co-generation can accomplish multiple purposes with a given amount of fuel, thus avoiding the need for redundant and thermodynamically less efficient electric generation capacity in the utility system.

With thorough auditing of each industry's energy consumption and specific energy requirements, the technical feasibility of co-generation can be determined for specific facilities or processes. The existing utility rate schedules for industrial users provides electric power at costs far below the average cost to residential and commercial users and even farther below the marginal costs of new electric power capacity. As these utility rates are evaluated and possibly revised, the economic feasibility of industrial co-generation also may be enhanced as the most cost effective investments in power supply are identified.

We recommend that the Public Service Commission analyze the potential for industrial co-generation as determined from the detailed energy audits to be submitted in compliance with the state's emergency energy allocation plan. The commission also should assess whether the "Electric Supplier's

Territorial Integrity Act of 1971" (70-501 RCM) prohibits industrial or commercial co-generation of electric power. This law provides that "...an electric utility shall have the right to furnish electric service to any industrial or commercial premises if the estimated connected load for full plant operation at such...premises will be 400 kilowatts or larger within two years from the date of initial service..." (70-503(3) RCM).

A final issue deserving the commission's attention is whether existing electric utilities should be required to enter into purchased power contracts with those industries whose co-generation capabilities exceed their own private electric requirements. In those cases where the co-generated electricity is reliably available at a cost less than what the utility company could provide from its own facilities, the utility should show cause why it would refuse a co-generated electric sales offer. In lieu of this requirement, the designation of common carrier status for fixed energy utilities should be reviewed for its impact on improving the marketability of electric power generated by industry within Montana.

Energy Audits of Large Commercial and Industrial Utility Customers

On May 30, 1975, the Montana Public Service Commission exercised its emergency rule making authority by ordering natural gas utilities to prepare (in conjunction with major industrial and commercial gas users) energy conservation plans for improving the efficiency of energy usage by those large customers. If a utility customer did not file an emergency conservation plan by a specific date or if their plan was deemed insufficient by the commission, the commission then could impose a monthly penalty curtailment of natural gas up to ten percent of the amount used by the offending customer during the same month of the previous year. This emergency order actually was not served upon utilities until September 1975. Under the Montana Administrative Procedures Act, the commission was required to conduct a hearing on this emergency order within six months of its imposition. During this time, there was no formal compliance by the utility companies nor by their major natural gas customers. In February 1976, this emergency order expired through default when the commission decided not to conduct the mandatory public hearing.

The need for an accurate audit of how natural gas and electricity are used by large industrial and commercial customers is more pronounced in 1977 than it was in 1975. Significant curtailments of industrial interruptible gas supplies are forecasted for the immediate future, and there are indications that the Bonneville Power Authority may begin to reduce electric power sales to large industrial customers in northwest Montana. With the severe weather conditions in the eastern United States and federal considerations of emergency allocation of interstate natural gas supplies, Montana should prepare a comprehensive emergency energy conservation plan which would minimize the economic disruptions of a statewide or national energy emergency.

We recommend that the Montana Public Service Commission order all utility companies and their major industrial and commercial customers to immediately prepare detailed evaluations of energy use in their operations and to prioritize those energy needs according to the basic minimum requirements of each customer. These energy audits should be submitted to the Public Service Commission for review and inclusion in a statewide emergency energy allocation plan.

Estimated Energy Savings in Calendar Year 1980

The energy savings expected under this program measure are speculative. An energy conservation rate structure that goes into effect in calendar year 1980 obviously will save energy; co-generation of electricity and process steam also will save energy. In addition, the required industrial and large commercial energy audits will disclose areas in which energy can be saved in a cost effective manner.

It is anticipated that the combined effects of all of these measures will be a projected 1980 electric energy demand that is reduced by at least 1 percent. If residential and commercial electric energy demand grows at 3 percent per year and the other demands (primarily industrial) remain constant, the projected 1980 energy savings will be at least 1.14 trillion Btu's (11,300 Btu's per Kwhr).

Costs of Implementation

Again, implementation costs (see Table C25) for this program measure are speculative. It likely will require extra personnel to expand the consumer council study. Placing major additional requirements on the Public Service Commission also will require additional staff. We project that at least two additional staff people will be required for the Public Service Commission during 1977 and 1978, with an additional two people required for 1979 and 1980.

Table C24

MILESTONE CHART

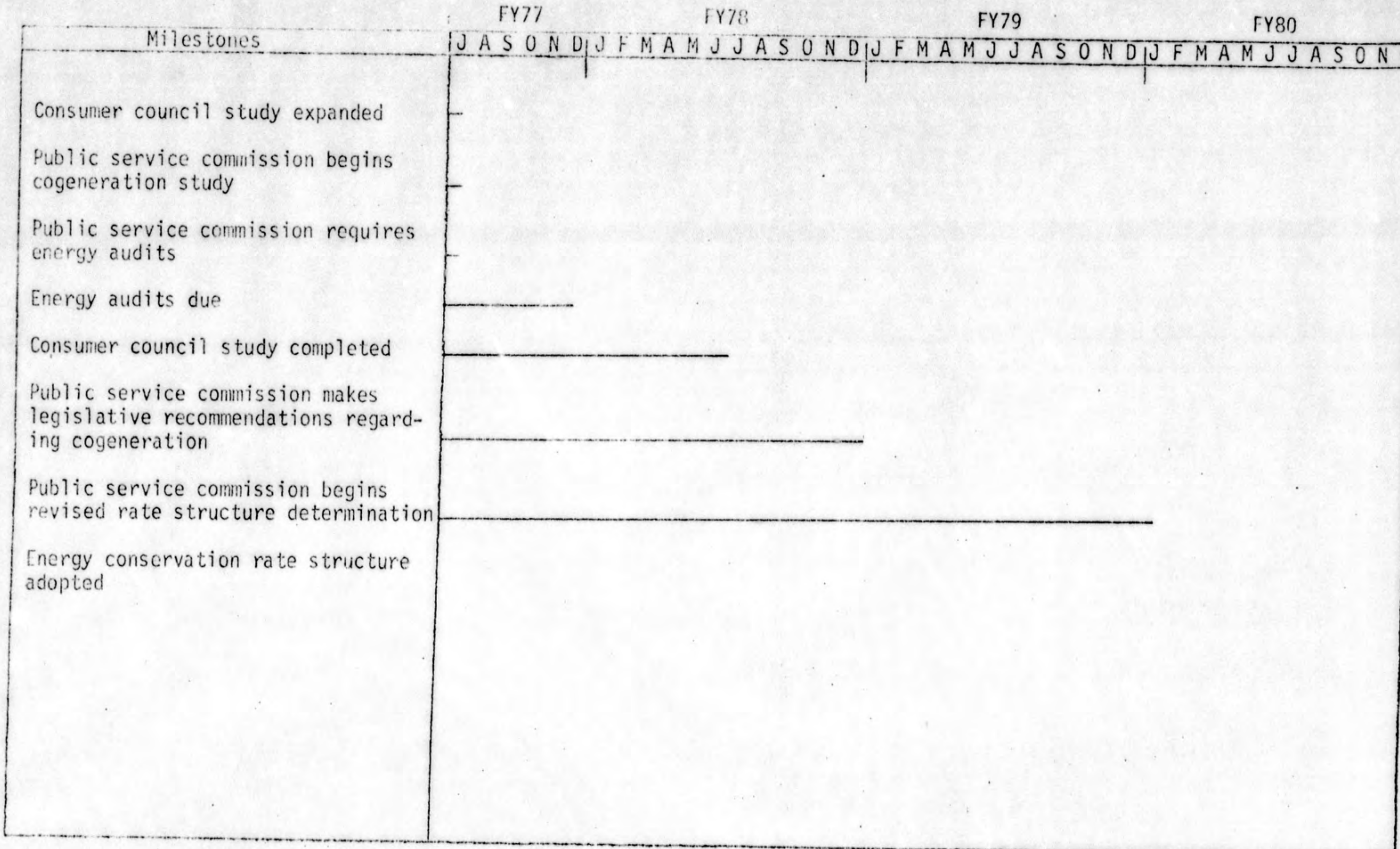


Table C25.--Costs of Implementation

1977	$ 50,000 (estimated)	Expanded Consumer Counsel study
	50,000	Public Service Commission staff
1978	50,000	Public Serivce Commission staff
1979	100,000	Public Service Commission staff
1980	100,000	Public Service Commission staff

PROGRAM MEASURE NO. 10--ENERGY CONSERVATION EDUCATION

Narrative Statement

Commitment to a coordinated program of public education in energy conservation may prove to be the most effective method of saving energy, especially in the long run. Thus, education is central to our plan. The following reasons are offered for placing high priority on educational measures:

a. since self-interest is a powerful individual motive, education can promote awareness of energy savings choices which are free from negative impacts;

b. voluntary compliance is the most acceptable form of behavioral modification in a democracy, and bureaucratic costs are minimized in an education program;

c. energy conservation is a positive and popular ethic (shared by many social groupings in Montana) which can be expressed in a comprehensive education program; existing programs and resources can be integrated to achieve maximum effects; and

d. proven energy saving methods exist for every energy consuming sector of our society simply waiting to be communicated to people; there also is likely to be significant spillover or demonstration effects from sector to sector.

The greatest value will result from an educational program which involves and orchestrates the activities within all major mediums of communication including schools, vocational and adult education, university system outreach, distribution of pamphlets and other materials, print and broadcast channels, demonstration projects, community display programs. This program measure has three components which address the need:

a. confirmation and expansion of existing programs centered in one or more of these mediums;

b. promotion and support of new and innovative programs for mediums previously lacking attention; and

c. provision of a state organizational framework for the continuing coordination of public and private education efforts in all mediums.

The key element in the education program measure is the creation of the coordinating mechanism. The state's Energy and Resource Policy Office (ERPO), proposed in the 1977 legislative session, is intended to provide the focal point for integrating energy conservation education and the conduit for channeling future funds for energy conservation research studies. The advisory council of ERPO, composed of representatives of major state agencies which implement other conservation program measures, is intended to provide visible state leadership through both the example of energy conservation in state operations and the aggressive support of education efforts in other mediums support. Thus, the advisory councils may be charged with the following tasks:

a. reviewing expenditures within programs of the university system, the public education system, and the cooperative extension service;

b. monitoring all other programs developed by private groups;

c. providing comment and review of education programs instituted for state and local government agency personnel; and

d. evaluating possible duplication in state efforts, such as programs of alternative energy development, energy conservation research, and energy conservation education.

The role of ERPO in these functions will be coordinated with the existing Citizens Advisory Committee on Energy (CACE). The membership of this committee is appointed by the governor and represents a broad spectrum of interests within the state. The task of CACE is to increase citizen participation in the process of developing the state's energy policies. Subcommittees have been formed to deal with energy conservation, alternative energy and technology, legal issues, and natural gas reserves. This same framework could be applied to address future energy issues within ERPO. The Citizens Advisory Committee has a $56,000 budget request before the legislature to continue its activities.

The Office of Energy and Resource Policy and the Citizens Advisory Committee on Energy will have input regarding other efforts to develop a core program of energy conservation education in the state. Two measures currently before the legislature will provide an expanded state role in energy conservation education. These are proposals to develop an energy conservation extension service and an energy conservation curriculum in the public school system.

The energy conservation extension service will be expected to utilize and expand the existing agricultural extension service to provide practical energy conservation and renewable energy information to citizens throughout the state. The possibility of coordinating with the recently approved federal energy extension service under the Energy Research and Development Administration (ERDA) is being explored. ERDA was appropriated $7.5 million for fiscal year 1977 to create an energy extension service utilizing existing organizations at the state and local levels which have established constituencies and distribution channels for providing information. ERDA will tailor this informaton to the conditions and needs of each individual area. Montana's efforts in developing an energy conservation extension service will be linked with ERDA's program.

The revised codes of Montana, Section 75-7509, require that conservation education be part of school curricula. Pupils are required to have a widespread understanding of conservation facts, principles, and attitudes. Conservation education is required to be integrated with instruction in related courses. The Citizen's Advisory Committee on Energy recommends that this provision be expanded by legislation to encourage opportunities for every student in the public school system in the state of Montana which emphasize a) principles of ecology, b) environment of Montana, c) energy conservation, and d) private enterprise and the market economy. The legislature is expected to act on this matter either through resolution or specific legislation.

While significant efforts must be made in the direction of creating innovative programs, it is equally important to sustain and coordinate a wide variety of existing private and public programs addressing many facets of the energy conservation problem. The Office of Energy and Resource Policy can provide strong leadership in the cultivation of a shared public conservation consciousness by promoting and assisting the efforts of programs such as the following currently existing examples:

1. Human Resources Development Councils in eleven areas of the state. The councils provide practical energy conservation and renewable energy information and administer the statewide weatherization program.

2. Montana University System. The universities and colleges of the state provide a tremendous reservoir of talent and information on energy systems, energy conservation, and renewable energy. Funding proposals are before the state legislature this session.

3. Citizens Groups. Various citizens groups such as the League of Women Voters, American Association of University Women, the Alternative Energy Resources Organization (AERO), the Environmental Information Center, and numerous others are sources of information on energy conservation. The activities of these groups should be encouraged since they provide "grass roots" contact with the citizens of the state.

4. Utility Company Advertising. The various utility companies in the state currently are advertising the benefits of energy conservation. The continuation and expansion of this program will account for measurable energy savings.

5. Adult Education Programs. For example, the Institute of the Rockies, an educational group in Missoula, currently is planning a statewide seminar program which will focus on energy, technology, and lifestyles.

It is expected also that the Office of Energy and Resource Policy will provide long-range leadership in the stimulation of new ideas in energy conservation. In addition to dispensing available monies for research in this area, the office itself should be the source of new ideas and assume responsibility for their formulation into policy initiatives.

Estimated Energy Savings for Calendar Year 1980

It is extremely difficult to establish precise figures for the amount of energy savings expected from comprehensive education efforts. The reasons are evident:

a. the truly significant amounts of saving are expected to show beyond the immediate short run when the effects of adoption of a conservation ethic are apparent;

b. the full spectrum of conservation education activities is not known, nor is it certain which activities can be attributed solely to the program set in motion by the state in response to ECPA; and

c. much of the energy savings attributable to education efforts must be measured indirectly, e.g., in the case of a program which stimulates participation in an incentive program such as solar loans or tax incentives (whose savings are measured directly).

For the purpose of illustrating the multitude of possible energy conserving targets, a sector breakdown including programs, principal mediums of communication, and expected range of savings follows:

Table C 26.--Examples of Energy Conservation Education Programs

Programs by Sector	Medium	Expected Savings
1. Residential		
a. insulation and temperature modulation	schools, pamphlets, prints, & broadcasts	immediate
b. publicity on tax incentive, loan, & weatherization programs	schools, pamphlets, prints, & broadcasts	immediate

Table C26.--Continued

Programs by Sector	Medium	Expected Savings
c. publicity on alternative energy generation	demonstration projects, community display	intermediate
2. Commercial		
a. same as residential, a, b, & c		
b. competitive energy savings demonstration projects	demonstration projects	intermediate
c. life cycle costing	pamphlets, demonstration projects	intermediate
3. Industrial		
a. energy auditing	pamphlets, workshops	intermediate
b. systems energy management	pamphlets, workshops, training	immediate
c. cogeneration	pamphlets, workshops	long-range
4. Transportation		
a. driver training, operation, maintenance	schools, vocational coop extension	immediate
b. energy efficient auto purchases	multiple, pamphlets	immediate
c. car pooling promotion	multiple, demonstration projects	immediate
d. alternative transport, bicycles, pedestrian	multiple, pamphlets	immediate
e. mass transit	multiple, demonstration projects	intermediate

Table C26.--Continued

Programs by Sector	Medium	Expected Savings
5. Agriculture		
a. cropping and fallowing	coop extension, pamphlets, demonstration	immediate
b. natural fertilizing	coop extension, pamphlets, demonstration	immediate
c. biomass conversion	coop extension, pamphlets, demonstration	intermediate
d. wind power	coop extension, pamphlets, demonstration	intermediate
6. Government		
a. agency training	workshops, pamphlets, demonstration projects	immediate
b. intergovernmental transfers	workshops, pamphlets, demonstration projects	immediate
c. private activity transfers	demonstration projects, pamphlets, prints, & broadcast media	intermediate
e. "model" renewable energy demonstration projects	demonstration project	intermediate-long-range

Notwithstanding the problems of calculating actual energy savings, the total potential can be estimated. Estimates are based on methodologies used by Skidmore, Owings and Merrill (SOM) of Portland, Oregon, for the Bonneville Power Administration to establish the effectiveness of energy conservation education programs used or proposed by both public utilities and state agencies. SOM projected that a coordinated educational program implemented by states and utilities could save 3 percent of the overall projected 1980 electric consumption in the Pacific Northwest. The proposed Montana program is even more extensive than those studied. According to SOM, the largest savings appeared possible in the commercial sector (5.8 percent), while the smallest savings took place in the industrial sector (2.5 percent). Residential savings amounted to 2.75 percent. While the SOM study focused only on electricity, Montana's educational program will focus on all energy consumption sectors and energy forms.

Based on SOM figures, we estimate conservatively that our program will reduce projected 1980 electrical consumption by 2 percent in the residential sector, 4 percent in the commercial sector, and 0.1 percent in the industrial sector. (Montana's industrial electrical consumption is dominated by an aluminum reduction plant with relatively fixed electrical consumption.) Since data on projected 1980 energy consumption by sector is unavailable, a conservative estimate places the growth of electrical energy consumption in the residential and commercial sectors at 3 percent annually and assumes constant industrial consumption. Thus, overall savings will equal 172.2 million kilowatt hours or 1.98 trillion Btu's (11,300 Btu's/Kwhr) in 1980.

In natural gas use, a conservative estimate sets 1980 consumption at the same level as that in 1975. Assuming a 3 percent reduction in residential and commercial sectors and a reduction of 2 percent in the industrial sector caused by educational programs, a total savings of 1.97 trillion Btu's for 1980 can be calculated. Using the same assumptions, a savings of .70 trillion Btu's of propane and fuel oil is counted. (Estimates in this sector are based on simple behavioral changes. For example, a program encouraging thermostat control--68°F day, 60°F night as opposed to a constant 70°F setting--can save nearly 15 percent of gas consumption in a typical residence.)

Finally, educational programs addressing transportation will influence people to buy smaller cars, radial tires, and other fuel savings options. Educational programs to promote proper driving and maintenance habits will also save energy. It is assumed that programs such as these can influence 15 percent of the motor vehicle users in Montana to procure and operate motor vehicles in a manner that would reduce their vehicular energy consumption by 10 percent, producing a 1.5 percent overall decrease in transportation energy consumption in 1980. This reduction amounts to 1.18 trillion Btu's under the assumption that transportation energy consumption will grow by 3 percent annually.

The total energy savings for 1980 from these educational programs is projected at 5.83 trillion Btu's, a figure likely to be lower than the actual savings. The source of data used to reach these conclusions is Montana Historical Energy Statistics (Terry Wheeling, Montana Energy Advisory Council, September, 1976). All consumptions used are stated explicitly therein. It should be emphasized that these projected savings are separate from those calculated for the other program measures. The savings associated with educational programs leading to participation in measures such as the conservation loan program or the renewable energy tax credit have been counted as part of the direct savings within those programs.

Costs of Implementation

As in the case of estimated energy savings, the costs of the programs in energy conservation education are difficult to calculate because of the close interface between public and private efforts and the problem of demarcating direct and indirect costs. The true value of the overall conservation program undoubtedly is underestimated by the assignable costs

Table C27
MILESTONE CHART

Milestones	FY77 J A S O N D	FY78 J F M A M J J A S O N D	FY79 J F M A M J J A S O N D	FY80 J F M A M J J A S O N
Office of Energy and Resource Policy operational; advisory council constituted and functioning; program coordination underway; long-range policy innovation initiatives begun.				
Program planning developed for implementation in new state funded programs; university system and coop extension.				
Program planning initiated for government agency, intergovernment demonstration projects; feasibility reports of model state demonstration projects by OERP advisory council.				
Office of Energy and Resource Policy legislative recommendations for expansion of energy conservation programs				

since the program benefits from the momentum of existing programs, from the presence of administrative structures in place to administer new programs, and from the existence of substantial materials available for distribution. For these reasons, the program can be considered highly cost effective, even considering the largely unknown probability of public response. Identifiable direct public costs include the following:

Table C28.--Costs of Implementation

1977	ERPO	$144,000
	energy extension service	$ 60,000
1978	ERPO	$144,000
	energy extension service	$ 28,000
1979	ERPO	$160,000
	energy extension service	$ 70,000
1980	ERPO	$160,000
	energy extension service	$ 70,000

Table C 29.--Summary of Program Measure Responsibility in State Agencies

No. 1.	State Building Code	Department of Administration Department of Health and Environmental Sciences Department of Community Affairs
No. 2.	Public Building Lighting Standards	Department of Administration Department of Community Affairs
No. 3.	Procurement; Life Cycle Cost Analysis and Vehicle Efficiency Standards	Department of Administration Department of Community Affairs
No. 3a.	Energy Managing, Auditing, and Retrofitting State Buildings	Department of Administration
No. 3b.	Renewable Energy Demonstration Project	Department of Administration
No. 4.	Right Turn on Red	————
No. 5.	Car Pool/Van Pool: Increase in Transit Level of Service	Department of Community Affairs
No. 5a.	Public Transportation and Railroad Assistance Fund	Department of Community Affiars
No. 5b.	Bikeway Construction	Department of Highways
No. 5c.	Enforcement of 55 m.p.h. Speed Limit	Department of Justice
No. 6.	Weatherization	Department of Community Affairs Department of Social & Rehabilitation Services
No. 7.	Conservation Loan Programs	Department of Revenue
No. 8.	Renewable Energy Tax Credit	Department of Revenue
No. 9.	Public Utility Measures	Public Service Commission
No. 10.	Energy Conservation Education	Energy Resource Policy Office

PROGRAM MEASURES 3, 5a, 5b, 5c, 10--PROGRAM NOTE: CRUDE OIL SAVINGS

Based on recommendations in the "Final Assessment of the Environmental Impacts of the State Energy Conservation Progam" (page 22), the projected savings in evaporative losses in refineries and additional savings in crude oil can be determined. The total gasoline equivalent from the preceding transportation measures is 41,719,144 gallons of gasoline per year. Assuming an efficiency of 91 percent at the oil refining process, the corresponding savings in refinery losses is 3,755,123 gallons of gasoline per year .47 trillion Btu's per year.

ADMINISTRATIVE ANALYSIS

A charge often leveled against Federal Government grant-in-aid programs is that they tend to distort a state's own priorities in the allocation of resources to public policies. Sometimes, the costs to a state in terms of required state legislation, administrative regulations, and/or matching funding requirements outweigh the benefits of the federal assistance. The growth of bureaucratic structure, the expansion of the network of intergovernmental relations, and heightened conflict among officials at national, state, and local levels all have been found to follow the acceptance of federal monies intended to meet a variety of social goals. Each state must carefully weigh for itself the net effect of participation in Federal Government induced programs requiring state compliance procedures.

This evaluation has been applied to the requirements of the Energy Conservation Policy Act. The state has concluded that there are substantial net benefits by complying with ECPA. In the first place, Montanans embrace fully the principle of energy conservation and welcome the commitment of all levels of government in the United States to an aggressive but cooperative program of husbanding the nation's scarce energy reserves. In fact, Montana's leaders have expressed their intention to be the nation's leaders in this vital area, proceeding well beyond ECPA's minimum standards in pursuit of significant long range energy savings through the development of renewable energy. Thus, Montana's priorities are the same as those of all of America in this crucial program, and the ECPA goals complement the state's mission.

In the second place, the heavy emphasis being placed on the voluntary dimensions of energy conservation in Montana, through vehicles such as economic incentive and education programs, allows for minimizing the problems and frictions inherent in changing bureaucratic structures and patterns of intergovernmental relations. Even prior to the ECPA solicitation, the state began considering seriously internal reorganization of several agencies and departments charged with various energy and resource functions. The ECPA stimulus, therefore, has proved to be mainly a catalyzing agent for many activities already set in motion. For this reason, the FEA role in energy conservation is accepted enthusiastically with the expectation that federal funds can assist greatly in the state's own program.

Finally, the introduction of a systematic statewide energy conservation program will create little state-local conflict over implementation strategies. Greater clarification in the state-local division of powers and responsibilities is a basic principle of a proposed new code of local government which is the culmination of a three year study of the powers, capacities, and resources of local governments. The state has the responsibility to require conformance of local governments in those energy conservation matters which are of concern to all Montana citizens. At the same time, maximum flexibility is allowed local governments in designing innovative and imaginative methods of energy conservation and alternative energy generation.

IMPACT ON LOCAL GOVERNMENTS

Just as the ECPA grant mechanism requires some alterations of state policies, the state government, in turn, must revise certain state-local relationships to produce compliance with the federal mandate at the local level. The implementation of an energy conservation plan involving local governments coincides with the last phase of a three year program of local government reorganization whose scope is unparalleled anywhere in the nation. The legislature currently is considering a massive recodification of local government laws which, if adopted, will change dramatically the powers, capabilities, resources, and functions of local governments throughout the state. In combination with existing constitutional provisions, earlier laws, and decisions recently reached by the electorates of many local units in the recently completed voter review process, this recoding signals a new era of maximum local self-determination in Montana. The requirements imposed upon local governments by an energy conservation plan must be weighed carefully in the context of these changes.

A well designed energy conservation plan can take advantage of this expanded local self-determination. Maximum opportunity for innovative conservation and alternative energy development projects at the local level is afforded by several changes in the status of local government:

a. the acquisition of legislative powers by counties previously hamstrung by restrictive state laws which had specified narrowly both the subjects of county resolutions and the procedures of fulfilling county duties;

b. the provision of much broadened service options and more flexible service delivery mechanisms within the revised code for both the counties and incorporated municipalities falling under the category of general powers of local governments;

c. the acquisition of self-government powers status by several local government units enabling them to perform any functions not denied specifically to this class of localities by the legislature;

d. constitutional stipulation that the powers of local government are to be construed liberally by the courts; and

e. constitutional provision of maximum opportunity for inter-local cooperation in developing joint jurisdictional solutions to solve service delivery problems.

The combination of these measures creates a number of possibilities for experimentation in different communities in a wide variety of creative conservation efforts. Those successful in one setting then can be replicated in other communities.

Although the details of the code still are pending possible alterations, it appears that the following examples of local innovation are possible:

a. counties with urban areas outside of the limits of an incorporated municipality have the authority to approve creation of an energy related service delivery function;

b. contiguous local government units can pool resources in the exercise of an energy creation of distribution functions which individual units may be unable to afford;

c. sixteen local government units can initiate unique community energy projects under self-government powers and can be selected for model projects;

d. planning and zoning restrictions do not appear to limit the possibility of alternative energy facilities;

e. provision of community development authority appears to allow a community to develop alternative energy facilities as an element of the fight against "blight and environmental decline;"

f. power is available to create subordinate solid waste disposal districts which could utilize innovative local recovery methods;

g. local traffic right of ways seem capable of being employed as a public use for distributing alternative energy; and

h. capital improvement districts can be established under a variety of user fee mechanisms, including criteria such as "relative usefulness" or "connection," which make it possible to create an alternative energy neighborhood where not all residents are required to participate.

These are but a few examples of the widened latitude provided to local governments in the area of alternative energy and conservation efforts.

They offer a great opportunity for the state to become a leader in testing the validity of the principle of decentralized energy generation and distribution.

The second major area of consideration is the possible friction between state and local levels of government in implementing mandated programs. Here again, the consequences of the three year state review of local government functions is pertinent. There currently is much greater acceptance of the principle of dividing primary responsibility for various service functions between state and local levels. Thus, while a certain activity which is primarily a state responsibility may be delegated to local governments, the delegation must be accompanied by the provision of the resources required to carry out the activity. Adherence to this principle is illustrated by the satisfactory manner in which the problem of local building code inspection has been handled.

The ECPA guidelines clearly do not require the state of Montana to violate the new compact of liberation with its local government partners. Certain conservation areas even afford an opportunity for strengthening the partnership through collaborative compliance with ECPA mandates. Procurement practices provide the best illustration since the state is authorized to select the methods most appropriate to its circumstances for inducing political subdivisions to adapt their practices to state procedures. In Montana, the choice has been made to work through established channels of state-local communicators in the Department of Community Affairs. Within this channel, cooperation and collaboration have been chosen as the method of achieving objectives. To this end, programs of orientation and training at the state level will be offered for local official participation as well. Regularized communication of new developments in training, procedures, or assistance will be made to local officials. State and local officials will participate jointly in planning and implementing future training and review sections. Local governments will be encouraged to participate in state purchasing contracts to maximize energy savings. In each of these respects, the emerging cooperative relationship between state and local governments is reinforced rather than threatened.

In summary, the ECPA mandates introduce no significant dysfunctional variables into the equation of state-local relationships in Montana. The timing is opportune since energy conservation relationships still can be included in the final package being wrapped in the legislature and confirmed as an important part of the bargain struck between state and local governments. There are no consequential bureaucratic costs of compliance resulting from ECPA in the state-local area.

IMPACT ON STATE AGENCIES

The various implementation strategies add mandates within a number of state agencies. Some changes are of immediate concern and require action of the 1977 Montana legislative session. Others can be handled through executive revision of existing administrative structures. The development of a comprehensive and workable energy conservation organizational structure may require both legislative and administrative attention over several years. As in any policy area, the evolution of the ideal bureaucratic structure will involve a sequential process of innovation and revision. This discussion outlines the organizational steps already taken and places them in the context of long range administrative goals.

The current legislative session will establish the Montana Energy and Resource Policy Office (ERPO) within the governor's office as the successor to the Montana Energy Advisory Council (under whose auspices this ECPA submission has been developed). This action will institutionalize the state's commitment to the careful and continuous scrutinization of all policies associated with energy development and energy conservation. A sharp focus and sustained public visibility is achieved by placing this mandate directly under the governor. Maximum coordination of all energy related activities also is produced. Energy conservation and the wise utilization of existing resources thereby is given equal stature with the goal of finding and developing new sources of energy supply.

Under terms of the legislation, energy conservation is given significant standing. ERPO is charged with developing periodic recommendations for energy conservation techniques which will comprise part of a comprehensive state energy policy. These recommendations will culminate in the formulation of a state energy conservation program dealing in further detail with the subjects contained in this report. Special focus is to be placed upon possible savings in the energy related activities of state government and upon public education in methods of energy conservation. Comprehensiveness of scope and coordination of conservation activities are enhanced by the stipulation of ERPO advisory council representation by state agencies dealing in key facets of the state's resource program. ERPO also will coordinate the disbursement of funds for energy conservation research and education.

In addition to ERPO's creation, the intensified concern with energy conservation will produce the following changes in agency structures and mandates. The Department of Administration is given significant additional responsibilities, some of which are to be carried out in conjunction with related state agencies. The Department of Administration is charged with producing the life cycle cost analysis for state buildings and procurement of major energy consuming equipment. The Department of Administration also is assigned primary responsibility for creating and implementing the building code provisions for thermal and lighting efficiency but must work with the Department of Health and Environmental Sciences in developing the code's contents and with the Department of Community Affairs in its implementation by local building code inspectors.

The Department of Community Affairs is given several new or expanded functions as a result of the need to promote conservation at the local level. Expansion of the weatherization program will require continuation of the cooperative effort involving the Department of Social and Rehabilitation Services. No new mandates or unmanageable problems of compliance are imposed by this program. These two agencies already have addressed methods of enhancing efficiency and promoting increased cooperation in achieving the goal of assisting low income persons in saving energy costs. The Department of Community Affairs also will assume a significant responsibility for disbursing funds within the Public Transit and Railroad Assistance Fund.

Finally, the Department of Community Affairs (DCA) will be expected to develop a major role in communication with local governments on a wide variety of energy conservation methods. DCA will be the link between ERPO and the cities, towns, and counties and should play a major role in making available to local officials the latest information on savings in areas such as purchasing, life cycle cost analysis, and training and education regarding building codes. In each of these cases, the added responsibilities will be commensurate with the important role charged to the Department of Community Affairs as the link between the state and local levels in Montana.

The Department of Revenue will have two major new responsibilities: the implementation of tax credit and accelerated amortization of cost systems for promoting installation or acquisition of renewable energy resource equipment and the low interest loan program for installation of energy conserving equipment and devices under the terms of provisions regarding the Coal Tax Trust Fund and the banking system.

Other agencies will be assigned duties consistent with their current primary missions, for example, the Department of Justice in the speed law enforcement program and the Public Service Commission in the state utility rate structure program. The Department of Natural Resources, current sponsors of the state's grant and loan programs for alternative energy development, likely will have a continuing involvement in those conservation activities which interface its mandate. The intergovernmental framework will be complicated in the future by the possible development of a source separation solid waste recovery system within the Department of Health and Environmental Sciences and the consolidation of transportation functions within a new Department of Transportation.

ASSESSMENT OF ENERGY SAVINGS

The energy savings estimated in this plan are based on projections. Projections are a "best guess" of what will happen in the future based on numerous assumptions. If those assumptions do not match reality, the projections will be wrong. There are many variables that simply cannot be quantified. Thus, in addition to adopting the measures outlined, the state must monitor patterns in energy consumption within Montana very carefully to insure that the various program measures are indeed having the desired effect. The worst mistake that the state could make would be to do nothing.

In recognition of this, the Montana Energy Advisory Council's report to the governor recommends that a Governor's Energy and Resource Policy Office should be established. The Energy and Resource Policy Office would have numerous responsibilities. Among them are specific responsibilities related to data collection and analysis. This office will be the central collection point for energy information in Montana. The office would prepare long range projections of the supply and demand for energy in Montana on an annual basis. Specifically, they would collect the data necessary to measure the effectiveness of the program measures contained in this document.

Legislation to create this Energy and Resource Policy Office has been introduced into the Montana House of Representatives (H.B. 204). The charter of the office would be to recommend energy conservation techniques and other appropriate energy policies to the state. Specifically, this legislation assigns the following duties to the Energy and Resource Policy Office.

a. serve as the central repository within the state government for the energy and resource related research carried on in and for the state;

b. prepare recommendations for an emergency allocation plan specifying actions to be taken in the event of an impending serious shortage of energy;

c. undertake a continuing assessment of trends in the consumption of all forms of energy and analyze the social, economic, and environmental consequences of those trends;

d. collect and analyze data relating to present and future demands and resources for all sources of energy and project energy requirements for the state and various service areas within the state;

e. evaluate policies governing the fixing of rates and prices for energy in terms of their relationship to energy conservation and make recommendations with respect to those policies;

f. analyze energy related activities of agencies of state government and make recommendations with respect to those activities;

g. prepare, on a continuing basis, recommendations for a comprehensive energy policy for the state of Montana and study the impact and relationship of the state energy policies to international, national, and regional energy policies;

h. formulate a state program for energy conservation, including without limitation general commercial, industrial, and residential areas and the evaluation of energy systems as they relate to lighting, heating, refrigeration, air conditioning, building design and operation, and appliance manufacturing and operation;

i. inform and educate the public about ways of conserving energy; and

j. develop and prepare on a continuing basis, the policy and plans required by 70-827(1)(a).

D. ENVIRONMENTAL RESIDUALS STATEMENT

The state of Montana has made a commitment to environmental protection. Every citizen's right to a clean and healthful environment is protected constitutionally in Montana.

Environmental residuals specifically were considered in developing this plan from both a state and a national perspective. Environmental residuals were calculated using FEA methodology for each program measure, and no program is included which, in our judgement, has a significant negative environmental impact.

Special consideration was given to programs which would increase the amount of insulation in Montana residences. It is known that certain types of insulating materials present environmental and occupational health and safety hazards both in their manufacture and use. To counteract this potential problem, a bill will be introduced into the 1977 Montana Legislature to prohibit certain uses of specific insulating materials (primarily asbestos) and to develop criteria for safe substitute materials. This legislation was a direct result of our analysis of potential environmental problems related to energy conservation.

In general, we found that a decrease in energy consumption results in positive environmental benefits due to reduced environmental degradation from energy conversion. Also, the aspect of individual participation in energy conservation promotes an increased sense of community and a feeling of participation in an action that is socially important. Thus, participating in a large scale, coordinated energy conservation program may have, in fact, a synergistic environmental benefit. People conserving energy realize that their actions will have positive environmental consequences and hence, may open their eyes to other areas where they can act individually in an environmentally beneficial manner.

The FEA environmental residuals summary follows on the next pages.

TABLE VII-3

TITLE: DIRECT EMISSION FROM DIESEL BUS OPERATION
(Environmental Impact per 10^{12} Btu of Diesel Oil)

Impact	Col. A Coefficient for Reduction	Col. B Energy Reduction	Col. C Resultant Emission Reduction
WATER (TONS)			
Acids	-		
Bases	-		
Dissolved Solids, Mis.	-		
Suspended Solids	-		
Non-Degradable Org.	-		
Biological Oxygen Dem.	-		
Chemical Oxygen Demand	-		
AIR (TONS)			
Particulates	45.7	.01	.457
Oxides of Nitrogen	1296	.01	12.96
Sulfur Dioxide	94.8	.01	.948
Hydrocarbons	127	.01	1.27
Carbon Monoxide	787	.01	7.87
Carbon Dioxide	85000	.01	850.00
Aldehydes	20.7	.01	.207
OTHER			
Thermal Rejection (Btu)	-		
Occupational Death (Men)	-		
Occupational Injuries (Men)	-		
Occupational Man Day Lost (Man-day)	-		
Solid Waste Tons	-		

Note: Data courtesy of FEA.

TABLE VII-4

TITLE: EMISSIONS FROM PRODUCTION AND DISTRIBUTION OF VEHICLE FUELS (Environmental Impact per 10^{12} Btu of Vehicle Fuels)

Impact	Col. A Coefficient for Reduction	Col. B Energy Reduction	Col. C Resultant Emission Reduction
WATER (TONS)			
Acids			
Bases			
Dissolved Solids, Mis.	0.4	5.55	2.22
Suspended Solids	0.76	5.55	4.22
Non-Degradable Org.	2.41	5.55	13.38
Biological Oxygen Dem.	0.76	5.55	4.22
Chemical Oxygen Demand	4.66	5.55	25.86
AIR (TONS)			
Particulates	3.2	5.55	17.76
Oxides of Nitrogen	26	5.55	144.3
Sulfur Dioxide	23.5	5.55	130.43
Hydrocarbons	26	5.55	33.3
Carbon Monoxide	3	5.55	16.65
Carbon Dioxide	–	5.55	
Aldehydes	4.15	5.55	23.03
OTHER			
Thermal Rejection (Btu)	–		
Occupational Death (Men)	0.0007	5.55	.0039
Occupational Injuries (Men)	.05	5.55	.2775
Occupational Man Day Lost (Man-day)	2.5	5.55	13.83
Solid Waste Tons	48	5.55	266.4

Note: Data courtesy of FEA.

TABLE VII-4

TITLE: EMISSIONS FROM PRODUCTION AND DISTRIBUTION OF VEHICLE FUELS
(Environmental Impact per 10^{12} Btu of Vehicle Fuels)

Impact	Col. A Coefficient for Reduction	Col. B Energy Reduction	Col. C Resultant Emission Reduction
WATER (TONS)			
Acids			
Bases			
Dissolved Solids, Mis.	0.4	5.55	2.22
Suspended Solids	0.76	5.55	4.22
Non-Degradable Org.	2.41	5.55	13.38
Biological Oxygen Dem.	0.76	5.55	4.22
Chemical Oxygen Demand	4.66	5.55	25.86
AIR (TONS)			
Particulates	3.2	5.55	17.76
Oxides of Nitrogen	26	5.55	144.3
Sulfur Dioxide	23.5	5.55	130.43
Hydrocarbons	26	5.55	33.3
Carbon Monoxide	3	5.55	16.65
Carbon Dioxide	–	5.55	
Aldehydes	4.15	5.55	23.03
OTHER			
Thermal Rejection (Btu)	–		
Occupational Death (Men)	0.0007	5.55	.0039
Occupational Injuries (Men)	.05	5.55	.2775
Occupational Man Day Lost (Man-day)	2.5	5.55	13.83
Solid Waste Tons	48	5.55	266.4

Note: Data courtesy of FEA.

TABLE VII-5

TITLE: SPACE HEAT, COMMERCIAL, NATURAL GAS
(Environmental Impact per 10^{12} Btu)

Impact	Col. A Coefficient for Reduction	Col. B Energy Reduction	Col. C Resultant Emission Reduction
WATER (TONS)			
Acids	-		
Bases	-		
Dissolved Solids, Mis.	-		
Suspended Solids	-		
Non-Degradable Org.	.02	2.289	.046
Biological Oxygen Dem.	-	2.289	
Chemical Oxygen Demand	-	2.289	
AIR (TONS)			
Particulates	9.25	2.289	21.2
Oxides of Nitrogen	152.06	2.289	348.1
Sulfur Dioxide	.314	2.289	.719
Hydrocarbons	3.95	2.289	9.04
Carbon Monoxide	9.72	2.289	22.25
Carbon Dioxide	61,000	2.289	139629.
Aldehydes	4.9	2.289	11.22
OTHER			
Thermal Rejection (Btu) X 10^9	.89	2.289	2.04
Occupational Death (Men)	.0002	2.289	.0005
Occupational Injuries (Men)	.03	2.289	.069
Occupational Man Day Lost (Man-day)	92.8	2.289	212.42
Solid Waste Tons	-		

Note: Data courtesy of FEA.

TABLE VII-6

TITLE: SPACE HEAT, COMMERCIAL, DISTILLATE OIL
(Environmental Impact per 10^{12} Btu)

Impact	Col. A Coefficient for Reduction	Col. B Energy Reduction	Col. C Resultant Emission Reduction
WATER (TONS)			
Acids	–		
Bases	–		
Dissolved Solids, Mis.	.4	.596	.238
Suspended Solids	.76	.596	.453
Non-Degradable Org.	2.4	.596	1.430
Biological Oxygen Dem.	.76	.596	.453
Chemical Oxygen Demand	4.66	.596	2.78
AIR (TONS)			
Particulates	57.26	.596	34.13
Oxides of Nitrogen	242.98	.596	144.82
Sulfur Dioxide	137.45	.596	81.92
Hydrocarbons	37.17	.596	22.15
Carbon Monoxide	75.00	.596	44.7
Carbon Dioxide	85,000	.596	50660
Aldehydes	11.4	.596	6.79
OTHER			
Thermal Rejection (Btu)	–	.596	
Occupational Death (Men)	.0007	.596	.0004
Occupational Injuries (Men)	.05	.596	.0298
Occupational Man Day Lost (Man-day)	2.5	.596	1.49
Solid Waste Tons	48	.596	28.61

Note: Data courtesy of FEA.

TABLE VII-7

TITLE: SPACE HEAT, COMMERCIAL, RESIDUAL OIL
(Environmental Impact per 10^{12} Btu)

Impact	Col. A Coefficient for Reduction	Col. B Energy Reduction	Col. C Resultant Emission Reduction
WATER (TONS)			
Acids	–		
Bases	–		
Dissolved Solids, Mis.	0.39	.299	.117
Suspended Solids	0.76	.299	.227
Non-Degradable Org.	2.41	.299	.721
Biological Oxygen Dem.	0.76	.299	.227
Chemical Oxygen Demand	4.66	.299	1.39
AIR (TONS)			
Particulates	80.06	.299	23.94
Oxides of Nitrogen	226.9	.299	67.84
Sulfur Dioxide	540.5	.299	161.62
Hydrocarbons	36.4	.299	10.88
Carbon Monoxide	3.47	.299	1.038
Carbon Dioxide	85,000	.299	25415
Aldehydes	7.5	.299	2.24
OTHER			
Thermal Rejection (Btu)	–		
Occupational Death (Men)	.0007		.0002
Occupational Injuries (Men)	.049		.015
Occupational Man Day Lost (Man-day)	2.52		.753
Solid Waste Tons	48.02		14.36

Note: Data courtesy of FEA.

TABLE VII-8

TITLE: SPACE HEAT, COMMERCIAL, COAL (26.2x10^6Btu/ton) (1% Sulfur)
(Environmental Impact per 10^{12} Btu)

Impact	Col. A Coefficient for Reduction	Col. B Energy Reduction	Col. C Resultant Emission Reduction
WATER (TONS)			
Acids	-		
Bases	.99	0	
Dissolved Solids, Mis.	26.7		
Suspended Solids	5.77		
Non-Degradable Org.	-		
Biological Oxygen Dem.	-		
Chemical Oxygen Demand	-		
AIR (TONS)			
Particulates	443.9		
Oxides of Nitrogen	125.8		
Sulfur Dioxide	755.4		
Hydrocarbons	48.34		
Carbon Monoxide	206.1		
Carbon Dioxide	111000.		
Aldehydes	1.33		
OTHER			
Thermal Rejection (Btu)	-		
Occupational Death (Men)	.07		
Occupational Injuries (Men)	1.22		
Occupational Man Day Lost (Man-day)	92.2		
Solid Waste Tons	8,696		

Note: Data courtesy of FEA.

TABLE VII- 9

TITLE: SPACE HEAT, RESIDENTIAL, NATURAL GAS
(Environmental Impact per 10^{12} Btu)

Impact	Col. A Coefficient for Reduction	Col. B Energy Reduction	Col. C Resultant Emission Reduction
WATER (TONS)			
Acids	–		
Bases	–		
Dissolved Solids, Mis.	–		
Suspended Solids	–		
Non-Degradable Org.	.02	3.416	.068
Biological Oxygen Dem.	–		
Chemical Oxygen Demand	–		
AIR (TONS)			
Particulates	9.24	3.416	31.6
Oxides of Nitrogen	127.5	3.416	435.5
Sulfur Dioxide	.31	3.416	1.1
Hydrocarbons	3.96	3.416	13.5
Carbon Monoxide	9.68	3.416	33.1
Carbon Dioxide	61,000	3.416	208,376.0
Aldehydes	4.86	3.416	16.6
OTHER			
Thermal Rejection (Btu) X 10^9	.890	3.416	3.0
Occupational Death (Men)	.0002	3.416	.0007
Occupational Injuries (Men)	.03	3.416	.10
Occupational Man Day Lost (Man-day)	.90	3.416	3.1
Solid Waste Tons	–		

Note: Data courtesy of FEA.

TABLE VII-15

TITLE: ELECTRIC GENERATION, STEAM (COAL-FIRED)
(Environmental Impact per 10^{12} Btu)

Impact	Col. A Coefficient for Reduction	Col. B Energy Reduction	Col. C Resultant Emission Reduction
WATER (TONS)			
Acids	12.1	6.99	84.6
Bases	1.0	6.99	7.0
Dissolved Solids, Mis.	62.5	6.99	436.9
Suspended Solids	9.0	6.99	62.9
Non-Degradable Org.	1.3	6.99	9.1
Biological Oxygen Dem.			
Chemical Oxygen Demand			
AIR (TONS)			
Particulates	7.35*	6.99	51.4
Oxides of Nitrogen	348	6.99	2432.5
Sulfur Dioxide	160*	6.99	1118.4
Hydrocarbons	8.4	6.99	58.7
Carbon Monoxide	23.1	6.99	161.5
Carbon Dioxide	104000	6.99	726,960.0
Aldehydes	0.68	6.99	4.8
OTHER			
Thermal Rejection (Btu) X 10^9	249	6.99	1740.5
Occupational Death (Men)	0.0759	6.99	.53
Occupational Injuries (Men)	1.32	6.99	9.2
Occupational Man Day Lost (Man-day)	96.26	6.99	672.9
Solid Waste Tons	1394	6.99	9744.1

*Local utilities must be consulted to take account of abatement factors for particulates and sulfur emissions.

Note: Data courtesy of FEA.

TABLE VII-1C

TITLE: SPACE HEAT, RESIDENTIAL, DISTILLATE OIL
(Environmental Impact per 10^{12} Btu)

Impact	Col. A Coefficient for Reduction	Col. B Energy Reduction	Col. C Resultant Emission Reduction
WATER (TONS)			
Acids	-		
Bases	-		
Dissolved Solids, Mis.	.4	.352	.14
Suspended Solids	.76	.352	.27
Non-Degradable Org.	2.41	.352	.85
Biological Oxygen Dem.	.76	.352	.27
Chemical Oxygen Demand	4.66	.352	1.64
AIR (TONS)			
Particulates	39.16	.352	13.78
Oxides of Nitrogen	69.18	.352	24.35
Sulfur Dioxide	136.45	.352	48.03
Hydrocarbons	37.17	.352	13.08
Carbon Monoxide	20.80	.352	7.32
Carbon Dioxide	85,000	.352	29,920
Aldehydes	11.34	.352	3.99
OTHER			
Thermal Rejection (Btu)	-		
Occupational Death (Men)	.0007	.352	.0002
Occupational Injuries (Men)	.05	.352	.018
Occupational Man Day Lost (Man-day)	2.5	.352	.88
Solid Waste Tons	48	.352	16.90

Note: Data courtesy of FEA.

TALLY SHEET
OF REDUCTIONS IN EMISSIONS, ETC.
(OTHER)

		Thermal Reject	Occupational Death	Occupational Injury	Occupational Man-day Lost	Solid Waste
1						
2	GASOLINE VEH.					
3	DIESEL BUS					
4	REFINERY, VEH. FUEL	———	- .004	- .278	- 13.9	- 266.4
5	S.H. COMMERCIAL GAS	2.04	- .0005	- .069	- 212.4	- ———
6	S.H. COMMERCIAL D. OIL		- .0004	- .0298	- 1.49	- 28.61
7	S.H. COMMERCIAL R. OIL		.0002	.015	.753	- 14.36
8	S.H. COMMERCIAL, COAL					
9	S.H. RESIDENTIAL, GAS	- 3.0	- .0007	- .10	- 3.1	0
10	S.H. RESIDENTIAL, D. OIL		- .0002	- .018	- .88	- 16.90
11	ELEC. GEN - GAS T. - GAS					
12	ELEC. GEN - GAS T. - OIL					
13	ELEC. GEN - STEAM - GAS					
14	ELEC. GEN - STEAM - OIL					
15	ELEC. GEN - STEAM - COAL	1740.5	- .53	- 9.2	- 672.9	- 9744.1
		1745.5	- .54	- 9.71	- 905.4	-10,070.4

Note: Data courtesy of FEA.

TALLY SHEET
OF REDUCTIONS IN EMISSIONS, ETC.
(WATER)

		ACIDS	BASES	DIS. SOLIDS	SUS. SOLIDS	NON-DEG. ORG	BIO. O.D.	CHEM. O.D.
1								
2	GASOLINE VEH.							
3	DIESEL BUS							
4	REFINERY, VEH. FUEL			- 2.2	- 4.2	- 13.4	- 4.2	- 25.9
5	S.H. COMMERCIAL GAS					- .046		
6	S.H. COMMERCIAL D. OIL			- .238	- .453	- 1.430	- .453	- 2.78
7	S.H. COMMERCIAL R. OIL			- .117	- .227	- .721	- .227	- 1.39
8	S.H. COMMERCIAL, COAL	0	0	0	0	0	0	0
9	S.H. RESIDENTIAL, GAS	0	0	0	0	- .068	0	0
10	S.H. RESIDENTIAL, D. OIL	0	0	- .14	- .27	- .85	.27	1.64
11	ELEC. GEN - GAS T. - GAS							
12	ELEC. GEN - GAS T. - OIL							
13	ELEC. GEN - STEAM - GAS							
14	ELEC. GEN - STEAM - OIL							
15	ELEC. GEN - STEAM - COAL	- 84.6	- 7.0	- 436.9	- 62.9	- 9.1		
		- 84.6	- 7.0	- 439.6	- 68.1	- 25.6	- 5.2	- 31.7

Note: Data courtesy of FEA.

TALLY SHEET
OF REDUCTIONS IN EMISSIONS, ETC.
(AIR)

	Particulates	Ox. of Nitro.	Sulfur Dioxide	Hydro-Carbons	CO	CO_2	Aldehydes
1 TOTAL	- 538.1	-5241.3	-1624.7	-1277.0	-12,0660	-1,594,330	-68.421
2 GASOLINE, VEH.	- 344.7	-1656.9	- 83.4	-1117.6	-11,787.2	-414,220	
3 DIESEL BUS	+ .5	+ 13.0	+ .9	+ 1.3	+ 7.9	850.0	.2
4 REFINERY, VEH. FUEL	- 17.8	- 144.3	- 130.4	- 33.3	- 16.7	___	-23.0
5 S.H. COMMERCIAL GAS	- 21.2	- 348.1	- .719	- 9.04	- 22.3	-139 629	- 11.22
6 S.H. COMMERCIAL D. OIL	- 34.13	- 144.8	- 81.92	- 22.15	- 44.7	-50660	- 6.79
7 S.H. COMMERCIAL R. OIL	- 32.94	- 67.84	- 161.62	- 10.88	- 1.04	-25415	- 2.24
8 S.H. COMMERCIAL, COAL	___	___	___	___	___	___	___
9 S.H. RESIDENTIAL, GAS	- 31.6	- 435.5	- 1.1	- 13.5	- 33.1	208,376	- 16.6
10 S.H. RESIDENTIAL D. OIL	- 13.78	- 24.35	- 48.03	- 13.08	- 7.32	-29,920	- 3.99
11 ELEC. GEN - GAS T. - GAS	___	___	___	___	___	___	___
12 ELEC. GEN.- GAS T. - OIL	___	___	___	___	___	___	___
13 ELEC. GEN - STEAM - GAS	___	___	___	___	___	___	___
14 ELEC. GEN - STEAM - OIL	___	___	___	___	___	___	___
15 ELEC. GEN - STEAM - COAL	- 51.4	-2432.5	1118.4	- 58.7	-161.5	- 726,960	4.8

*includes program measures 3,5,5a,5b,5c, 10
**includes program measures 1,2,3,3a, 9&110 and industrial sector
***includes program measures 1,6,7,8,9,10
+includes LPG

Note: Data courtesy of FEA.

E. A VISION FOR THE FUTURE

The need for energy conservation has been made clear in the last few days by the natural gas crisis in the eastern United States. While Montana fortunately has been spared the disastrous effects which are occurring right now on the east coast and in the midwest, the lesson is clear. Energy conservation is essentially the only alternative that can immediately free additional supplies of energy. Increasing energy supplies from other sources often takes years of development and planning.

While the eastern United States has been deluged with snow and cold weather, Montana and the Pacific Northwest, areas that produce a great deal of energy through hydroelectric generation, have been unusually dry. Thus, a weather caused energy crisis in the east simply may be the forerunner of a drought related energy crisis in the northwest. Through conservation, Montana can act now to insure that future supplies of energy are available. By postponing action, the state will only insure that the "energy crisis," when it does strike Montana, will be even more severe.

Energy conservation and renewable energy development both are decentralized in application. They are implemented at the individual, community, or local government level. Both can develop a community spirit and a sense of participation, thrift, and cooperation. Conservation is, in many respects, a personal option. In fact, it is the ultimate of public participation in energy planning. Conservation is something that everyone can do to help secure their individual energy supplies. Conservation is a way to bring the various sectors of Montana's society together with the common purpose of supplying more energy to keep Montana prosperous. Jobs will not be lost by conserving energy. As is obvious presently, jobs are lost by wasting energy.

In addition, we have concluded that energy conservation is much more than a short term "crisis" stop gap measure. A number of reputable nationwide studies have shown that up to 50 percent of the energy currently used in the United States is wasted. If this 50 percent waste is seen as an energy supply, total energy consumption in the United States could be doubled through conservation without requiring energy to be supplied by any other source. Thus, conservation is seen as a long term energy supply source.

It is the long term analysis that we do not want to lose sight of. FEA guidelines require short term energy savings of 5 percent by 1980; but looking out toward the future, much more substantial savings are obtainable. Our proposed conservation loan program, the statewide building code, the transportation trust fund, public utility measures, the renewable energy tax credit, and educational programs are all long range programs. The energy savings from implementing some of these measures will accumulate slowly and not reach full impact for 10 to 20 years (or more).

A stringent energy conservation building code coupled with more efficient lighting and hot water heating could save 45 percent of the energy used in the residential sector in 20 years. A conservation building code applied to the commercial sector would reduce energy consumption in that sector by 50 percent by the year 2000. Montana industry, through process changes, housekeeping, co-generation of electricity and process steam, and other conservation measures likewise could save up to 30 percent of the energy consumed in that sector within 20 years.

Our investigation indicates that renewable energy also can be very important in Montana's future. Eighty nine percent of the energy currently used in the residential sector and 53 percent of the current commercial energy use in Montana is converted to low grade heat (<100°C). Solar radiation easily could supply energy of this quality. The Lockheed Corporation recently determined that the wind electric generation potential of eastern Montana was 25 times Montana's current total energy consumption. The energy potential of Montana's wood waste and forest residues annually exceeds 51 trillion Btu's, and agricultural crop residues nearly have the same energy potential. Our proposed renewable energy tax credit and conservation loan program will foster renewable energy development in Montana. They will stimulate investment now in energy sources which likely will be indispensible in the future. A renewable energy industry may develop within Montana and thus promote economic development. There is absolutely no reason why wind mills or solar collectors cannot be produced here. Montana's enormous renewable energy base, coupled with its favorable economic incentives, could make it a leader in renewable resource development. Montana has enormous reserves of coal--enough to supply the state's own needs for thousands of years. Montana is meeting its obligation to share this coal with the rest of the nation as is demonstrated by the state's exponentially increasing rate of coal production. Montana citizens also have both a sense of history and the realization that exponential growth cannot continue forever.

If the United States decides to produce most of its energy from coal, Montana's enormous reserves of coal will be used in a very short time, perhaps within 50 to 100 years. Montana's history is rich with "ghost towns" from past mining days; the state now must insure that we do not become a "ghost state" in the not too distant future. Montana's coal can supply our posterity with energy, plastics, pharmaceuticals, and petrochemicals for centuries if it is managed wisely. Since all fossil fuels are finite, we realize that we face a future without their use as energy sources. Oil and gas reserves already are well on the road to depletion. Coal must be used wisely and efficiently as our last "transition fuel" bridge to a non-fossil fueled energy future. To consume all of the coal in a short period of time and thus deprive our future generations of the many benefits and utilities of its use would be a terrible mistake.

Thus, Montana must take the lead and be an example to other states in demonstrating that other sources of energy supply are available, namely, conservation and renewable energy. Ultimately, the United States and Montana will have to seek alternate sources of energy. Why not begin to develop these alternatives now while we still have those enormous reserves of coal which will be so valuable in the future?

Now is the time to begin a coordinated program to both conserve energy and develop renewable energy supplies. Such a program will insure the availability of near term energy supplies and, perhaps more importantly, aid in securing a stable economic future. If the state does not begin such a program soon, we most assuredly will look back and wish we had.

PLEASE NOTE: THE PRECEDING PAGES WERE TREATED AS A UNIT IN THE ORIGINAL DOCUMENT.

[redacted]

DRAFT

PROPOSED MONTANA RENEWABLE ENERGY PROGRAM

from

The Montana Energy and MHD Research and Development Institute, Inc.
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January 28, 1979

Brian - this is excellent & well worth reading. Very ambitious program, with the best of intentions.

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INTRODUCTION: MONTANA RENEWABLE ENERGY PROGRAM

Montana, through state government leadership and state policy, leads the United States in its commitment to financial support of alternate renewable energy resource development and utilization. Public support of this program is widespread and based upon a sophisticated understanding of the logical match between the values and lifestyles of Montana with the positive social, economic, and environmental impacts of extended development of those renewable energy resources of sun, wind, water, and plant residues that already contribute so much to Montana's agriculture and lifestyle. It is recognized that the on-going national energy problem offers a great opportunity to integrate new energy production systems into the economy of Montana in such a way that they will enhance job opportunities for labor, expand economic opportunity for old and new businesses, and enrich the people by providing new technical, scientific, and business challenges. The colleges, universities, technical organizations, and businesses, as well as the emerging generation of young men and women will participate in and benefit from this program. The Montana Renewable Energy Program represents an unique way to simultaneously develop and enrich the state without compromising the quality of life or degrade the environment.

The Montana Department of Natural Resources and Conservation (DNRC) has had a very active program since 1975 which has supported numerous research, development, and demonstration projects throughout the state. To date, the key accomplishments of this program have been the creation of a very healthy public awareness, understanding, and support of alternate renewable energy, widespread demonstration of the potential of solar space heating throughout the state, and the initiation of limited research and development activities in other renewable resource areas.

Montana has made a significant contribution to the overall United States energy R&D activities through the DNRC program. In turn, the state program has received considerable benefit from the national programs; however, the national program by its very nature will not satisfy all of Montana's needs. There are unique economic and environmental problems in Montana which must be addressed before full use can be made of national program information and results. Furthermore, the national energy R&D effort has received the benefits of Montana's developments that with various degrees of adoptation can be used in other states and regions. Much of the past state program support has had this as one of its objectives. Now, however, is the time for a significant expansion, integration, and extension of the program. A properly structured, funded, and managed plan of research, development, demonstration, and commercialization is necessary in order for the state to fully benefit from the renewable resources available.

The Montana Alternative Renewable Energy R&D program must be more fully and formally integrated into the national U.S. Department of Energy programs. It must also be extended to include a strong commercialization effort and be expanded in terms of resources devoted to the total program activities.

This document contains seven specific subprograms for wind, biomass (agriculture and forest products and residues used for direct combustion, the production of alcohol, and the generation of methane), geothermal, solar, and small scale hydroelectric renewable energy sources. The proposed duration of each of these subprograms is six years if the funding level requested is provided. At the end of this time, the technologies and supporting Montana business structure will have been developed for those renewable energies which have proven to be economically viable. State support beyond the six years will be minimal and will be limited mainly to coordination and information exchange. No large scale funding of development or demonstration projects should be necessary.

The support for this program is based upon a match of almost five federal dollars for every state dollar contributed. This match is not arbitrary but is based upon the concept that there is at least five times as many opportunities to use the results of this program outside Montana as within the state. Simple equity dictates that the division of funds for support be based upon the probable benefits to be obtained by each of the parties participating in the program.

The long range objective of this proposed Renewable Energy Program is to ensure the proper place of these resources in Montana's future economy. Diversification of energy sources will be just as important in the future as it is now. The utilities and their electric distribution system will become more valuable. Eventually, replacements for natural gas and liquid fuels must be found either by a complete energy form replacement or from gases and liquid fuels derived from biomass or from coal for some finite time period. Here again, the large energy companies and their distribution systems will continue to play a leading role. A new and important member of the energy team, the farmer/rancher and communities, is developed by this program.

Montana is an agricultural state with very little in-state processing of the products of beef and grain. Furthermore, our ranchers and farmers pay high transportation costs to get these products to the processing points and markets. The proposed program will provide some energy self-sufficiency and a significant extension of the agricultural activity into the processing area. The economic diversity of the farm, ranch, and forest communities will be expanded by energy "crop" growth and processing. The program provides Montana the opportunity to produce new, needed energy products and to participate in the processing of the products--a double economic impact.

The proposed subprograms are to be integrated into the Montana Department of Natural Resources and Conservation, Energy Division's "Montana Alternative Renewable Energy Sources Program Plan" published in January 1979. This present DNRC plan is for a two year program using funds from the coal severance tax as provided under the present allocation scheme. The DNRC plan projects funding of approximately $800 and $1,100 thousand for the next two years and will require additional funding in future years, before all objectives are met. What is proposed here is a significant expansion in effort of the DNRC plan while maintaining its program philosophy, management, and control. This expanded effort will answer the question of the usefulness to Montana of its renewable energies and, at the same time, will develop the necessary Montana businesses so that future state energy planning can be based upon technical and economic experience in renewable energy sources.

A primary motivation for the continuation and significant expansion of the present DNRC program is based upon the projected economic return to the people of Montana. The great majority of the important renewable energy resources are owned or controlled by individual land owners in Montana, e.g., biomass, solar, wind, and geothermal. A statewide program using these resources will, in addition to directly benefiting the resource owner, create the supporting businesses and manufacturing activity. Thus, one objective of the Renewable Energy Program is increased economic activity within the state at the individual and small-to-intermediate business level. This program is not dependent upon large corporations moving into the state, but rather, the creation within Montana of new businesses. By the year 1985, this expanded program has the potential of generating business activity in the millions of dollars which will directly benefit the citizens of Montana.

Agricultural/forest products and residues (biomass), geothermal, and wind are the three renewable resources with major subprograms that will be fully developed and commercialized under this plan. Farm and forest residues will be used for production of alcohol and methane and for direct combustion to produce heat and possibly electricity. Wind will be used for electricity generation. Geothermal resources will be used for space and industrial/agricultural heat. Full commercialization means to perfect the applicable technologies for Montana, establish the economics of utilization, create the supporting industrial base, and finally manufacture/build and install the system/facilities throughout the state. Montana capital and Montana citizens can do this via indigenous internal growth and with only a relatively minimum initial funding from the state and national government.

One element of the biomass portion of this program is directed to community- or county-size alcohol plants of a nominal 10^6 gallons/year output which would be fully integrated into the local community. A plant of this size can be built, owned, and operated by the community or individuals with minimal outside assistance. The initial market for the alcohol and the by-products would be the community and surrounding region. Support for five plants is proposed.

The second major element of the biomass program is the direct combustion of forest or farm residues in community-size heating plants and for individual residential-size heating units. Many regions within the state have residues which because of climate, soil, or harvesting practices must be disposed of frequently at some expense to the land owner. These residues can be converted into an additional cash crop. Support for four plants is proposed.

During the six years of the program, alcohol plants and direct combustion plants will be partially funded, and testing and evaluation of home size furnaces and stoves will be continued. The degree of state financial support will be limited to design and 90 percent or less of the construction costs of the facilities. At the end, the technology and operating costs will be established to such a degree that the succeeding plants established in the state can be fully financed by private funds.

The last element of the biomass program is biogas generation. Three sizes of biogas (approximately 65 percent methane) facilities will be developed under the biogas subprogram. One community waste, supplemented with agriculture or forest residues, biogas generator facility will be designed and constructed. Two dairy farm or feed lot size facilities will be installed, and finally a smaller farm or ranch size model will be developed. Three design iterations are provided for in the small size and a total of nineteen units will be purchased for ranch and farm testing and evaluation.

The integration of a community-size biomass program will also include appropriate supporting agricultural activities. For example: alcohol production creates high protein feed which can be used to feed cattle, and the manure from the cattle can be used to generate methane which in turn can be the heat source for the alcohol production.

The wind element has two major portions--first, the individual land owner wind generation concept and secondly, the large utility-owned wind farm concept. The land owners in Montana possess an enormous wind energy potential which, with the development of properly scaled and designed wind electric or direct mechanical generators, can be "harvested" for farm and ranch use. In addition, it can be fed back into the electric grid system. The farmers would be paid for any excess electricity they generated by the utility company; hence, the land would provide a second cash crop. Support for 60 farm-size (20 KW) wind generators is proposed. In addition to the siting of individual wind generators, Montana possesses numerous prime sites, some in conjunction with hydroelectric generation facilities that could be used for large wind farms with a generation capacity of as high as a few hundred megawatts. The Bureau of Reclamation, Corps of Engineers, and the utility companies will be encouraged to establish wind farms with a generating capacity of 250 MW by 1986, an amount equal to that to be generated on farms and ranches. Besides this electric generating capacity, this commercialization plan will create the manufacturing, erection, and maintenance industries in the state to support this renewable energy re-use.

The geothermal hot water resources of the state will be evaluated for community and industry-size facilities for space heating and industry/agricultural applications. A prime site in the state will be developed to provide a central community heating system. If an appropriate user can be identified, a program will be developed that will demonstrate the use of geothermal heat in industry or agriculture. Support for two geothermal sites is proposed.

The solar and small scale hydroelectric subprograms are funded at less than one million dollars each for the four year period. These subprograms require less state support because of state-of-the-technology due to past state and federal funding. Three tasks remain to be completed in the solar subprogram. These are: the evaluation of the solar demonstrations that have been funded, assistance in providing commercially available low cost solar panels for homes, and assistance in the design of solar heating systems for commercial buildings, apartments, or communities. The small scale hydroelectric subprogram will provide for the design and cost analysis of up to twenty hydroelectric generation sites in the state and funding to support up to 90 percent of the construction for ten sites. The electricity output from these sites will be limited to no more than 20 KW.

It is recommended that the Energy Division of DNRC continue the management of this expanded renewable energy program with assistance from major subcontractors for each of the renewable energy resources. By properly structuring the contractual responsibility and work, this program can be managed without an increase in the permanent staff of DNRC. One program objective is to establish within the state the technology and management capability for renewable energy sources. This is to be done by building up Montana private industry and business and not by an expansion in the number of state employees. The major portion of the work will be performed competitively in response to "Requests for Proposals" (RFP) and only a limited amount will be by unsolicited proposals. During the first three years, three or four temporary staff personnel will be needed in the Energy Division to start the program, establish office operating procedures and policies for the expanded effort, and provide the necessary close subcontractor direction required during the initial phases of the subprograms.

The key to program control in this plan is the annual in-depth total program review by subprogram element performed by a review team composed of legislators, DNRC subcontractors, and nationally renown experts. All activities will be reviewed, and any necessary budget adjustments will be proposed to the Montana state legislature and the U.S. Department of Energy for the coming year. It is vital that the program remain dynamic and that adjustments in expenditures be allowed and encouraged in a public policy directed manner so that advantage can be taken of unexpected program accomplishments or opportunities. In the same respect, expenditures should be cut or terminated in any subprogram that does not meet the projected economic pay off for the state.

The total funding recommended for these programs is $46,800 thousand. This is the amount obtained by adding all the subprogram totals in this plan plus an additional $5,225 K for DNRC management during the six years of the program. Montana's share is $8,600 K and is based upon projected return from the coal tax revenue. It is recognized that the state legislature can only make a two year commitment, and that is all that is necessary from the state and the U.S. Department of Energy to start the program. If successful, the remaining funds would be requested from the 1981 and 1983 legislature and the U.S. DOE. For full funding of the first two years, the state must provide $900 K in 1979 and 1,100 K in 1980 and the federal government $2,700 K and $4,400 K in each of the two years. The funding level requested is significant, but the program is structured so that each succeeding year's budget is spent only if the prior year's activities were successful.

The program will be coordinated with the Department of Agriculture and Small Business Administration Energy Loan programs. The USDA Business and Industrial loan program can become a vital part of this program in supporting the development of the required industrial base in Montana. In addition, the products developed must be "approved" by the USDA so that the farmers and ranchers can obtain FHA loans in support of purchase. Public Law 95-315 changes the Small Business Act to provide funds for energy related activities and facilities.

This document details a flexible, diverse but integrated expanded alternative renewable energy program that simultaneously addresses major national needs as well as the unique requirements of Montana. This program is designed to serve the broad public policy needs of Montana through stimulation of development in the private sector. Furthermore, this program recognizes and addresses the needs for new community scale technology that will allow the communities to have at their command technology that will not be imposed from outside the state by organizations that have optimized the production for their benefit. Moreover, these technologies and energy sources will reverse the long term trend of Montana's economy of being based upon exporting unprocessed agricultural and natural resources. Unlike coal, where processing involves significant environmental impacts with existing technology, the development of alternate renewable energy resources can be developed with minimal negative impacts.

FOSSIL ENERGY

U.S. Department of Energy

ELECTRIC POWER FROM COAL

AN INTRODUCTION TO MAGNETOHYDRODYNAMICS

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA ·

NOTICE

Material contained herein was prepared by the Division of Magnetohydrodynamics, Fossil Energy Programs, Energy Technology Secretariat, U.S. Department of Energy.

Produced by Dynatrend Incorporated under Contract ET-78-C-01-2629, Task 40.

PRINTED IN THE U.S.A.
August 1979

This booklet presents, in simplified form, a basic description of coal-fired MHD power generation: what it is, how it works, its commercial potential, what's being done to develop the technology, and prospects for the future.

FOSSIL ENERGY PROGRAMS

Division of Magnetohydrodynamics
U.S. Department of Energy

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

QUESTION: WHAT IS MHD?

Magnetohydrodynamics (MHD) is the science underlying the interaction of an electrically conducting fluid with a magnetic field.

In practical terms, MHD means the generation of electric power by passing a fluid conductor through a magnetic field. Conventional generators use a solid conductor.

MHD converts the energy of the moving fluid to electrical energy directly. The conventional intermediate mechanical step is eliminated. The MHD converter combines the conventional "turbine" and "generator" in a single unit. In essence, it's an electromagnetic turbine.

The idea of substituting a fluid conductor for a solid conductor in power generation is not new. Michael Faraday conducted experiments in 1831 in which he passed mercury through a magnetic field to demonstrate the principle. He speculated that the Thames, flowing in the Earth's magnetic field, might be capable of generating power.

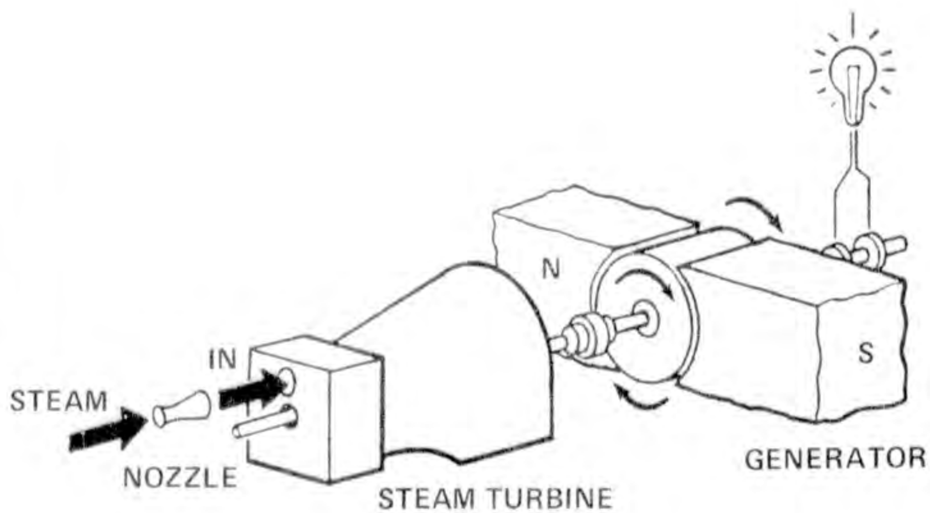
The MHD generator performs the functions of both the turbine and generator and has no moving parts. Consequently, it can operate at temperatures which would quickly destroy the materials of a conventional turbine. This increase in upper cycle temperature limit gives MHD a significant advantage over other Rankine/Brayton power conversion devices.

MHD's importance to the U.S. fuel economy thus lies in its potential capability to produce more power from the direct combustion of a ton of coal than any currently available power conversion system. It further provides environmental advantages that derive not only from the fact that less coal is burned for a given amount of electricity produced, but also from the specific MHD process conditions which suppress SO_X and NO_X emissions.

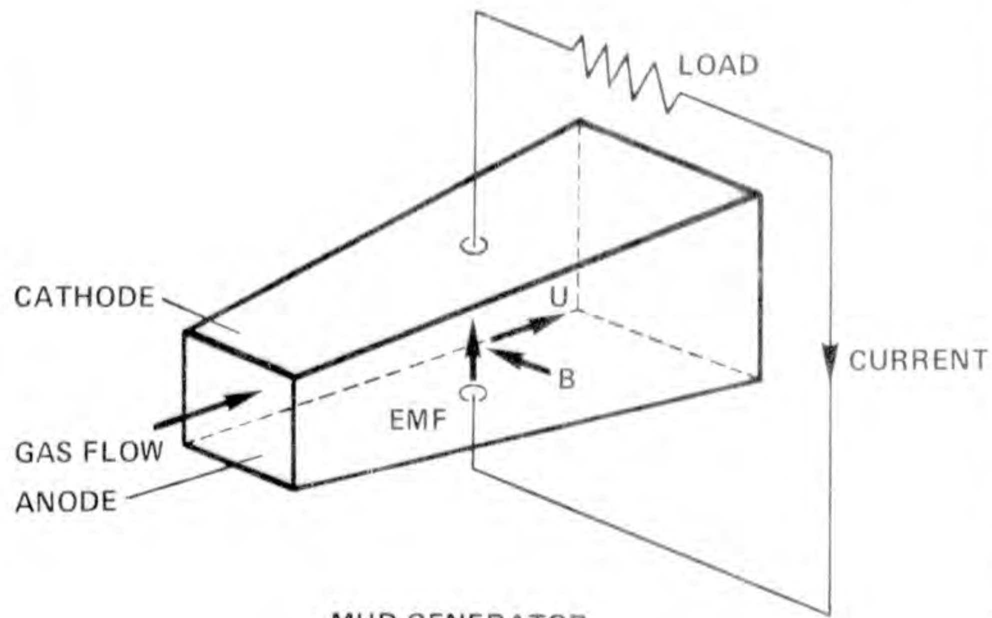
QUESTION: HOW DOES MHD WORK?

A conducting fluid flowing at velocity, U, through a magnetic field, B, induces an electric field, E, in a direction perpendicular to both the flow direction and the field direction.

If the flow is contained in a duct, the two walls perpendicular to the induced field, E, will be at different electrical potentials. If these two walls, or elements thereof, are connected through an external electric load, the induced field, E, will cause electric currents to flow through the fluid and external load in a closed path, as shown in the accompanying sketch.



CONVENTIONAL STEAM GENERATOR



MHD GENERATOR

QUESTION: WHAT DETERMINES THE PERFORMANCE OF AN MHD GENERATOR?

Enthalpy extraction is proportional to:

$$\frac{\sigma B^2 ML}{P}$$

where:

σ = conductivity, Mhos/meter

B = magnetic field, Tesla

M = Mach number

L = channel length, meters

P = pressure, atmospheres

Typical values required to achieve a 20% enthalpy extraction from the channel are:

$\sigma \sim 8$ Mhos/meter

$B \sim 6$ Tesla

$M \sim 0.8$

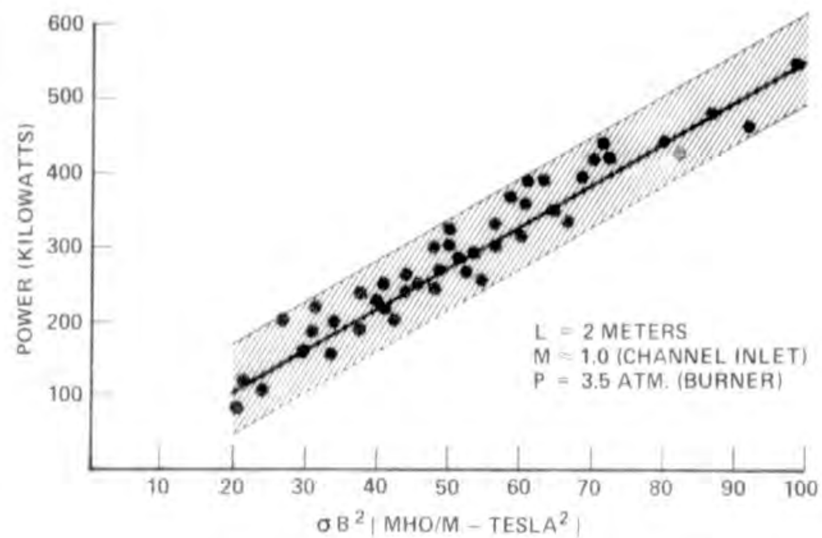
$L \sim 20$ meters

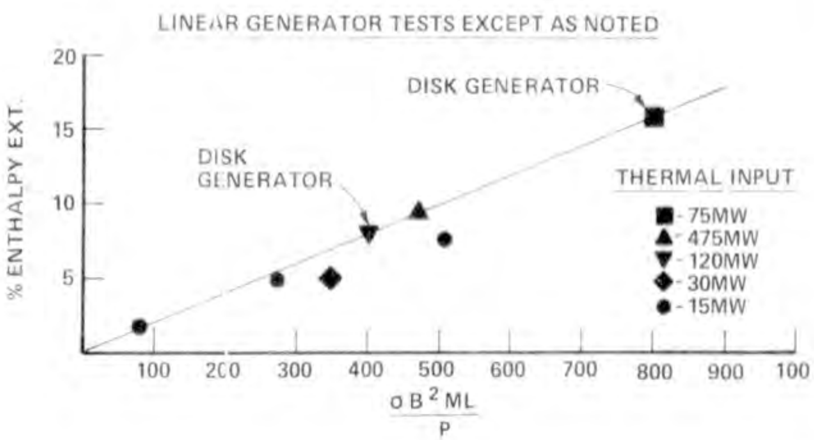
Conversion of the thermal energy of the conducting fluid to electrical energy (enthalpy extraction) is proportional to the product of the fluid conductivity, the square of the magnetic field strength, the fluid velocity, and the channel length divided by the pressure.

High temperature combustion and potassium "seeding" are required to attain the necessary conductivity level. High magnetic field strengths are produced by superconducting, cryogenically cooled, magnets. Wall losses must be minimized by maintaining a sufficiently large volume to area ratio in the duct. Enthalpy extractions of 20% or more would be necessary for commercialization. Theoretical analyses substantiated by experimental data have been applied to project design and operating conditions required to achieve this.

QUESTION: HAS PERFORMANCE BEEN VERIFIED EXPERIMENTALLY?

If the performance data of random tests are plotted against the parameter explained on the previous page, they fall on a reasonably straight line. These data represent a considerable range of test conditions relating to conductivity, magnetic field strength, power input, channel length, and, to lesser extent, velocity. Large generators with magnetic fields of 6 Tesla, under conditions indicated for σ, M, and P, are expected to provide enthalpy extractions in excess of 20%. (See figure below.)





This plot demonstrates the reproducibility of performance data. A total of forty-seven (47) test points fall within the scatter band shown between values of 20 and 100 for σB^2. Performance dependency on conductivity and magnetic field is illustrated under relatively constant conditions of M, L, and P. (See figure above.)

QUESTION: HOW DOES MHD INCREASE POWER CONVERSION EFFICIENCY?

The amount of energy available for power conversion depends fundamentally on the temperature difference between the heat source and the heat sink as first suggested by Sadi Carnot in 1824. The ideal Carnot efficiency can thus be expressed as:

$$\frac{T_1 - T_2}{T_1} \quad \text{or} \quad 1 - \frac{T_2}{T_1}$$

T_1 = the absolute temperature of the heat source

T_2 = the absolute temperature of the heat sink

This basic expression may be extended to cover all reversible cycles where the two temperatures are defined as mean temperatures found by dividing the heats added and rejected reversibly by the change in entrophy in each case.

In conventional turbines, T_1 is limited by the ability of rotating components to withstand high stresses at high temperatures. But because MHD has no rotating parts, it can survive temperatures which would destroy a conventional turbine. Thus, by coupling an MHD "electromagnetic" turbine, operating at a very high temperature, with a Rankine steam turbine, operating at conventional temperatures, overall plant efficiencies can be raised from the 25-35% range to the 45-50% range.

QUESTION: WHAT ARE THE PRINCIPAL DESIGN CHOICES?

The basic system design choice for large scale, coal-fired MHD power plants is between open cycle and closed cycle systems.

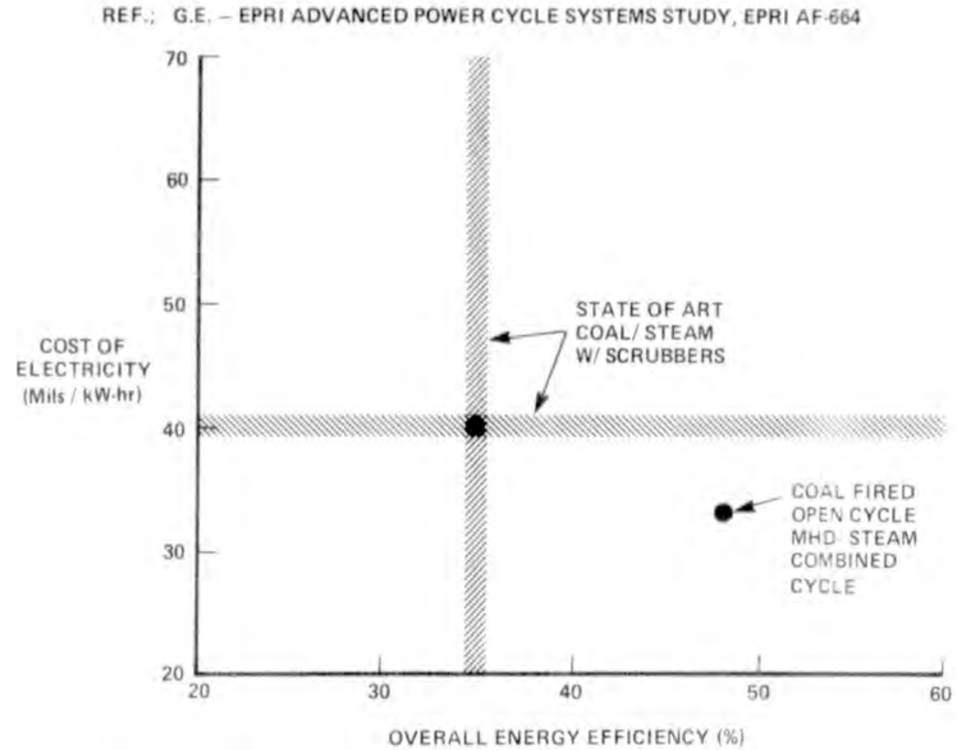
In an **open cycle** system, the working fluid for the MHD flow train is the high temperature (4500°F) combustion products of coal burned with preheated air. Oxygen enrichment may be used to lower required oxidizer preheat temperatures. Potassium is added to provide a combustion gas of high electrical conductivity. The potassium "seed", which is recovered, also serves as a scavenger for sulphur in the coal fuel.

Closed cycle plasma MHD employs a cesium seeded noble gas, such as argon, as the MHD working fluid. A two-flow-path system is employed. In the first flow path, which is open, a heat exchanger is coal-fired to approximately 2900°F. Then, by appropriate valving, the noble gas in the second, closed loop is circulated through the heat exchanger to heat the MHD working fluid to operating temperature. Relative to open cycle, the lower operating temperature of closed cycle plasma MHD is possible because of non-equilibrium ionization of the seed material which results in comparable gas electrical conductivity.

Closed cycle liquid metal MHD also uses a two-flow-path system, analogous to closed cycle plasma MHD. The principal difference is that in the liquid concept, the MHD working fluid is initially a two-phase mixture (liquid/vapor) of an alkali metal, from which the vapor phase is separated before entering the MHD channel. Both phases are then recirculated.

Currently, the **open cycle** system concept using linear MHD channels is favored for MHD electric power plants. The closed cycle concept together with other channel design concepts, such as the disk, are viewed as alternatives for second generation MHD power plants.

QUESTION: HOW MUCH WILL MHD POWER COST?



Cost and performance studies of advanced coal-fired power generating systems indicate the potential superiority of MHD. These studies,[1] federally funded, were conducted by major U.S. commercial power system manufacturers. The combined cycle MHD-steam plant was shown to be the only directly-fired coal-based cycle capable of achieving efficiencies in the 45-50% range. Cost of electricity for the MHD system was estimated at 32 mils/kwh. These projections are significantly better than the 35% efficiency and 37 mils/kwh capability of a modern, coal-fired steam plant as calculated under the same set of assumptions.

A study[2] conducted by the General Electric Company for the Electric Power Research Institute showed MHD with the lowest cost of electricity (33.7 mils) and the highest efficiency (~50%).

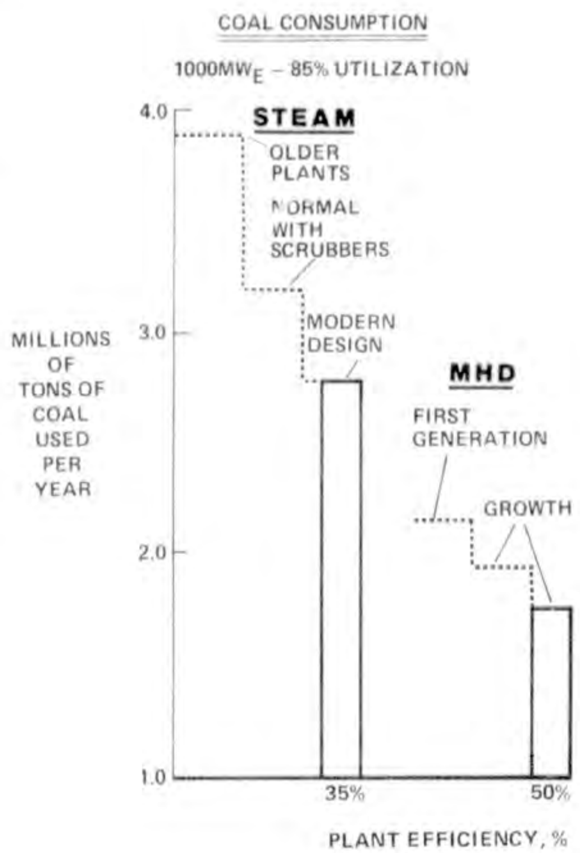
[1]NASA TM-73871, Sept. 1977 [2]EPRI Report AF-664, Feb. 1978

QUESTION: WHAT COULD MHD DO FOR THE U.S. ENERGY ECONOMY?

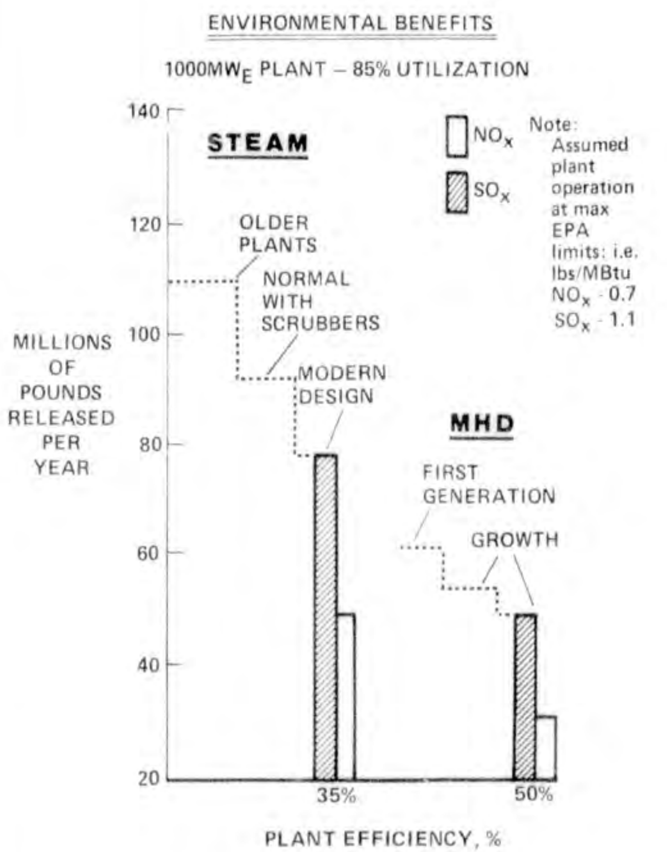
A combined MHD-steam plant is potentially capable of producing up to 50% more power from a ton of coal than a modern base load steam plant. A "mature" 1000 MW_E MHD-steam combined cycle plant operating at 85% availability (7446 x 10^3 MWH/yr) would require about 800,000 tons of coal a year less than the conventional plant. Even an early commercial "first generation" version, conservatively designed, would save between 300 and 700 thousand tons. By exploiting inherent MHD growth capabilities, a single advanced 1000 MW_E MHD commercial plant could be expected to save up to 1 million tons of coal per year.

The economic implications of MHD power lie in the strong national need to replace foreign oil with domestic coal in the production of utility power. The opportunities for conservation, transportation savings, mining benefits, and environmental improvements are underscored by the efficiency advantages of MHD in central station power generation.

A secondary advantage of MHD could become an important factor in the future of the industrial economy. Because MHD operates at high cycle temperatures, it provides opportunities for co-generation, i.e., production of both electrical and thermal energy. This is a primary concern of energy intensive industries like primary metals and chemicals.



QUESTION: DOES MHD POWER PROVIDE ANY ENVIRONMENTAL ADVANTAGES?



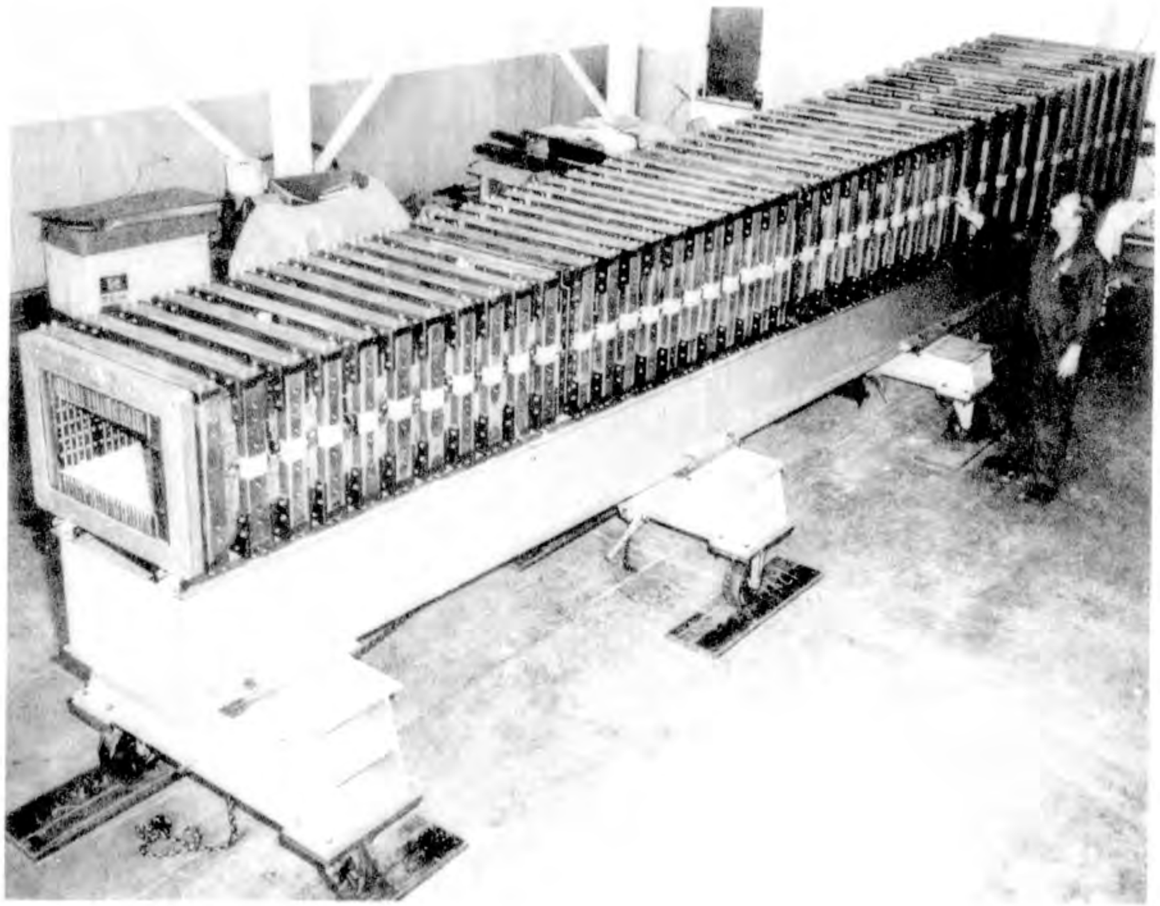
A basic environmental advantage of MHD derives from its higher efficiency. Coal savings were described on the preceding page. These savings translate directly to reduced environmental intrusion. If we assume two plants of identical power generating capacity, side by side, one a first generation MHD-steam plant and the other a modern steam-only plant, both operating at present maximum permissible EPA emission limits, the MHD plant will produce about 1/3 less SO_X, NO_X, particulate, and CO_2 than the conventional plant.

MHD offers further environmental benefits. The potassium which is added to the coal combustion gases as a carbonate salt combines with the sulphur compounds from the coal to form potassium sulphate. This can be recovered in the steam bottoming plant and regenerated to the carbonate for reuse. Experimental data indicates that SO_X emissions may be virtually eliminated with coals of less than 1% sulphur. Even with high sulphur coals (4%), SO_X emissions could be cut to about one half of the EPA maximum standard.

Controlled combustion in the MHD system permits close management of NO_X emissions – about 1/5th of the EPA limit. Particulates also can be maintained well below federal requirements. The high efficiency of MHD energy conversions also reduces thermal pollution – water and air – significantly.

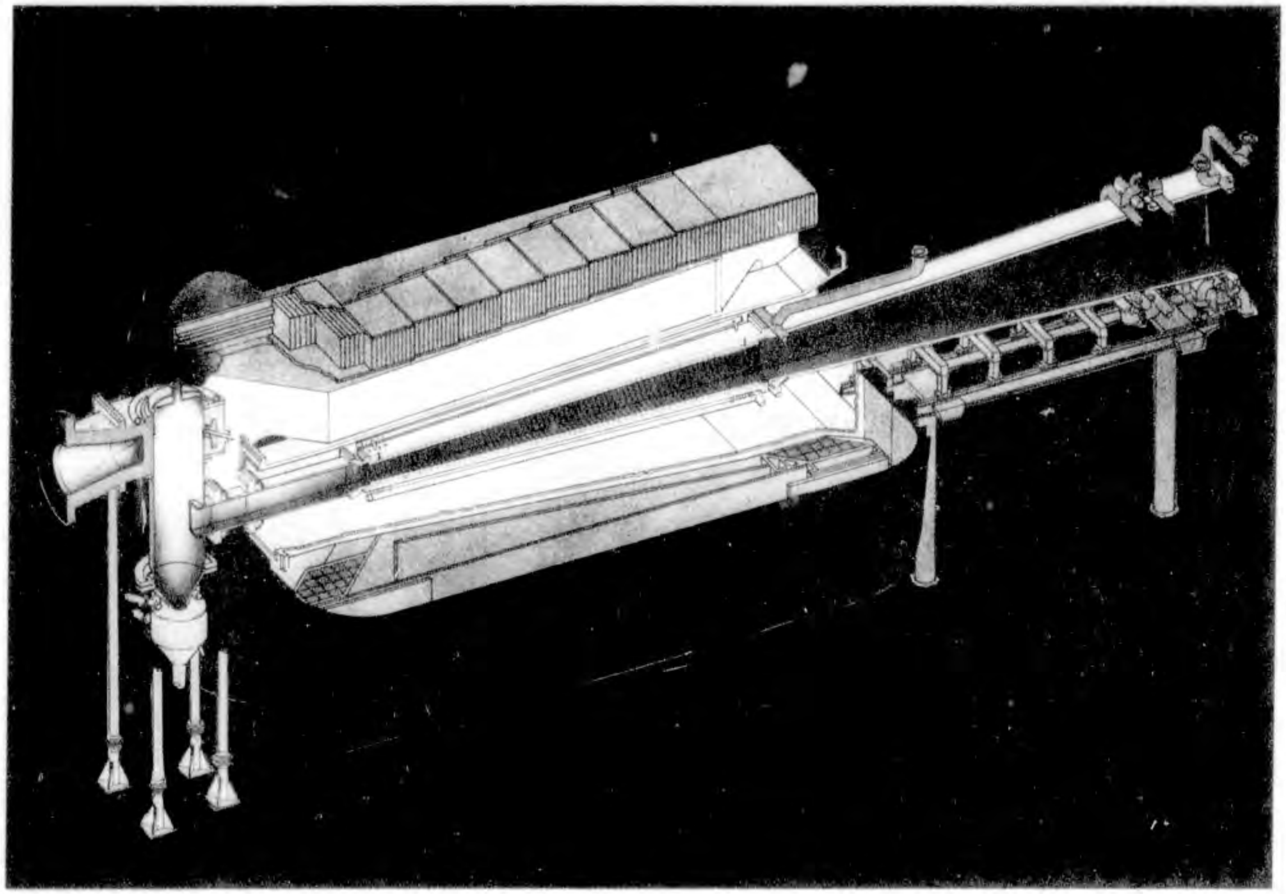
QUESTION: WHAT WOULD AN MHD CHANNEL LOOK LIKE?

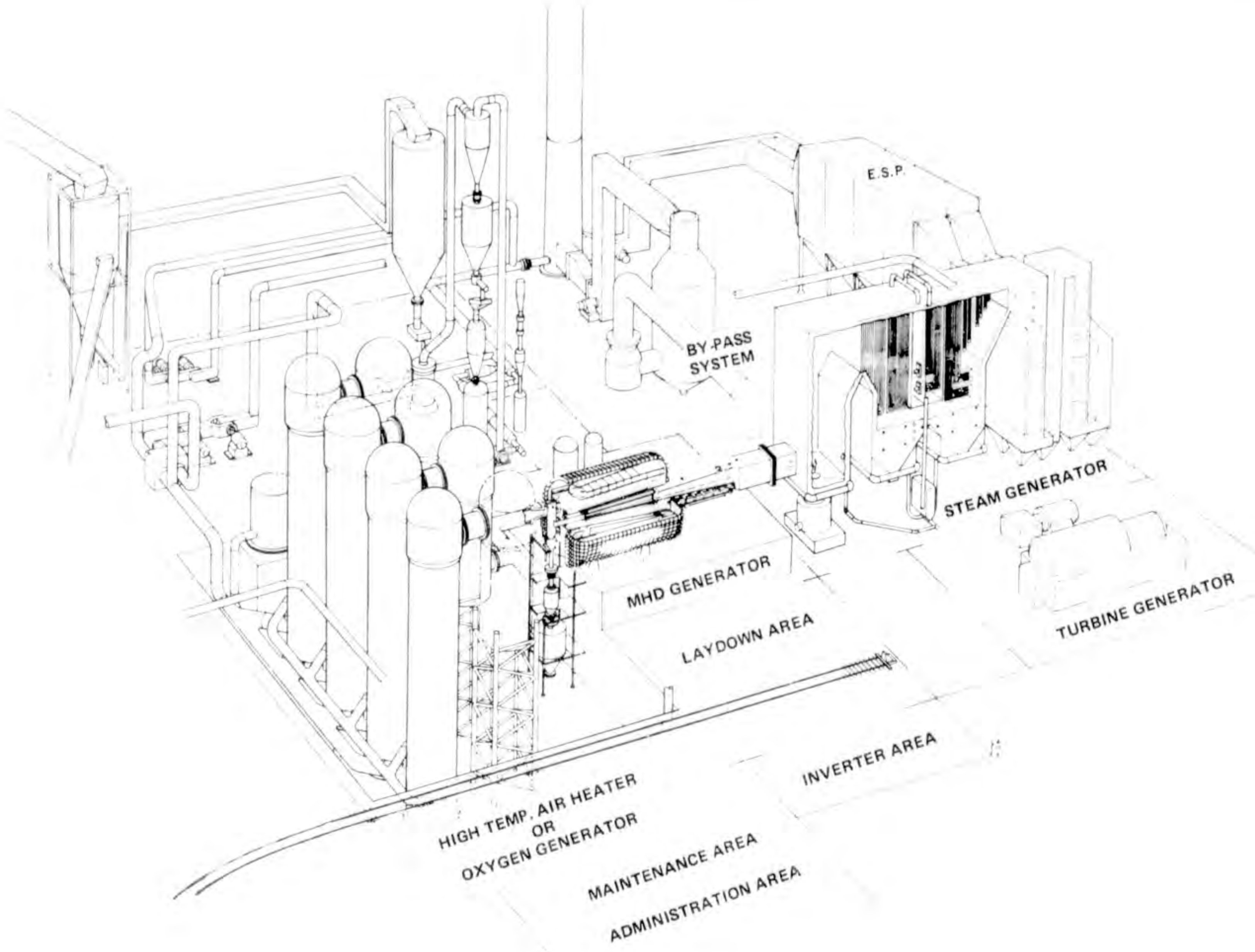
The figure below is a photograph of an experimental channel which will be used in a series of experiments to study size effects on channel performance characteristics. (Courtesy of USAF, Arnold Engineering Development Center.)



QUESTION: WHAT WOULD AN MHD GENERATOR LOOK LIKE?

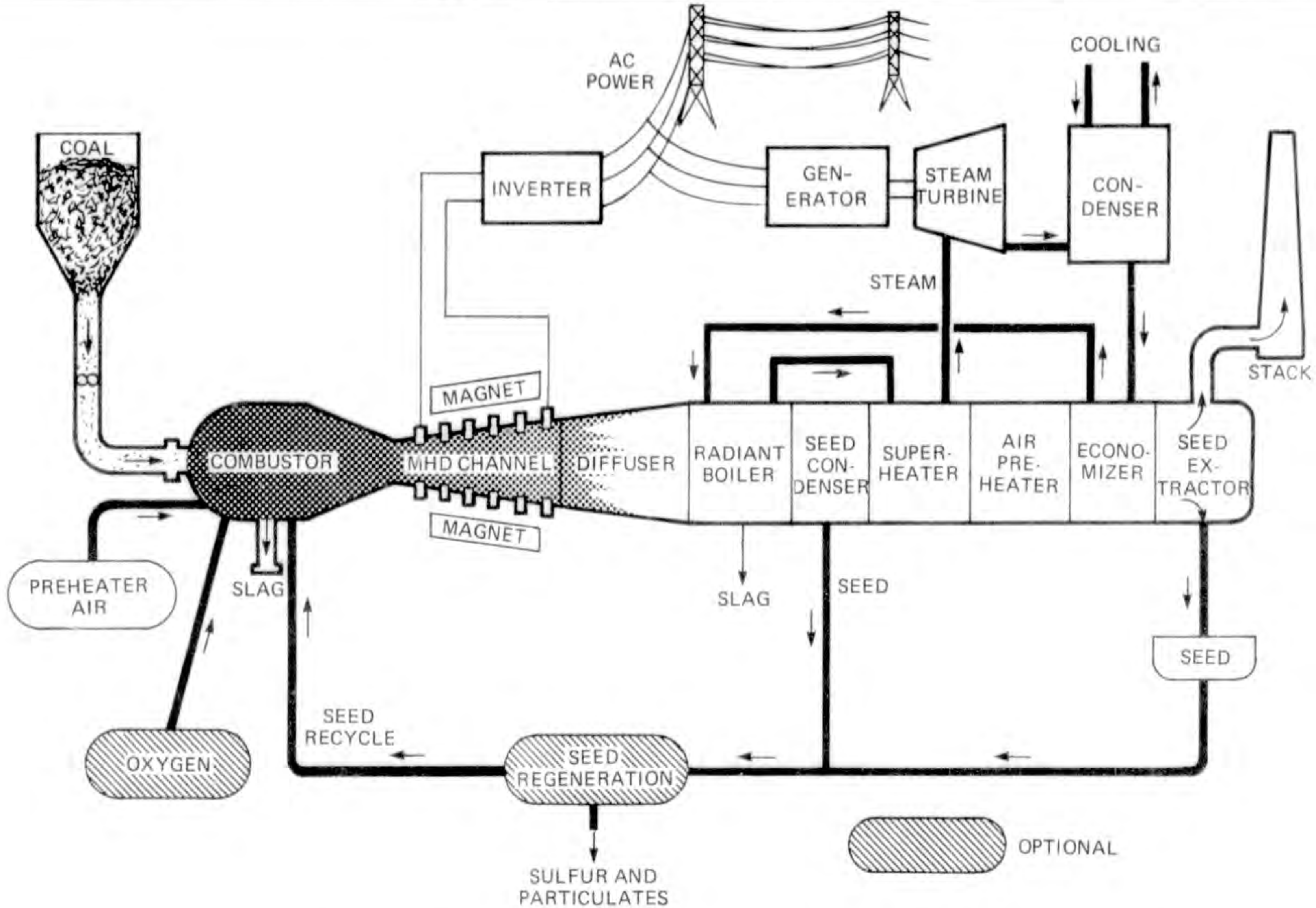
The figure below is an artist's sketch of a 250 MWT generator assembly, including the coal combustor, channel, magnet and diffuser. The sketch is based upon preliminary design and performance studies of a plant of this scale. (Courtesy of Avco Everett Research Labs.)





This is an artist's drawing, based upon preliminary design studies, of the possible arrangement of a 250 MWT experimental plant. (Courtesy of Avco Everett Research Labs.)

QUESTION: WHAT WOULD AN MHD POWER PLANT LOOK LIKE?



This schematic shows one possible arrangement of the major components of a combined cycle MHD-steam power station. Basic cost and performance tradeoff studies are being conducted on air heating, oxygen enrichment, and seed recycling conditions. (Courtesy of TRW.)

QUESTION: WHAT IS THE STATUS OF MHD DEVELOPMENT?

COAL COMBUSTOR

Development has progressed to the testing of 20 MWT prototypes. Three different designs capable of rejecting from 70 to 90% of the coal ash as molten slag are being evaluated. Another design which carries all of the ash product in the combustion gas stream is under development by the University of Tennessee Space Institute (UTSI) using the DOE Coal-Fired Flow Facility (CFFF). Selected designs will be scaled up to 50 MWT for integrated generator testing at the DOE Component Development and Integration Test Facility (CDIF) in Butte, Montana.

CHANNEL

Principal development effort is being conducted at the 20 MWT scale under conditions closely simulating those anticipated in commercial systems. Steady design improvements of critical life-limiting elements (electrodes, insulators, side wall structures) has improved durability by two orders of magnitude over the past four years. Channel life expectancies in excess of 2000 hours are indicated. Preliminary design tests of 50 MWT prototypes is expected to commence at the CDIF in 1980.

MAGNET

A forty ton superconducting magnet, designed and built by the Argonne National Laboratory, is being operated successfully in conjunction with the MHD generator tests under the joint U.S. – U.S.S.R. program at the U-25 B Facility near Moscow. Performance has met design predictions. Superconducting magnets are under design and construction for installation in the CDIF, CFFF, and the MHD facility at Stanford University. Performance and cost studies of commercial scale magnets are being pursued.

INVERTER

Development is proceeding in parallel with channel loading and control circuitry development. A new force commutated design recently inverted the full power output of an experimental channel for over 12 hours. Average power fed into the 480V line was 200 kw. This design possesses significant efficiency and control advantages over standard line commutated systems. Improved versions of the advanced design will be integrated in experimental 50 MWT generator subsystems for CDIF tests in the 1982–1985 period. This work is funded by the Electric Power Research Institute (EPRI).

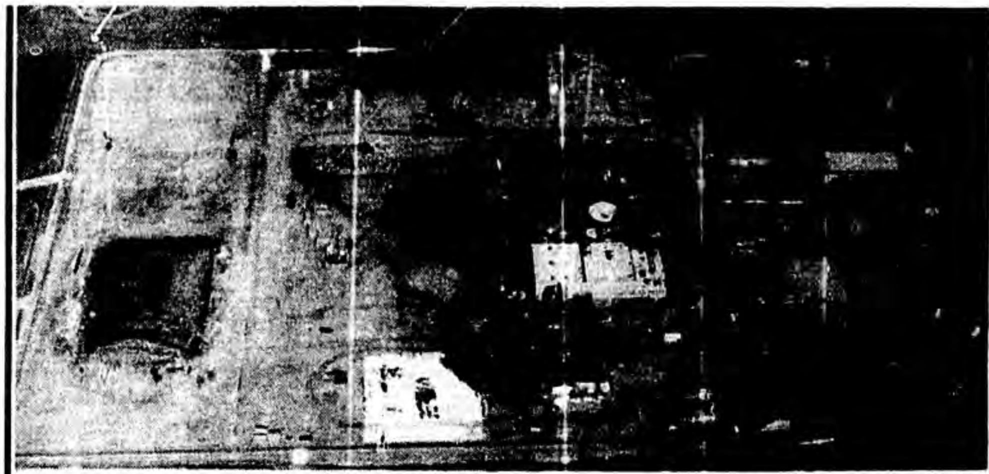
mhd and the cdif

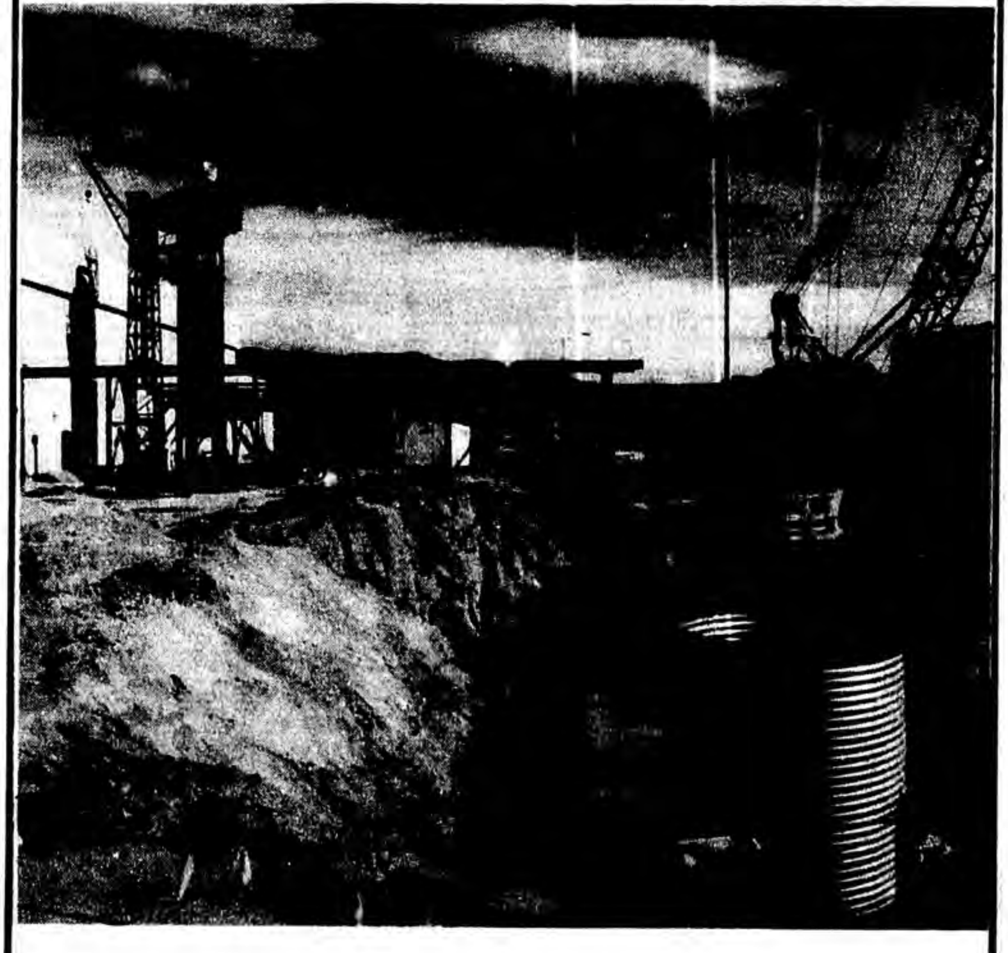
MERDI has devoted much of its time and talents in the past three years to studying magnetohydrodynamics (MHD) — its generation, the impacts of its development — and to assuming an important role in the national MHD program.

MHD is an energy conversion process that generates electricity by passing an electrically-conductive fluid through a magnetic field. While the concept of MHD originated more than 140 years ago, MHD technology is relatively new and still in the research, development and demonstration stage. The MHD process, coupled with a conventional steam turbine electrical generation system, has the potential to substantially increase the efficiency of the overall process of converting a fossil fuel into electrical energy.

The MHD process is based on the interaction between a strong magnetic field and a hot (approximately 5000° F) highly ionized gas (plasma) flowing at near or above sonic velocity. This interaction produces an electrical current. A combined MHD-conventional electrical generation process has the advantage of being able to utilize America's abundant coal reserves in a manner that produces less air and water pollution than existing electrical generation systems, and uses less water.

Major efforts in MHD research have been made by the United States, the Soviet Union, Great Britain, Japan, Germany and the Netherlands. The Soviet program has concentrated on a natural gas fired, open-cycle process; the Department of Energy is directing an





MHD technological exchange program with the Soviets.

An open-cycle process is one in which the hot gases from the combustion of the fossil fuel directly form the power-producing plasma, pass through the process once (including the heat recovery and bottoming cycle) and then are exhausted in the atmosphere. The technical advantages of open-cycle, coal fired MHD plants include increased efficiency, less thermal pollution, less particulate emissions, reduced water consumption, reduced nitrogen oxide and sulphur dioxide emissions and no moving mechanical parts in the MHD power-producing section.

It appears possible to increase the efficiency of a conventional power plant from 30 or 35 percent to nearly 60 percent by adding an MHD cycle. In the MHD process, the hot gases leaving the magnetic field exceed 3000° F, and total electrical generation depends on the use of this remaining heat to generate additional electrical power. This can be accomplished by using these hot gases to power a steam turbine generating plant; the coupling of a conventional power plant with an MHD cycle is known as a topping and bottoming cycle.

The major components in the open-cycle MHD process include a combustor, a channel (or generator), a magnet and an electrical converter (inverter). The combustor is a device similar to a rocket engine which produces a very high-temperature, electrically-conductive plasma through the combustion of a fossil fuel and the injection of an alkaline salt.

To provide satisfactory ionization, the plasma should remain in a 4500° to 5000° temperature range. And since power generation is directly proportional to the plasma velocity, a nozzle attached to the combustor accelerates the plasma to supersonic or slightly subsonic conditions, depending on the design of the channel.

Upon leaving the conbustor and nozzle, the plasma enters the generator. This channel is enclosed in a magnet that creates a magnetic field perpendicular to the flow of plasma; the result is an electromotive force mutually perpendicular to both the plasma flow and the magnetic field directions.

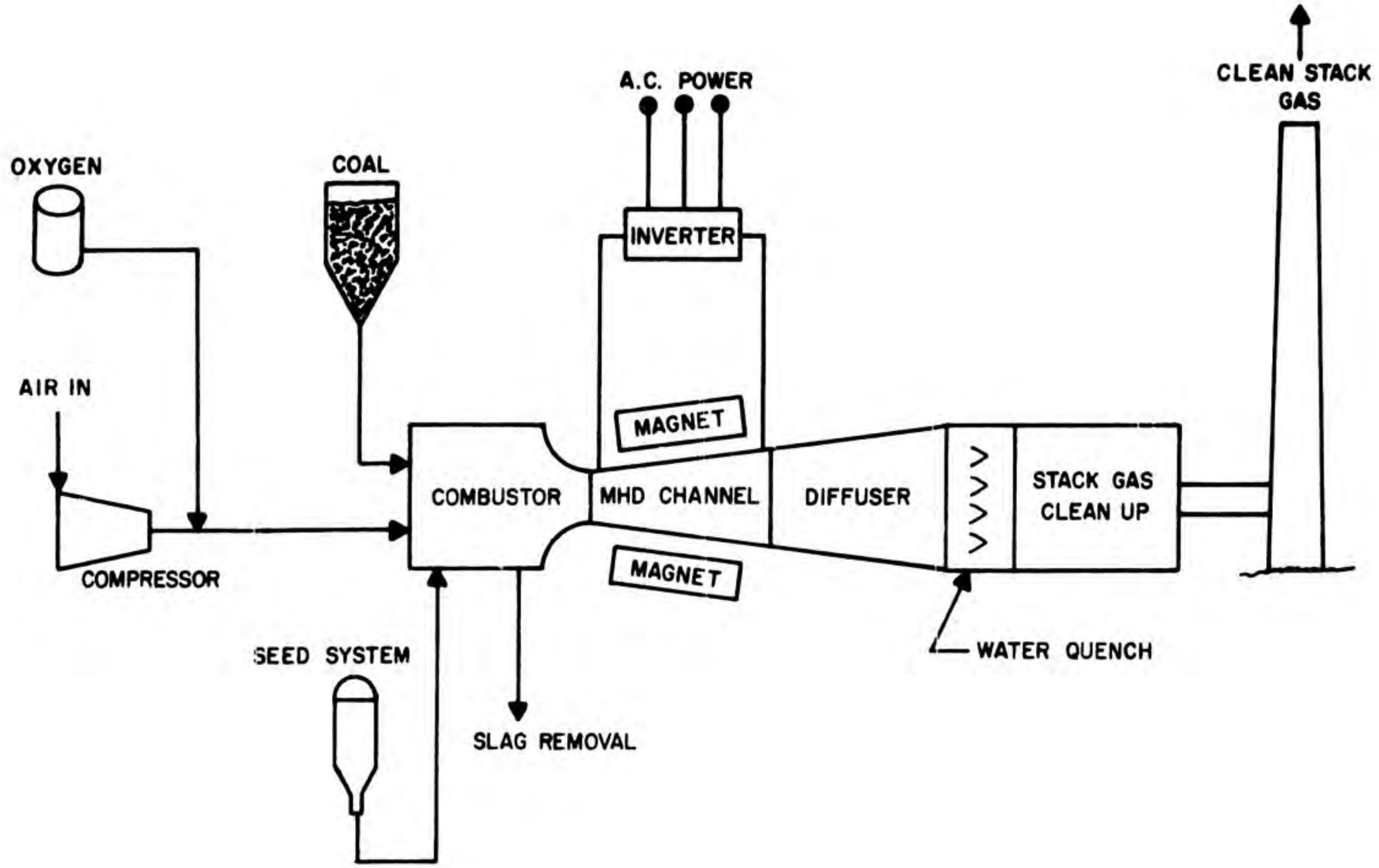
To take advantage of this force, the generator is built with a rectangular cross-section. The top and bottom walls are lined with electrodes to provide an electrical circuit for the induced potential voltage in the plasma; the two side walls are insulators to prevent short circuits between the two electrode walls (anode and cathode).

The inverter receives direct current from the electrodes and converts it into alternating current compatible with existing power grids. At this point, the MHD portion of the process is complete and the electricity is ready for transmission to the customer.

MERDI is actively involved in the MHD research and development program in the United States. The first phase of the program includes systems engineering and analysis, facility design and construction, and component development testing. Future efforts involving the Engineering Test Facility (ETF) will stress the testing of complete power trains, performance optimization, durability testing and the verification of major design and scale-up factors.

The ultimate goal is to demonstrate the commercial feasibility of full-scale combination MHD/steam turbine electrical power generation systems.

The Department of Energy Component Development and Integration Facility (CDIF) is being built in Butte as part of the first phase for the purpose of conducting component development and systems performance tests on the key hot gas components of an MHD power train. The CDIF is designed to test not only coal fired combustors and MHD channels at a 50 megawatt thermal (MW_t) power input level, but also to test related support equipment such as a 6 tesla superconducting magnet and an inverter system. The construction of this facility is under the management of the Department of Energy Idaho Operations Office.



CDIF EXPERIMENTAL FACILITY

Located on a 53-acre site in the Butte Industrial Park, the CDIF is scheduled to begin testing operations in late 1979. Plans include five tests of 100-hour duration during the first year, with tests eventually reaching 1000 hours in length. These initial tests will use a 50 MW_t combustor and a 3 tesla iron core magnet, while later tests will include coal fired combustors, a 6 tesla superconducting magnet and an inverter to convert direct current from the MHD channel into alternating current compatible with a commercial power grid.

MERDI/CDIF, the Institute organization dedicated exclusively to CDIF functions, has been designated by the Department of Energy to manage the operation, maintenance and testing activities. Included in these responsibilities are the procurement and management of services from subcontractors, as necessary, to ensure the safe and efficient conduct of facility and experimental test operations at the CDIF site.

To adequately provide the management and support services required, MERDI/CDIF is organized into four basic divisions in addition to having groups working on safety and quality assurance. The four divisions include Project Control, Test and Systems Engineering, Operations and Technical Support. These divisions and groups are staffed with highly technical personnel educated and experienced in a wide range of engineering and related fields.

The Project Control Division is responsible for the planning, scheduling, budgeting and control of activities for MERDI/CDIF, subcontractors and support groups. This division also provides a central liaison function to coordinate efforts between MERDI/CDIF and other companies involved in CDIF testing.

Providing basic analytical engineering capabilities, the Test and System Engineering Division also prepares test specifications and procedures, test data analyses, system simulation modeling and technical evaluations, and provides support to other MERDI/CDIF divisions. Project engineering functions are performed as necessary to install and operate MHD test trains; technical liaisons are also provided with vendors and experimentors.

The Operations Division manages those activities inherent in experimental test operations — the calibration of instrumentation, facility and test train operations, data acquisition and the assurance of safe and efficient test runs. The Technical Support Division ensures that facility and test train components are properly maintained, and this staff manages corrective maintenance and facility modifications as required.

Safety and Quality Assurance personnel see that all activities, procedures and operations associated with MERDI/CDIF comply with established standards.

Outside of the MERDI/CDIF divisions, support on CDIF work is received from the Socioeconomic, Environmental, Engineering, Applied Research, Computer Support and Communication Services divisions; tasks range from the Butte-Silver Bow Community Attitudinal Survey and other socioeconomic work to monitoring and evaluating ambient air and water quality.

With a well-rounded staff and duties properly delegated, MERDI/CDIF can well accept its responsibility to manage activities at the CDIF site and to represent the Institute in its contribution to the national MHD effort.

QUESTION: WHAT IS THE STATUS OF MHD DEVELOPMENT? (CONTINUED)

STEAM PLANT

Steam "bottoming" plant development work has centered mainly on seed recovery, NO_X control, and "slagging" problems. Design feasiblity has been demonstrated with regard to principal system requirements. Work is now being initiated to establish a firm engineering base for the design of a commercial prototype boiler of about 300–500 MWT capability. Preliminary 20 MWT integrated subsystem development tests will commence in the 1981–1982 period. Early 5 MWT scale subsystem test results have been encouraging.

SCALING

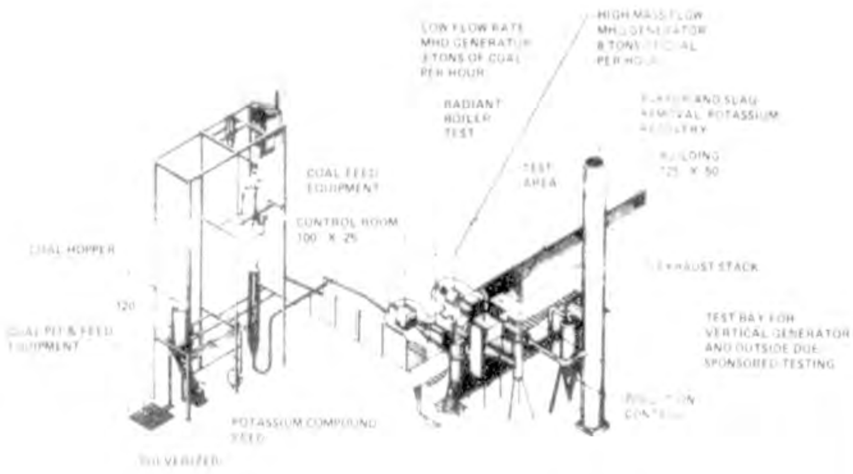
Experiments intended to establish data essential for design scale-up allowances are being conducted at 20 MWT, 50 MWT, and 250 MWT. Experiments to date have confirmed existing scale models. Important additional 250 MWT experiments are scheduled for the 1980–1981 period.

AIR HEATING

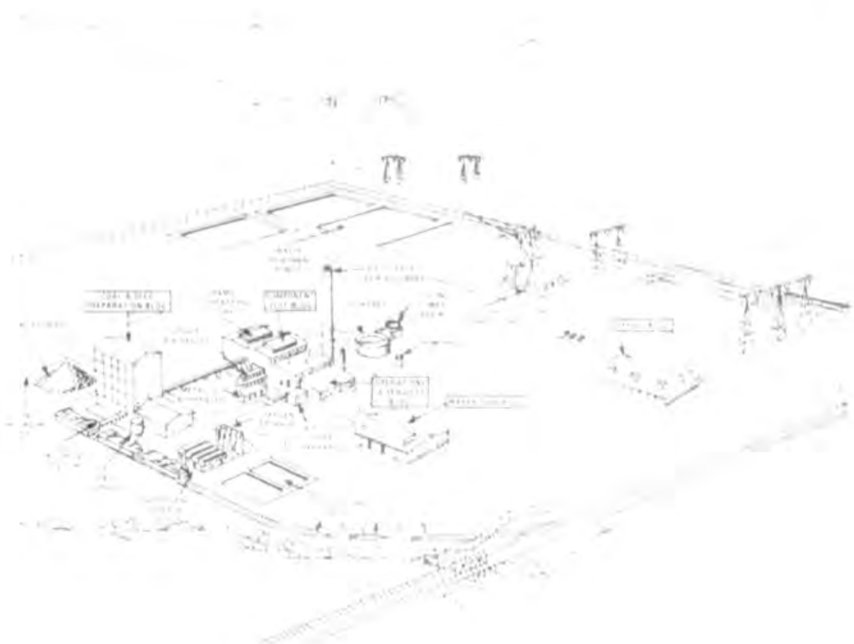
Development has focussed principally on heat transfer, slagging behavior, design, durability, system studies, and materials testing. Directly-fired conditions have been simulated by injecting fly ash slag and seed products into representative heat-transfer sections. Indirect firing has been demonstrated in a small-scale, prototypic, clean-gas fired regenerative heater. Accumulated test times of approximately 1000 hours under the directly-fired test conditions and 2000 hours with the indirectly-fired prototype, both at temperatures up to 3000°F, indicate the technical feasibility of high temperature air heaters.

ANALYTICAL AND RESEARCH SUPPORT

Computer codes have been developed and experimentally verified to predict design and operational effects on generator performance. This work is being continued in close coordination with the experimental development program. Critical support research has provided basic design information relating, especially, to generator performance.



DOE-MHD COAL-FIRED FLOW FACILITY, TENNESSEE, OPERATED BY THE UNIVERSITY OF TENNESSEE SPACE INSTITUTE (UTSI)



CDIF SITE LOCATION DIAGRAM, MONTANA, OPERATED BY MONTANA ENERGY AND MHD RESEARCH AND DEVELOPMENT INSTITUTE, INC. (MERDI)

QUESTION: WHAT IS THE MHD PROGRAM DOING?

OBJECTIVE

The objective of the program is to develop the MHD technology required to determine the commercial viability of MHD/steam power generation systems. The goal is to develop basic component and subsystem technology required for the design, construction, and operation of an MHD commercial demonstration plant.

REQUIREMENTS

Specific development requirements are being defined by analyses of cost and performance demands projected for commercial acceptance.

IMPLEMENTATION

Development work is being directed towards the analytically-derived commercial requirements, and qualification (milestone) test performance requirements are being specified to progressively validate the technology basis necessary for the design of commercial-scale components and subsystems.

FACILITIES

Essential development and test facilities are being constructed for qualification testing and to accelerate development of critical components, i.e., the DOE Component Development and Test Facility (CDIF) in Butte, Montana, and the DOE Coal Fired Flow Facility (CFFF) in Tullahoma, Tennessee.

INDUSTRIAL PARTICIPATION

Necessary industrial participation is being sought through competitive solicitation of critical component and subsystem engineering development work.

SUPPORT RESEARCH

Relevant research, in support of the development program, is being conducted in materials, diagnostics, combustion, fluidynamics, magnetohydrodynamics, analytical modeling, and scaling.

SYSTEM ANALYSES

Analytical studies are being conducted to (a) determine development requirements, (b) evaluate basic cost and performance tradeoffs, (c) evaluate major design and operating sensitivities in relation to commercial requirements, and (d) define alternative design and operational conditions for possible first generation commercial demonstration.

SUMMARY

- MHD is potentially capable of producing 50% more electricity from a ton of coal than any other existing direct combustion power cycles.
- Studies indicate that MHD power would cost less than modern coal-fired steam plant power.
- The inherently high efficiency of MHD power generation means less environmental intrusion. Also, the MHD cycle is compatible with high sulphur coal.
- Encouraging progress has been made in channel design, coal combustion, power output, power management, magnet design and construction, air preheating, and seed recovery. No fundamental technical problems have been identified which would preclude ultimate commercialization.
- Commercialization depends upon continuing development success in the resolution of component and subsystem design issues, particularly regarding boiler performance, scaling uncertainties, and systems compatibility.
- The MHD program is directed toward these issues. Specific performance requirements are being derived from analyses of projected commercial plant applications and needs. Necessary facilities are being constructed to validate development progress and to qualify selected prototype designs.
- Basic component and subsystems technology, essential to the design of a scaled-up commercial prototype plant, is expected to be available in the 1983–1984 period. System studies are being conducted to allow trade-off comparisons of potential "commercial demonstration" prototypic plant concepts.

DEPARTMENT OF ENERGY • UNITED STATES OF AMERICA

MHD

FOSSIL ENERGY PROGRAMS

Division of Magnetohydrodynamics
U.S. Department of Energy
Washington, D.C. 20545

MEMORANDUM

To: Representatives Brian Rogers and Hugh Malone, Co-Chairman, Power Alternatives Study Committee
From: Mark Wittow
Re; My trip to the Montana Energy Research and Development Institute (MERDI) in Butte

A. Summary

I spent twenty-four hours in Butte at MERDI. Jerry Plunkett, the director of the Institute, arranged the details of my visit. I spent a great deal of time talking with Dr. Plunkett about the guiding ideas of the Institute as well as their actual operations.

Ed O'Hair, who authored Montana's renewable energy development plan, discussed that plan and his work with the Center for Innovation (a MERDI offshoot) with me. I toured the coal "magnetohydrodynamic (MHD) component development and integration facility (CDIF)", which is a two hundred million dollar project funded by the U.S. Dept. of Energy and administered by MERDI. I spent a couple hours at the National Center for Appropriate Technology (NCAT), another MERDI offshoot, and talked with technical staff working in the areas of agriculutre, solar technologies, weatherization and small hydro, as well as the deputy director for policy development. I also had a number of shorter conversations with other MERDI staff, which I will discuss below.

The staff at the Montana Energy Research and Development Institute possess a wide range of government, business and industrial experience. They are directed towards seeing their programs put into practice and run well, as opposed to an orientation towards general research work. During the past two years, they have developed what I feel are excellent renewable energy and conservation programs for Montana, as well as being national leaders in stimulating technological innovation and coal research.

The energy problems of Montana parallel those of Alaska in a number of ways. Both states export a large portion of their energy reserves, have a widely dipersed population and are seeking a stable economic base and long-term jobs. The Montana Institute programs are oriented towards those development goals, and we would be wise to seek their advice on our own programs for that reason alone. MERDI's directors are very interested in seeing Alaska develop energy programs similar to their own. They have great confidence in what they are doing, and would like to share their experience with a kindred state. They expressed interest in helping Alaska in the following areas:

1. offering occassional advice on the Committee's study of the potential for conservation and renewable energy use in ~~Alaskax~~ Railbelt Alaska.
2. contributing to a study of the potential of coal in meeting the power needs of the Railbelt area. They have done a great deal of work on the development of Montana's coal reserves, and are the national leader for the MHD project, which burns coal at 50% greater efficiency than conventinal methods of power generation at much lower levels of pollution. They are also pursuing the development of an efficient, clean coal furnance for home heating needs.
3. advice on the possible establishment of an Alaska Center for Innovation, which would ~~sh~~ help inventors and small businessmen determine the commercial feasibility of their ideas and provide marketing assistance.
4. advice on the possible establishment of an Alaska Energy Development ~~Institute~~ Institute, which would provide a stable, independent basis for expertise in energy development.

The following sections detail some of the specifics of my visit.

B. Origins of MERDI

The Institute was established under the leadership of former Senator Mike Mansfield (now U.S. Ambassador to Japan), with a $15,000 grant. Mansfield recruited Jerry Plunkett to run the Institute. Its expressed mission was to work for the kinds of energy development that would provide mngx long-term jobs in the private sector. With this mission in mind, MERDI was located in Butte, where a once-huge copper mining operation had left nothing behind but unemployment and a big hole in the ground.

Plunkett told me that he had designed the Institute in reaction to abstract, academic research that had little effect on actual problems. He discussed work he had done in Guatemala, Africa and various universities, and his dissatisfactions with most research work in the energy field. He pointed out the huge commitment of time and money that has gone into nuclear power during the past twenty-five years, with very little power production to show for it. Little attention has been paid to the usefulness of applied, practical work, since that work as no place in the academic journals. Plunkett was critical of the lack of marketing experience in the U.S. Dept. of Energy, and their orientation towards a small number of huge, advanced technology projects to the dx detriment of more attainable goals.

C. National Center for Appropriate Technology (NCAT)

NCAT was set up by Plunkett during the first years of MERDI. He told me that he had founded the Center to provide the training programs and technical work necessary to achieve proper conservation practices in the homes of the ten million low-income families in the U.S. These home are among those with the highest energy costs in the country, but an investment of approximately two thousand dollars per home would cut annual energy costs in half. Although NCAT has begun work in this area, they have taken a broader path, doing technical work and information gathering in axxaxxaxxxmfxxxxx agriculture, biomass, building technology and solar energy. There seems to be some mild tensions between the older staff at MERDI and the younger staff at NCAT, with the MERDI people feeling that NCAT is too-enamored of individual small-scale technology development and is paying insufficient attention to the need for training and larger projects. Some NCAT staff scoffed that MERDI wasn't interested in work that wasn't big. Plunkett explained that his definition of "appropriate technology" included <u>all</u> sizes and complexities, depending on the use.

Because of the brief nature of my visit, as well as the national nature of NCAT's efforts, I had a hard time evaluating the success of their work. They have a tremendous variety of projects going, oriented around a concept of small-scale, community technology. They are doing very useful work in evaluating the efficiency of various forms of insulation and solar collectors, and are disseminating a lot of information on small hydro technology and weatherization .

NCAT runs on a budget of about 3.2 million dollars a year, which they receive from the federal Community Services Agency. In addition to their own work, they distribute about 650,000 dollars a year to other groups through grants for program assistance. The technical research staff of NCAT

(32 people) are employed by MERDI, although they work at the NCAT building. The Center pays MERDI $838,000 a year for their services.

D. Coal--the Magnetohydrodynamic (MHD) Generation project

MERDI is administering a Dept. of Energy program to develop a facility that will use the MHD process for large-scale generation of electric power. In the MHD process, coal is treated, then super-heated in a magnetized field. The resulting ionization gives off direct electricity; the hot gases that are produced in the process then turn more standard power turbines. Almost no waste products are left after the process is complete. The MHD process produces anywhere from 25-60% more power than conventional methods using coal, and uses a great deal less than water than the synfuel production process. Work on the project began in 1977 and will continue through 1986; total funding will be something over 200 million dollars. Some results will begin coming in next year.

E. Center for Innovation

The Center was established as a MERDI spinoff with grants from Montana and neighboring states. It receives its operating funds from the U.S. Economic Development Administration and the Dept. of Energy. The Center aids small businessmen and inventors in taking their ideas from conception to market, by providing help with patent work, detailed technical and marketing analyses, publicity, marketing and sales approaches and assembling start-up funds.

The Center for Innovation has reviewed 1300 proposals since beginning operation in June 1977. They have helped over 100 proposals -- about 15 have achieved commercial success, and almost one hundred are receiving active support. The Center attributes its success to the fact that the program is administered through part-time field representatives who have a variety of contacts in business and industry. The director of the Center also felt that they have managed to work with the inventor at his or her level while providing needed technical, administrative and commercial help. MERDI would like to see more Centers for Innovation started, since having them dispersed in different regions would improve each Center's effectiveness.

F. Power Facility Siting

MERDI is working to establish criteria for studying the social, economic and environmental impacts of siting major power facilities. They expressed dissatisfaction with the quality of work done in most impact statements by groups such as Dames and Moore. The director of their efforts, Terry Kirkland, would like to see their work used in Alaska. I did not have time to discuss the details of their work in this area but Mr. Kirkland has promised to send us materials.

G. Renewable Energy Development (a summary of comments by Ed O'Hair and Jerry Plunkett)

MERDI's goal is to use renewable energy development as an economic development tool. Projects need to be community-sized, and structured in a way that will provide incnetives for stable economic growth. In Montana, wind power and alcohol-based fuels are the best options.

The focus of renewable energy efforts needs to be on the reliability of the technologies, as well as simply putting them into place. The key is to create enough demand for the technologies to enable mass production at low costs, uder conditions that will benefit the state. If projects are designed at a modest scale, duplication can be built in, enabling a second contractor to learn form the mistakes of the first without failiures ruining the project for good. All work on renwable energy should be integrated, and directed to the needs of the local communities.

Montana is favoring renewable energy development because, in the long run, it is the only path of energy development that fits in with desired ways of life. Since coal is only an intermediate solution to the energy problem, fission and fusion are the only other alternatives. Both those forms would result in a highly centralized power s stem with social and security effects repulsive to a democratic society.

H. Conservation and General Energy Planning (again, a summary of the ideas of O'Hair and PLunkett)

MERDI's efforts have been directed towards the goal of efficiency, and not self-sufficiency; energy resources should be traded freely for best advantage. The entire energy system should be addressed. A large, diverse system, allowing for interchange, cogeneration, waste heat use, etc. is desirable. Where electric distibution is cheap and efficient, it is a desirable source of energy. Electricity is best used for industry, not as a primary source for home heating.

An efficient energy system also needs to be designed in a way that won't adversely impact chosen lifestyles -- just as you can't force good nutritional habits, proper uses of energy can't be forced.

Retrofitting projects should be contracted out to the private sector to build up their capabilities. The costs of conservation should be compared to the cost of <u>new</u> increments of power (marginal cost analysis). The four foundations of a good energy study:

1. economic impacts of technologies -- marginal cost analysis
2. social " " " -- desirability of decentralization, etc.
3. end use of energy analysis
4. system efficiency in delivering energy resources to end use.

I. Relationship Between the Academic World and POssible Institutes, Centers.

O'Hair and Plunkett both stressed the need for independence from university ties if energy development programs are to be successful. Both have worked in universities, and feel that their differing orientations and lack of understanding about economic development prevent the possibility of a good program operating under university auspices. They discussed the Nationa Science Foundation Innovations program. They were critical of it, stating that it accomplished nothing more than having engineers take business courses and businessmen take engineering courses.

Log of trip to Butte, Montana -- Mark Wittow for Power Alternatives STudy Committee

October 25 and 26, 1979

Oct. 25

10:20 am -- arrive in Butte

10:30-noon -- conversation with Jerry Plunkett on general goals of the Montana Energy Research and Development Institute and state and federal energy policy.

noon-1:30pm -- Lunch with MERDI division directors, braod overview of MERDI's work, scheduling of the rest of the day.

1:30-3pm --Explanation and tour of the MHD facility with Frank Fogarty and Ed Wong.

3-5pm -- Meeting Ed O'Hair on Montana renewable energy programs and their Center for Innovation.

5-6pm -- Discussion with O'Hair and Plunkett on Structure of MERDI, ties with the university, possible options for Alaska.

6-7pm -- informal talks with Dept of Energy and MERDI staff.

7-10pm -- dinner with Plunkett and a Westinghouse electric power engineer

Oct. 26

7-8am -- Breakfast with Plunkett and John Orth, Deputy Director of MERDI. Discussed role of MERDI in Alaska, possible work on coal.

8-10am -- Visit to National Center for Appropriate Technolog

general policy -- John McBride
operations, microhydro -- Sherr Eisenbart
conservation -- Toby Benson
Solar technologies --Larry Palmiter and Bill Wadsworth
agriculture-- Suzanne Merriam

11 am -- departed Butte