The Potential for Energy Conservation in Montana

by
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Resources Development Internship Program
Western Interstate Commission for Higher Education

Montana Environmental Quality Council

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Student Intern

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Sponsored by

Montana Environmental Quality Council

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INTRODUCTION - ABSTRACT

Montana is not independent when it comes to energy. It must rely on other areas to keep functioning. Life style in this state depends on the availability of energy in petroleum from Montana and Wyoming oil fields, natural gas from Canada, and electricity from dams in Montana and the Northwest.

Montana, as well as the entire United States, has become increasingly dependent on dwindling, non-renewable supplies of fossil fuels. Coal gasification and coal-fueled power plants are becoming more attractive alternatives as natural gas and oil supplies dwindle. As a partial solution to the pending energy crisis, the nation is eyeing Montana's vast low-sulfur coal fields.

Energy is being foolishly wasted. At all levels--international, national, regional, state, and local-careful planning for energy development, use, and conservation is essential. There are certain energy requirements, and these must be met by careful development and allocation of energy resources. However, the environmental, social, and economic costs of energy development and consumption must be carefully evaluated. It has been learned somewhat late that the "price" of energy includes not only the cost of recovery, storage, and distribution, but factors such as environmental degradation and social problems arising from energy development and use (such as oil "boom" towns).

Since Montana shares the energy problem with the rest of the Northwest, the nation, and the world, Montana energy policy must be coordinated with regional, national, and international programs. A national energy policy is urgently needed with well-planned, uniformly applied energy decision-making rules. Effective state and regional programs can then be developed to complement each other and minimize social, economic, or environmental problems. Montanans must examine the energy situation on many levels; the nation views Montana coal as well as other energy resources differently than Montana does.

National Energy Policy

An important step toward a coordinated national energy policy has been Senate endorsement of U.S. Senate Resolution 45 that calls for a national energy policy. Another move has been the creation of a single office to coordinate the 64 agencies with energy responsibilities. Other national policies should include:

- --Increased federal excise taxes on petroleum products. Revenues would be used for energy research and development. (U.S. Senate Bill 70) Not only would this measure finance research and development, but it would also promote conservation because of higher fuel costs.

--Research and development of new energy forms as well as increasing efficiency of use and cleaning up environmental problems of existing energy forms.

--Review of contractual relationships, preference clauses, water use priorities.

Regional Energy Policy

Montana, with Idaho, Oregon, Washington, Nevada, and California, should coordinate regionwide energy conservation efforts. Coordination among state energy policies hopefully began with the recent Conference of the Western State Governors in Oregon.

State Energy Policy

Montana does not have an energy policy, but the Environmental Quality Council, as directed by the legislature, is preparing an energy policy study for the purpose of establishment of a state energy policy. (For details, see "An Overview of Montana's Energy Policy Study," by Walter I. Enderlin, which precedes this article in the Second Annual Report.)

State Government Promotion of Energy Conservation

State government has powers to promote energy conservation that include utilities regulation, land use control, tax incentives or disincentives, police power (such as rationing), and education.

Regulatory power over utilities

The Public Service Commission is Montana's agency to regulate utilities. The commission has authority over utility rates, advertising practices, and to some extent, capital expansion and financial operation of utilities.

Authority over land use control

The state has limited powers over land use except in utility siting. Hopefully, future legislatures will strengthen state powers and incorporate energy consciousness into other aspects of land planning. Too often, new land developments are planned without considering available energy supplies, existing energy systems, or most energy-efficient land uses. The relationship between increased energy demand due to some types of land development, and environmental degradation should be considered. Development pressures on Montana are increasing. To avoid past errors, the state must respond with enlightened land use regulation.

Authority to levy taxes

Incentives such as tax deductions for improving building insulation or other energy saving measures would encourage conservation. Tax disincentives such as taxing inefficient motor vehicles, or an additional tax on gasoline would also encourage energy conservation.

Police Power

If necessary, the state could ration energy (fuel oil, electricity, etc.) However, this would have to coordinate with any national rationing in progress. Lists of essential services should be compiled to determine high priority energy users so essential services (health care, food storage, transportation, etc.) have enough energy. The Public Service Commission has ordered Montana gas and electric companies to file plans for load shedding (amounts of energy that could be cut back) and/or curtailment (who could be cut back first). The governor's office is also working on similar recommendations.

Montana's state government has power to promote energy conservation and also is setting a good example of saving energy. The governor has directed all state agencies to reduce energy consumption by 10 percent. His conservation suggestions include:

--Reduce interior lighting wherever possible by reducing the size and/or number of lights used. Turn off lights during lunch, after hours, during sufficient natural light.

--Discontinue exterior lighting except for security or safety.

--Discontinue use of air conditioners and space heaters unless needed for health or technical reasons. Keep heating and cooling unit filters clean.

--Schedule maintenance and janitorial work during daylight hours, if possible. If that is not possible light only the area being serviced.

--Turn on office machine motors only when in use.

Other state government conservation actions might include requiring appliance efficiency labelling, establishing lower speed limits, establishing a bikeway system, limiting outdoor electrical promotional advertising, and creating a statewide environmental education program. Some of these actions would require legislation.

The Public Service Commission has ordered all jurisdictional electric companies to discontinue furnishing electricity for outside advertising and display after businesses have closed each day, effective January 1, 1974. The companies were also ordered to refuse requests for new electric service to light outside advertising billboards after September 19, 1973. Gas companies were ordered to discontinue furnishing natural gas for new open-flame gas torches, effective September 19, 1973.

Environmental education

A well-funded, statewide environmental education program (including adult education programs) is sorely needed in Montana. For example, young Montanans should be aware of social, environmental, and economic costs of coal development; They will soon be contributing to decisions on energy development. The environmental education program should include a teacher training program and consider specific Montana environmental problems such as energy conservation.

Local government conservation efforts

Local government also must consider energy availability in relation to density zoning, land use classification and control, building code regulation, transportation planning, solid waste disposal, outdoor and indoor illumination standards, and recycling plans.

Energy Consumption Cutbacks

Opportunities for energy savings are plentiful in each of Montana's four main energy consumption sectors--residential, commercial, industrial (including power plants), and transportation.

Residential and commercial

A significant energy saving could be accomplished by improving insulation standards, setting thermostats lower for heaters and higher for air conditioners, using electric heat pumps, utilizing heat from light systems and unconventional energy forms (geothermal, solar, wind) for space and water heating, requiring appliance energy efficiency labelling, encouraging citizens to avoid cooking during periods of peak energy use, lowering lighting standards levels, encouraging use of fluorescent lights rather than incandescent, and incorporating energy consciousness into home building and maintenance.

Industrial

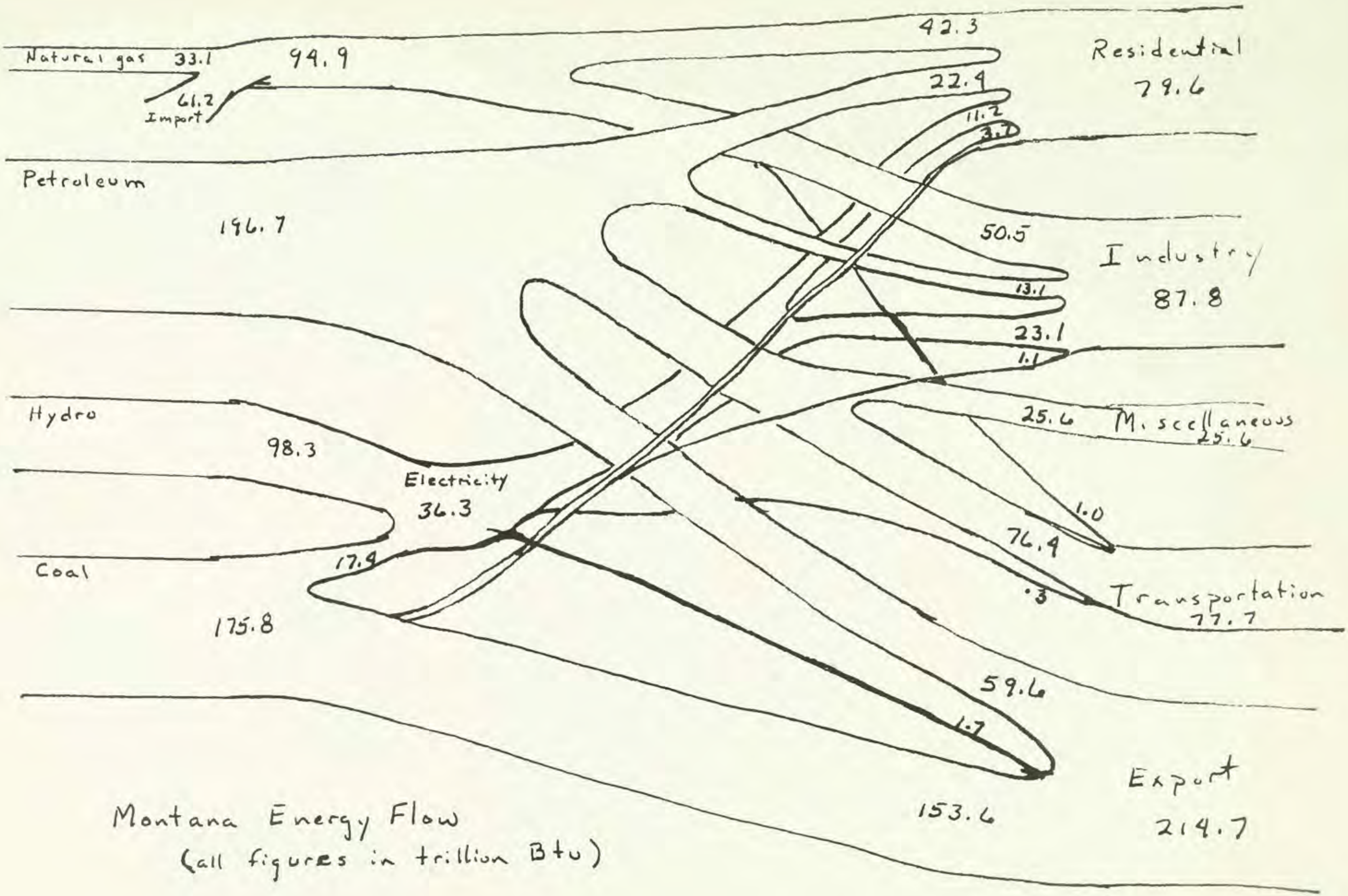
Industry is a big energy consumer in Montana. Energy conservation measures include rescheduling work hours and production to off-peak periods, reducing maximum loads, using standby generators and photocell switches, reevaluating ventilating, cooling, and lighting systems, resetting thermostats, maintaining equipment, and utilizing waste heat from power production, from other industries or from the industry's own production.

Transportation

Energy could be saved in transportation by encouraging car pooling, improving traffic flow, establishing attractive bike and pedestrian paths, increasing gasoline tax, reducing speed limit, using electric vans for postal service, coordinating transportation planning with urban planning, eliminating "milk run" air flights, and improving city and state bus and train service and encouraging their use.

Effects of implementing these suggestions should be carefully evaluated. Some proposals may seem trivial. Some may seem too radical. All should be investigated.

ENERGY SOURCES



Montana Energy Flow
(all figures in trillion Btu)

Source:

Conversion Factors (Stanford Research Institute Figures)

Energy Form	Btu Content
Petroleum	
Still gas	1500/cubic foot
LPG	95,500/gallon
Gasoline	125,000/gallon
Jet fuel	5.5 million/barrel
Kerosine	5.7 million/barrel
Distillate fuel oil	5.85 million/barrel
Residual fuel oil	6.2 million/barrel
Petroleum coke	6.0 million/barrel
Lubricants	144,495/gallon
Greases	19,254/pound
Asphalt	36.8 million/short ton
Road oil	39.2 million/short ton
Petrochemical feedstocks	5.4 million/barrel
Waxes	5.4 million/barrel
Coal	26.2 million/short ton
Gas	1075/cubic foot
Wood	10-18 million/cord
Hydroelectric Geothermal Nuclear	10,000/kwh
Electricity	3413/kwh

NATURAL GAS

Reserves

Recoverable proved reserves in 1960 were estimated at 263,759 billion cubic feet for the United States and 626 billion cubic feet for Montana.[1] By 1970, the U.S. natural gas reserves totalled 290,746 billion feet and the Montana reserves totalled 1,100 billion cubic feet.[2] Montana's natural gas reserve of 1,024 billion cubic feet consisted of 715 billion cubic feet of non associated natural gas, 127 billion cubic feet of associated and dissolved natural gas and 182 billion cubic feet of natural gas in six underground storage wells.[3] The ultimate storage capacity of gas reserves in 1971 was 213 billion cubic feet.[4]

Production

Six natural gas processing plants produced 35 billion cubic feet of natural gas in 1972, almost twenty percent below the 1970 production.[5]

The peak production of natural gas liquids was estimated at a peak of 948,000 barrels in 1967; 1972 production was 500,000 barrels.[6]

Consumption

Since 1930 Montana has annually consumed more gas than has been developed. One out of every 14 wildcat drillings in 1972 was a producer. For example, in 1970 Montana consumed 92 trillion Btu of gas while only producing 44 trillion, leaving a deficit of 48 trillion Btu.[7] Most of the imported gas was from Canada. Now, however, the National Energy Board of Canada which has the authority to determine established reserves, market requirements and exportable surpluses of gas for Canada, found Canada's 30 year supply deficit by 1.1 trillion cubic feet and cut back on exports. Montana Power Company was denied an additional gasoline request of 20 mcf/day and is re-negotiating import agreements at increased gas prices.[8]

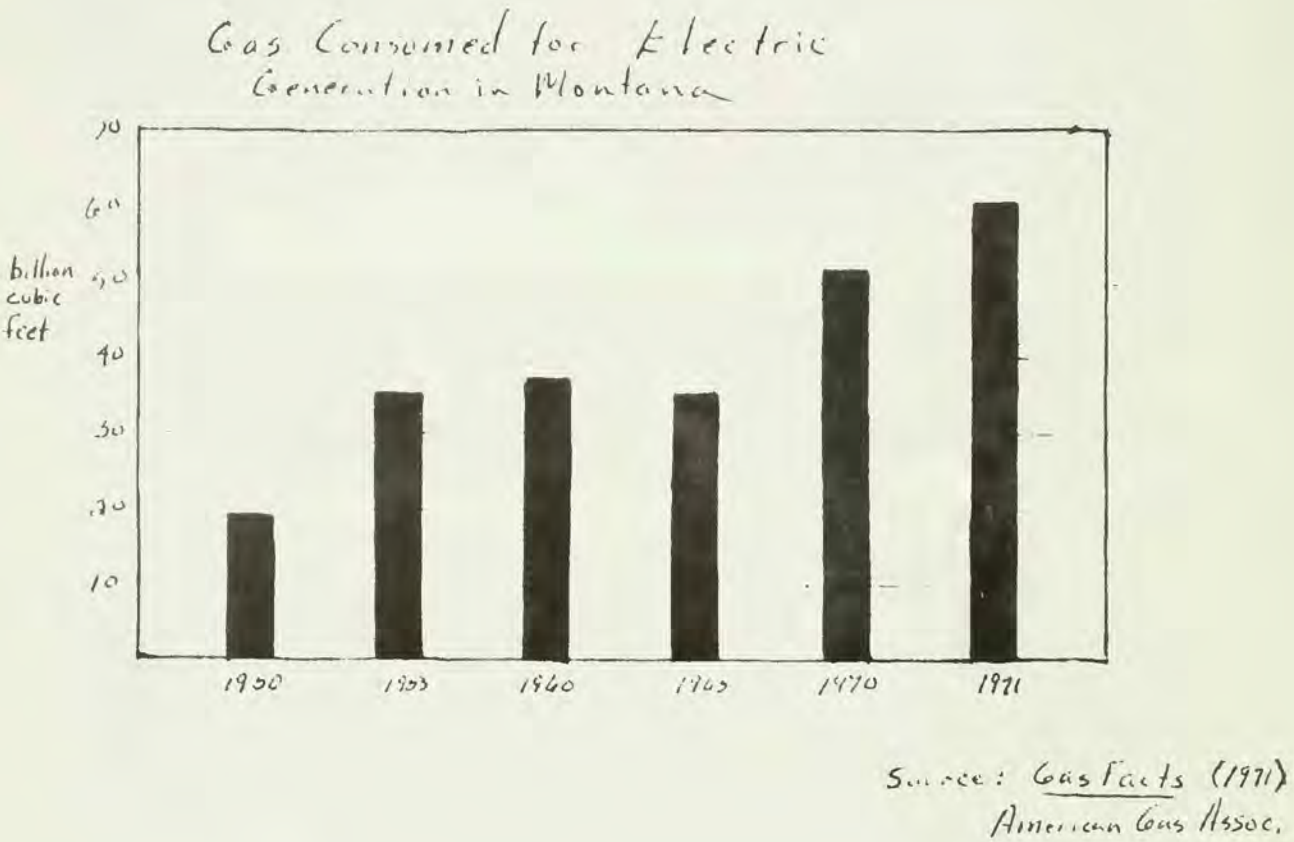
Customers and Sales

Customers	1968 (thousands)	1972 (thousands)
Residential	129	134
Commercial	16	17
Industrial	1	1
Total	196	152

Sales	1968 (million therms)	1972 (million therms)
Residential	224	235
Commercial	146	154
Industrial	266	364
Other	26	35
Total	662	788

Source: US Statistical Abstract

Forty-six percent of Montana gas was consumed by industry, thirty percent by homes and twenty percent by commercial businesses. The following chart shows the natural gas consumption for electricity generation in Montana:



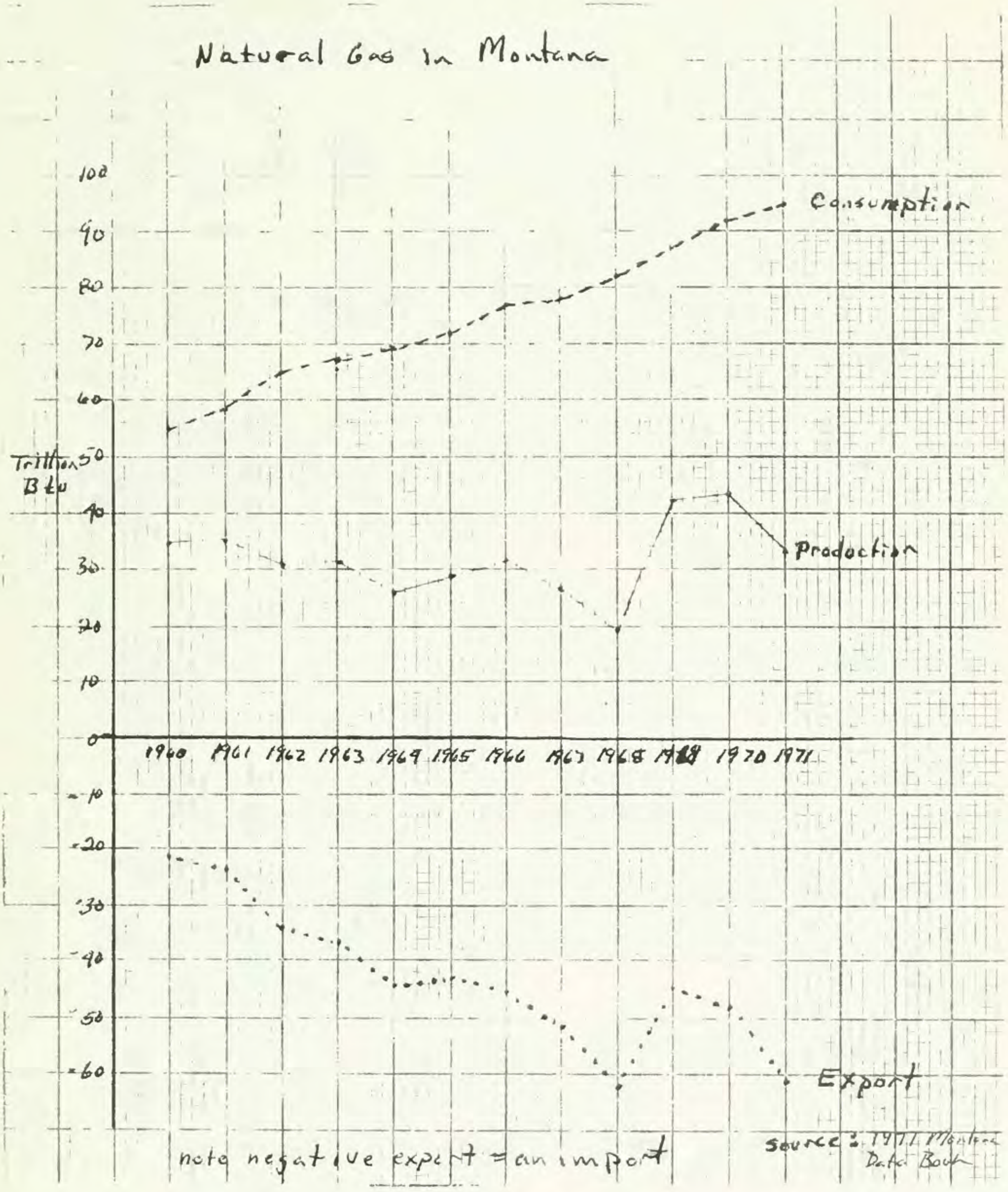
Transportation

Montana has a total of 6,130 miles of gas utility main pipelines, including 1,150 miles of field and gathering pipelines, 2,730 miles of transmission pipelines, and 2,250 miles of distribution pipelines.[9]

Northern Natural Gas Company and Montana Power Company both have gas pipelines coming down into Montana from Canada. MDU has a pipeline from North Dakota and Wyoming.

Imports

Imports of natural gas have steadily increased from 21.2 trillion Btu in 1960 to 61.2 trillion Btu in 1971.[10]


Natural Gas in Montana
Consumption
Production
Export
Trillion Btu
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971
note negative export = an import
source: 1971 Montana Data Book

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FUTURE SOURCES OF GAS

The United States uses more natural gas than it produces and is becoming increasingly dependent upon imported supplies. Gas pumped through pipelines from Mexico and Canada supply us with 1-2 trillion cubic feet annually.[1] It would be possible to obtain more gas from Canada if the Canadian Energy Board adopted a more lenient attitude toward gas exports. However, U.S. utilities, including the Montana Power Company, are having difficulty in even obtaining last years levels of natural gas imports from Canada. Gas from Canada is estimated to amount to about a trillion cubic feet by 1980, and about 2 trillion feet by 1990.[2] Alaskan reserves are estimated at 300 trillion cubic feet, or slightly less than one third of the U.S. total gas reserve.[3]

A variety of other natural gas sources are being investigated: coal gasification, other liquid fuels such as naptha, conversion of manure, sewage sludge, and urban garbage, and imported liquified natural gas.

Nuclear Stimulation of Gas Reservoirs

Nuclear explosions can be used to release natural gas from tight gas-bearing formations. The blast fractures the rock, connecting gas containing pores. Nuclear gas-stimulation experiments have been conducted in New Mexico and Colorado and have been successful in releasing natural gas.

There are, however, economic and environmental drawbacks to this nuclear gas-stimulation. First, the process is fairly expensive. Second, there is a potential radioactivity contamination hazard. Radio-activity could enter the groundwater or natural gas or leak into the atmosphere. Perhaps the alternative of using conventional explosives to stimulate tight gas reservoirs should be more closely examined.

Gasification

Natural gas is the most versatile fossil fuel we have. It is also clean burning and relatively inexpensive. As industries and utilities are forced to comply with strict air pollution standards, natural gas is more in demand. However, the supply of natural gas is limited. Montana, for example, is consuming more gas that it is developing. Gasification of coal or naptha is beginning to look especially attractive, for areas where coal is abundant. Gasification transforms an abundant, dirty fossil fuel to a cleaner, more versatile fuel.

The gasification process is simple. Carbon from coal or naptha is combined with water at a high temperature to form methane (the principal component of natural gas). Naptha gasification is simpler and more advanced than coal gasification.

Three types of naptha gasification are being used commercially:

1. CRG (catalytic rich gas) process developed by the British Gas Council.

2. MRG (methane righ gas) process developed by the Japan Gas Company.
3. Gasynthan process developed by West Germany's Lurgi Mineraloeltechnik - GMGH and Badische Anilin-und-Soda-Fabrik AG

The three processes are similar except in the type of catalyst used. Vaporized naptha is superheated under pressure and desulfurized catalytically. The desulfurized steam is then subjected to superheated steam under high temperature and pressure conditions to form a mixture of methan hydrogen carbon monoxide and carbon dioxide. Then the catalytic methanation step forms methane molecules from molecules of hydrogen and removes carbon dioxide and water, leaving 95-98 percent pure methane.[4]

The U.S. has ordered 25 European plants. Over half of these plants will use the CRG process. There are major problems facing these plants. Almost all of the naptha must be imported, and naptha is used for other purposes besides gasification such as chemical feedstock.

An alternative is the use of coal for gasification. The U.S. in general and Montana in particular have vast coal reserves. The conversion of coal to synthetic natural gas is a feasible alternative to direct coal use. A problem, however, is that coal gasification requires large quantities of water. In dry areas such as Montana, the lack of abundant water may prove prohibitive.

Of the five coal gasification processes, only one, the Lurgi process is commercially used at the present time. Four U.S. processes, Hygas process developed by the American Gas Association and the Institute of Gas Technology; the CO_2 acceptor process developed by consolidation coal company, the Bi-Gas process developed by the Bituminous Coal Research Inc., and the Synthane process developed by the U.S. Bureau of Mines have been successful in laboratory tests. There are still engineering problems to be worked out, however.

Coal gasification is similar to naptha gasification. Coal is brought into contact with synthesis gas (a methane, hydrogen and carbon monoxide mixture) at high temperature and pressure, driving off volatile components. The devolatilized coal is then brought into contact with high temperature steam and forms synthesis gas containing forty to sixty percent methane. If necessary, the synthesis gas is converted with a catalyst shift process, forming CO_2 and H_2 from CO and H_2O. Then carbon dioxide, hydrogen sulfide, organic sulfides and water vapor are stripped from the gas. The remaining gas goes through the catalytic methanation process, followed by more water vapor removal, resulting in synthetic natural gas.

Northern Natural Gas Company and Cities Service Gas Company are examining the possibilities of a coal gasification project in the Powder River Basin area. As gas becomes more expensive and scarce, gasification of Montana coal will become more attractive to the rest of the nation. If coal gasification plants are developed in Montana, they must conform to the governmental environmental and esthetic standards.

Fuel from urban and agricultural wastes

Urban and agricultural wastes can be converted to a clean, convenient fuel, methane (the principles component of natural gas). This would not only reduce the amount of wastes to be disposed of, but would also augment our dwindling supply of natural gas. Methane from orgainc wastes is a renewable energy source and can be transported with existing gas transmission systems. The use of the methane requires no change in combustion equipment.

Microorganisms convert organic waste to gases (consisting of a large amount of carbon dioxide, a small amount of hydrogen, water vapor, ammonia, mercaptans, hydrogen sulfide, and volative amines) and sludge (a mixture of microorganisms and undigested organic material which may be used for landfill or fertilizer)[6]

One and a half billion tons of urban and agricultural waste is produced annually.[7] Each pound of waste yeilds 13 cubic feet of methane during anaerobic digestion.[8] Conversion of the urban and agricultural waste would yeild 40 trillion cubic feet of methane per year (more than the current U.S. natural gas consumption).

Anaerobic digestion is an integral process of most sewage treatment systems. Some systems utilize the gas for running generators to power pumps and other equipment, or for heating sewage to increase the rate of treatment. Sewage systems should be designed not only for removal of organic material, but also for optimization of gas production and for the utilization of the gas. For example, the addition of solid waste to sewage to supplement gas production should be investigated.

Feedlots are also a source of methane. Manure spontaneously releases methane under anaerobic conditions. A 100,000 cattle feed lot produces about 150,000 tons of dry organic wastes which can be converted into 1.5 billion cubic feet of methane (assuming a low 5 cubic feet methan per pound dried waste).[9] This amount of methane could supply the natural gas needs of 15,000 people with average annual per capita gas needs of 1 million cubic feet.[10]

Montana feedlots are presently too small, too few, and too far apart to produce large amounts of methane.

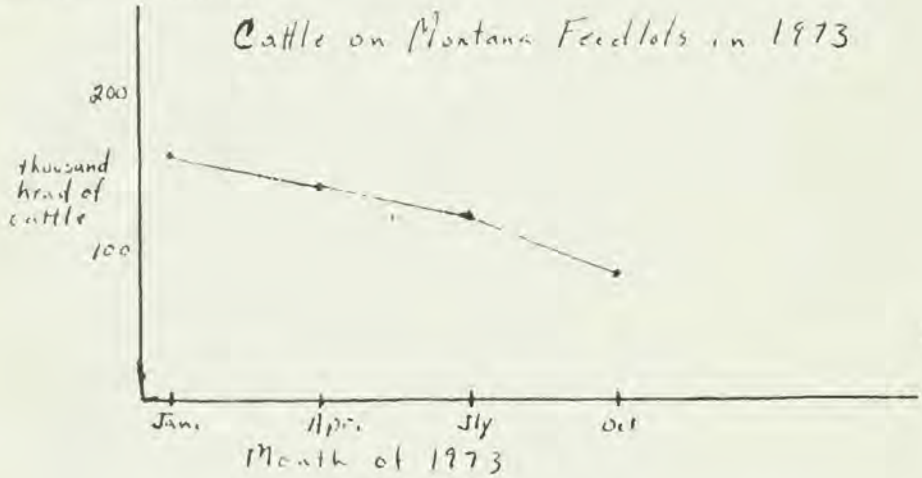
Montana produces 1.3 million cattle a year. Not all of these cattle are on feedlots:[11] only about 120,000 head of cattle were on feedlots in January 1969.[12] The number and size of Montana feedlots are growing however. In January 1973, 160,000 head of cattle were on feedlots.[13] The following chart shows the counties with the largest operations:

County	Number of Feedlots	Number of cattle on feedlots
Richland	48	10,700
Cascade	15	24,500
Stillwater	15	13,600
Yellowstone	56	64,300

Note: This county does not include warmup feedlots (those which send cattle to other feedlots), but only those feedlots preparing cattle for slaughter.

Source: Montana Crop and Livestock Reporting Service.

The number of cattle on feedlots is cyclical ranging from a high in January to a low in October.



Source: Montana Crop and Livestock Reporting Service, U.S. Dept. of Agriculture.

A 1,000 pound bovine produces an average of 64 pounds of wet manure and urine daily (10.3 lb dry mineral and organic matter).[14] All the cattle in Montana produce about 30 billion tons of waste per year (or 4.7 billion tons of dried waste equivalent). About six hundred thousand tons of dried waste were produced in 1973 by feedlot cattle (assuming an average figure of 125,000 cattle on deedlots). The wastes are not concentrated enough or in sufficient quantity to support a large methane conversion operation, but might be adequate in concentrated areas of large feedlots to support modest operations.

As the number of cattle on Montana feedlots grows, especially around urban areas, the utiliztion of feedlot waste for conversion to methane will become more attractive.

Pyrolysis of garbage, manure, and sewage sludge

In general, pyrolysis is the heating of garbage, manure, sewage sludge with little or no air to about 500° C in a furnace to obtain a mixture of organic gases and liquids and a residue of charcoal and mineral material. All of the products, excluding the mineral materials, are suitable for use as fuel. There are several different processes being tested in prototype plants. The Monsanto Standard system involves heating trash in a rotating drum. The gaseous and liquid products are burned and the solid residue is magnetically sorted to remove iron and the disposed of in a land fill. The method results in a ninety four percent reduction in trash volume.[15] Another method, the Garret pyrolysis process is similar to the Monsanto process but also recovers about 70 percent of the glass in a fairly pure residue.[16] There is little information on either the Lantz Converter or Northern Recycling Corporation's processes.

The Bureau of Mines has extracted fuel containing 6-8 million Btu of energy per ton of demetallicized refuse using the pyrolysis process (thermal decomposition without air). This process consumes one to two million Btu of electricity for every ton refuse pyrolyzed.[17]

One ton refuse yields:

154-230 16. char residue (8-13,000 Btu/lb.)
0.5-5 gal tar and pitch
1.2 gal. light oil (150,000 Btu/lb)
11,000-17,000 cubic feet gas (500 Btu/cubic ft.)
80-133 gal. aqueous liquor
18-25 lb ammonium sulfate [18]

Revenue from the byproducts would bring down the cost of solid waste disposal by pyrolysis.

Liquified natural gas

The first major liquified natural gas shipments by tanker were made in 1959 from Louisianna to Great Britain. The first shipment to the U.S. occurred in 1969 when we bought LNG (liquified natural gas) from Algeria. The first tanker carried 5,000 cubic meters of LNG, thirteen tankers each carried 40,000 cubic meters in 1971; by 1990 the U.S. is estimated to need 130 LNG tankers each with a capacity of 125,000 cubic meters.[19]

Natural gas can be liquified at normal atmospheric pressure at a temperature of 259° F. (boiling point of methane, one of the major componenets of natural gas).[20] The liquification process consumes 20 Btu per cubic foot, an insignificant amount compared to the heating value of about 1,000 Btu per cubic foot of natural gas, is less than half as dense as water.[21] Normally natural gas is lighter than air, but evaporating LNG is heavier than air due to its low-temperature. Even the mixture of LNG and warmer air, will spread along the ground. These properties of LNG pose questions regarding its safety.

LNG spilled from a tanker will float on water and then rapidly evaporate (the larger the spill the more rapid the evaporation). The evaporated LNG-air cloud will remain near the water because of its higher density than air. A potential safety hazard exists if the cloud from this type of spill or one from a pipeline leak should flow over a populated area and be ignited. LNG loading and storing facilities need to be carefully planned to avoid such hazards.

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PETROLEUM

Reserves

In 1971, Montana's crude oil proved reserves totalled 228 million barrels, less than .6 percent of the United States proved petroleum reserves of 38,063 million barrels[1] the reserve figures for Montana and the U.S. for 1960 and 1970 are listed below:

	Proved Reserves (million barrels) United States	Montana
1960	31,613	267
1970	39,001	242

Source: 1971 Statistical Abstract of the United States. (U.S. Bureau of the Census)

Production

Nine operating refineries processed 41.9 million barrels of crude in 1971 (including 12 million barrels of indigenous crude). The all time production high was 48.5 million barrels in 1968 due primarily to the 1967 Bell Creek Field discovery.[2] By 1972 production had declined to about 33.9 million barrels.[3] The total crude refined in 1972 is listed below:

Refinery	Crude refined (millions of barrels)
Big West Oil Company	1.2
Continental Oil Co.	17.1
Diamond Asphalt Co.	.1
Farmers Union Central Exchange (Cenex)	10.5
Humble Oil & Refining (Exxon)	15.4
Jet Fuel Refinery	.02
Phillips Petroleum Co.	2.1
Spruce Oil Co.	.8
Westco Refining Co.	1.2
Total	48.4

Source: Statement of Crude Oil Production and Valuation Calander Year 1972. (Board of Oil and Gas Conservation of the State of Montana)

Of the 48.5 million barrels of crude refined in Montana in 1972, 9.0 million barrels was indigenous, 13.7 million barrels was imported from Canada, and 25.8 million barrels was from Wyoming.[4] In 1971, an average of 123,279 barrels of crude oil was refined daily in Montana. In 1972 an average of 132,780 barrels was refined daily.[5]

The 1972 annual crude capacity in Montana was 52,429 thousand barrels. The throughput was 41,049 thousand barrels.[6]

Transport

Most Montana crude is transported from the field to the refinery by pipeline, although a small amount comes by tank car or truck. Wyoming and Canadian crude comes by pipelines.

Pipeline Mileage Data (1968) - Total 2,499 miles

Crude gathering lines	626 miles
Crude trunk lines	1,199 miles
Refined products lines	674 miles

Source: US Petroleum Facts and Figures, 1971 Edition, (American Petroleum Institute)

1972 Refinery Receipts of Crude (million barrels)

Domestic intrastate	
Pipeline	12.6
Tankcars and Trucks	.7
Domestic interstate	
Pipeline	16.4
Foreign	
Pipeline	11.5

Source: Mineral Industry Survey, Jan. 1973, (US Dept. of the Interior)

Consumption

Consumption of petroleum has been gradually increasing (see figure 1) from 120.9 trillion Btu in 1960 to 137.5 trillion.

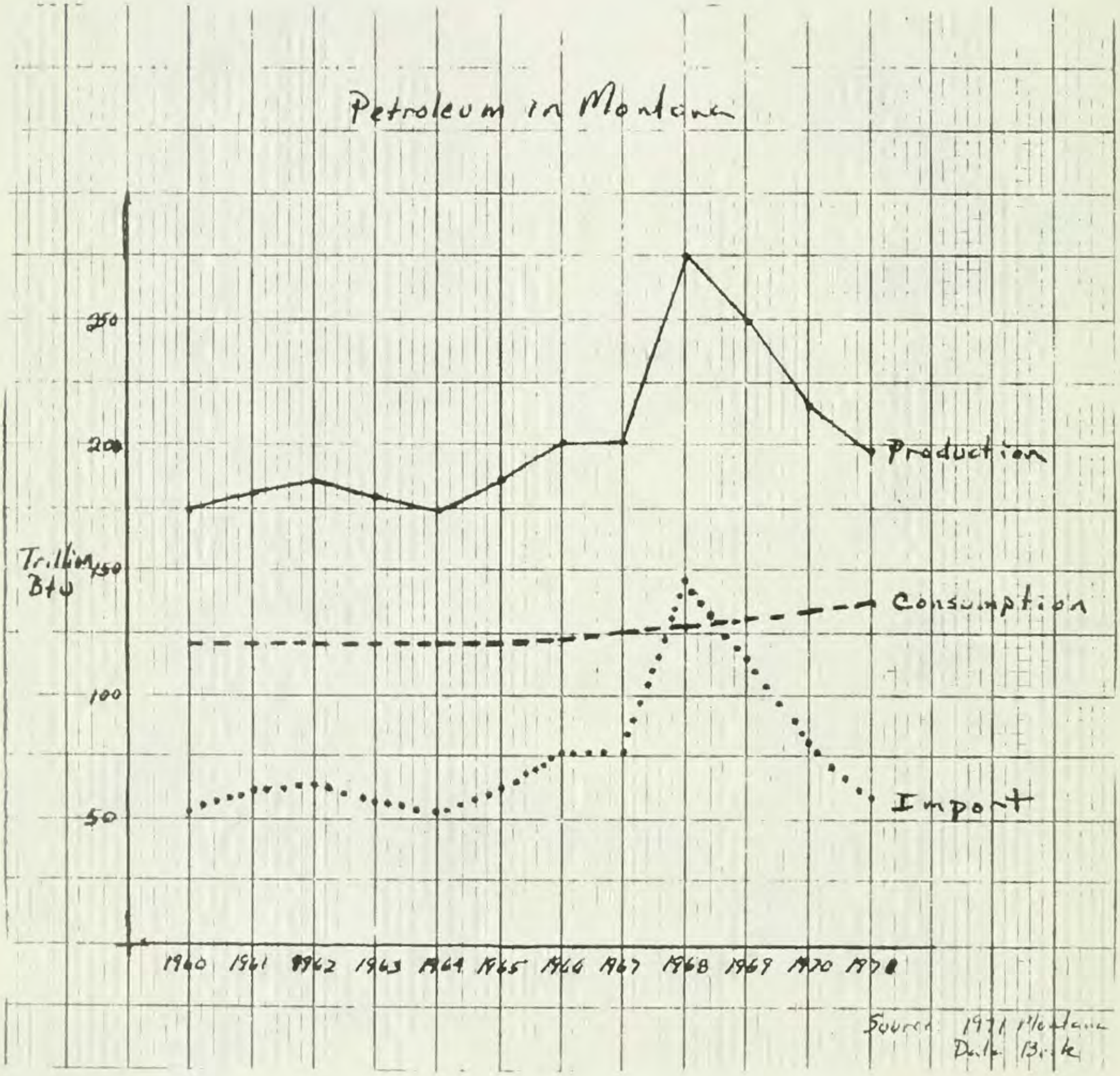
Product Sales

Distillate heating oil	1045	thous.barrel (1968)
Residual heating oil	419	" " "
Distillate fuel oil	4669	thous.barrel (1968)
railroads	1270	" " "
oil company fuel	10	" " "
industry	114	" " "
military	20	" " (1969)
misc.	1761	" " "
Residual fuel oil	1524	thous.barrel (1969)
railroads	179	" " "
power plants	105	" " "
oil company fuel	683	" " "
industry	232	" " "
military	54	" " "
misc.	45	" " "
Diesel oil misc. uses	1537	thous.barrel (1969)
on highway	1169	" " "
off highway	368	" " "
Kerosene	656	thous.barrel (1969)
heating	133	" " "
misc.	523	" " "
Oils	8066	thous.gallons (1967)
aviation	70	" " "
automotive	6196	" " "
industrial libricating	1629	" " "
other industrial	171	" " "
Greases	4394	thous.lb. (1967)
automotive and aviation	3222	" " "
industrial libricating & other	1172	" " "
Liquified petroleum gases and ethane	70999	thous.gallons (1968)
Petroleum Asphalts	237608	short tons (1968)
paving product	218353	" " "
asphalt cement	154582	" " "
cutback asphalts	47241	" " "
emulsified asphalts	16530	" " "
roofing products	3100	" " "
other products	155	" " "
Road oil	5905	short tons (1969)

Source: US Petroleum Facts & Figures, 1971 Edition. (American Petroleum Institute)

Export

Petroleum exports have increased from 53.7 Btu in 1960 to 59.4 Btu in 1970.[7]



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OIL SHALE

A possible future source of oil is oil shale. Montana has some low-grade oil shale in the southern portion of the state. Oil shale is a fine-grained, compact sedimentary rock--containing an organic, high-molecular weight mineraloid of nonuniform composition. Oil shale yields at least 10 gallons oil/ton rock oil when crushed and heated to 900^{0} F. Most development has been on deposits yielding 25-65 gallons per ton however.

The hydrocarbonaceous material in the shale, Kerogen, was formed from aquatic life (algae, waxy, spores, and pollen grains) and is mixed with inorganic components of the shale. Kerogen is an incompletely formed petroleum (due to lower pressure and temperature conditions than those necessary for petroleum). The shale coloration varies from brown, yellow, red, and tan and depends on the Kerogen composition and concentration.

Unrefined oil shale has a variable composition, but in general has more nitrogen and less hydrogen content than petroleum. Oil shale can be refined to yield residual fuel oil, distillate fuel oil, diesel fuel, gasoline, jet fuel, and liquified petroleum gas as well as petroleum-analagous byproducts.

The U.S. has the world's largest oil shale deposit. Brazil has the second largest and China, USSR, Republic of the Congo, Germany, Italy, England, France, Sweden, Canada and Thailand have substantial oil shale reserves.

The most extensive and valuable U.S. oil shale reserves are found in the Green River Formation in Colorado, Utah, and Wyoming. The shale deposits in this formation cover about 16 million acres. Some of the deposits extend down 7,000 feet (although not all of this is recoverable). Most of the high grade shale is found in the Piceance basin of Colorado which contains 80 billion bbl of recoverable shale oil. The shale deposits are greater than 30 feet thick and have an oil content of about 30 gallons per ton.

The process of converting oil shale to petroleum-analogous products is not yet commercially feasible although there have been experimental oil shale plants in operation for some time. One of the most promising methods for restoring oil shale is the Toscoll process.

The process of retorting oil shale is reported in Mining Engineering:

1. Mined and crushed to 1/2" diameter.

2. Preheated with hot flue gas from ceramic ball heater.

3. Mixed with hot ceramic balls in rotating drum.

4. Heated to 900^{0} G (Kerogen converted to hydrocarbon vapor).

5. Vapors drawn off, condensed, and treated in conventional oil processing units.

6. Spent shale and ceramic balls separated.

7. Balls recycled to heater.

8. Processed shale cooled, moistened and transferred to disposal site (above or underground) may be revegetated.

9. Crude oil processed at regular oil refineries into gasoline, diesel jet fuel, fuel oil, liquified petroleum gas and byproducts or processed to remove sulfur and nitrogen to produce high grade fuel oil or high quality feed stock for natural gas production.

There are problems with shale oil - reclamation of spent oil shale disposal areas and high water requirements for the retorting process.

China and the USSR have the most extensive oil shale operations (China has been operating oil shale retorting plants for 40 years). Other countries which have tried to develop the process are France, Spain, South Africa, Australia, Scotland and Sweden.

The first U.S. interest in recovering oil from oil shale came around 1920 due to the fear that domestic supplies of petroleum were not large enough. The development of oil shale was encouraged following World War II by the Synthetic Liquid Fuels Act. The Department of Interior is presently trying to determine if and how the United States oil shale will be developed.

Montana has some low-grade oil shale in the southern part of the state. It is difficult to determine the feasibility of recovering oil from the shale in the future. At the present time, the cost is prohibitive.

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COAL

Reserves

The original Montana coal reserve estimate was 222,047 million tons. Of the reserves, 2,363 million tons were classified as bituminous, 132,151 million tons as sub-bituminous, and 87,533 as lignite. The estimates are conservative, including coal only up to 2,000 feet below the surface. Remaining recoverable reserves total 110,848 million short tons.[1] The present estimate of strippable Montana coal is over 30 billion tons.[2]

Coal reserves cover 51,300 square miles of Montana, one-third of the land area. Most of the coal is found in the Fort Union and Powder River regions.

Heating value and sulfur content

The heating value of Montana coal is 6,500 to 8,300 Btu per pound for the lignites and 8,300 to 9,500 for the sub-bituminous "C" rank coals.[6]

Sulfur content ranges from 0.2 percent to 2.0 percent. Most of the coal has a sulfur content below 1.0 percent.[6]

Production

Mining and petroleum companies, as well as eastern power markets, have recently become interested in Montana coal due to its low sulfur content. The production of coal since 1968 has increased exponentially (see figure 1). Production increased from 519.0 thousand short tons (13.0 trillion Btu) in 1968 to 3,447 thousand short tons (85.8 trillion Btu) in 1970 and 7,064 thousand short tons (175.8 trillion Btu) in 1971.[3] The Montana Bureau of Mines estimated production could be as high as 20 million tons by 1975, but this appears unlikely, due to environmental constraints.[4]

The following chart shows the 1971 and 1972 production of bituminous and lignite coal in Montana in thousand short tons:

	1971	1972 (preliminary)
Bituminous	6,737	7,700
underground	20	20
strip	6,717	7,680
Lignite	327	340
Total	7,064	8,040
strip	7,044	8,020
underground	20	20

Source: Mineral Industry Surveys (U.S. Dept. of Interior)

Montana coal strip mines operated by the following companies are producing an estimated 11.0 million tons per year:

	Million tons per year	Location
Western Energy Company	4	Rosebud Co.
Peabody Coal Company	2	Rosebud Co.
Decker Coal Company	4	Big Horn Co.
Knife River Coal Company	1	Richland Co.

The following companies are developing areas which should be producing before 1976:

	Million tons per year	Location
Westmoreland Coal Company	5	Big Horn Co.
Consolidated Coal Company	Unknown	Mussellshell Co.

Source:

Limiting factors for coal development

Two limiting factors of the development of coal are water availability and land reclamation. Coal-based development requires an abundant supply of water. The coal reserves are located in semi-arid areas. If the coal gasification, coal by-product chemical plants or coal fired plants were mine-mouth plants (located near the mine) there might not be enough existing groundwater and runoff in the area. Much more information must be gathered concerning the availability of water, particularly groundwater in the area. A Montana Bureau of Mines report to the 1969 legislature indicated that groundwater is not sufficient for large industrial development.[5] Surface water also does not seem to be adequate for development. New dams, storage reservoirs, or aquaduct construction are required. Rivers in the area include the Missouri, Yellowstone, Powder, Tongue, Bighorn and Little Bighorn. Existing storage facilities are Bighorn Lake, Tongue River Reservoir, Fort Peck Reservoir. Moorhead Reservoir (Powder River) and Allenspur Dam are proposed storage facilities. In addition, an aquaduct system has been proposed by the Bureau of Reclamation.[6] All of these proposals, however, require careful consideration as to alternative water uses, environmental impacts and the possibility of locating coal-related industries nearer abundant water sources.

The second limiting factor for coal development is land reclamation. Most of the coal in Montana is suitable for strip mining. The mining of all of Montana's strippable reserves would result in 770,000 acres[7] requiring reclamation. The reclamation is to be done by the mining company. The best method for land reclamation for such dry regions includes contouring spoils, conditioning the soil, seeding and watering. A reclamation program is in effect now in Colstrip but it is too early to tell if it is successful.

Other environmental problems with coal development include dust, aquifer changes, and pollution from mine mouth plants. In addition, development has an impact upon the human environment with land use conflicts, and population, economic base, and employment changes.

Controls on coal development

The most important controls on Montana coal development are the Reclamation Bill and Utility Siting Act. The Reclamation Bill allows coal mining contingent upon meeting reclamation standards. The Utility Siting Act allows construction of power generating facilities only if air quality standards can be met. In addition, the taxes on coal have been increased and a Resource Indemnity Trust Fund has been created. These legislated controls guarantee a consideration of the environmental costs of energy.

Consumption

Consumption of coal in Montana has increased steadily and gradually from 419.7 thousand short tons (10.7 trillion Btu) in 1960 to 952 thousand short tons (22.2 billion Btu) in 1971. (See figure 1.)

Coal was a major heating fuel in Montana in the settlement days. Gas and oil soon replaced it as heating fuels. From 1880 to the early 1950's, the railroads were the main coal consumer. Now coal is being consumed principally for electricity generation.

Export

The combination of a slowly growing coal consumption in Montana and exponential coal production resulted in a dramatic coal export increase starting in 1968. In 1968, 171.4 thousand short tons (3.8 trillion Btu) of coal were imported. By 1971, 6,112 thousand short tons (153.6 trillion Btu) of coal were exported. (See figure 1.)

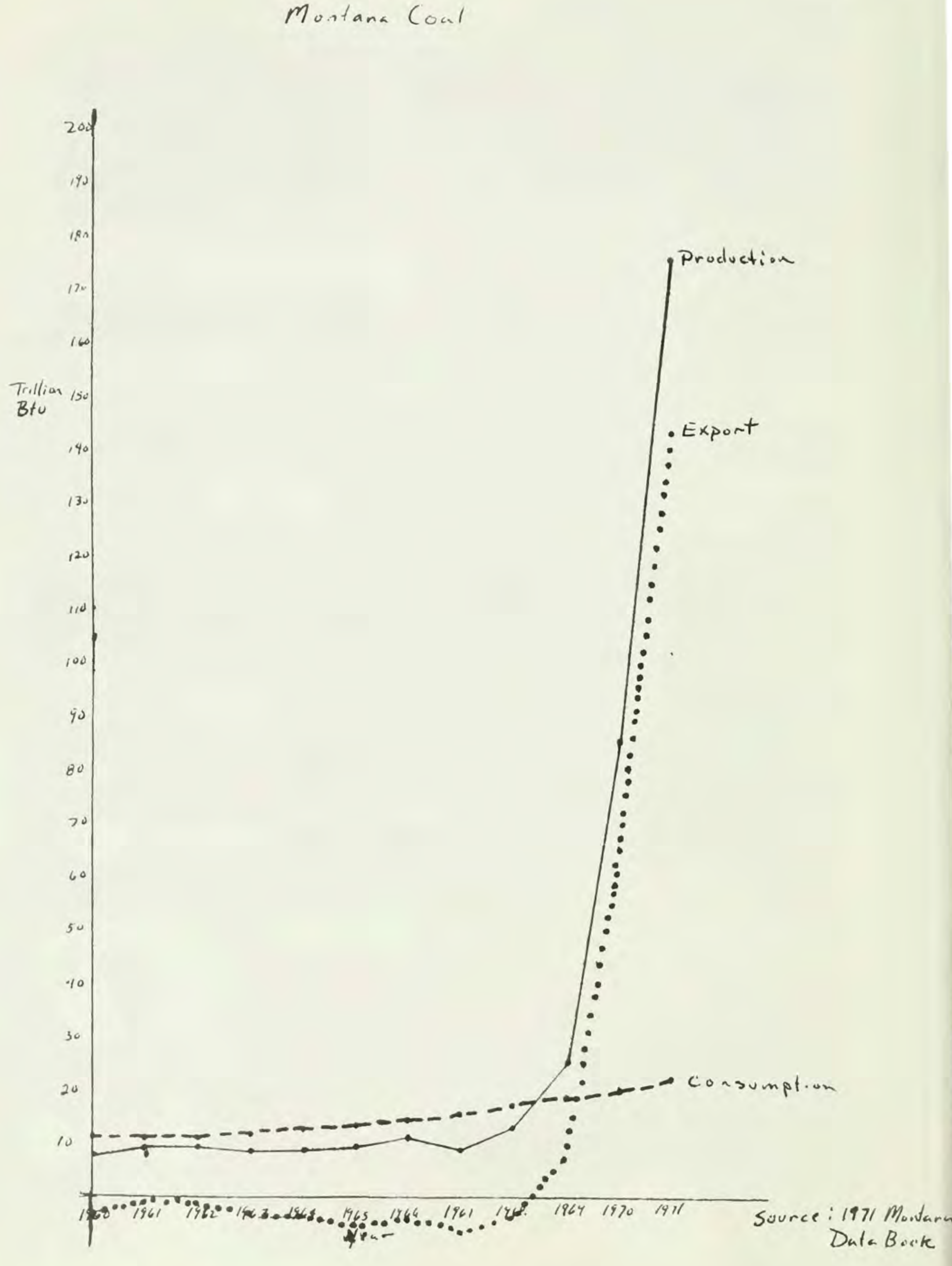
Transportation

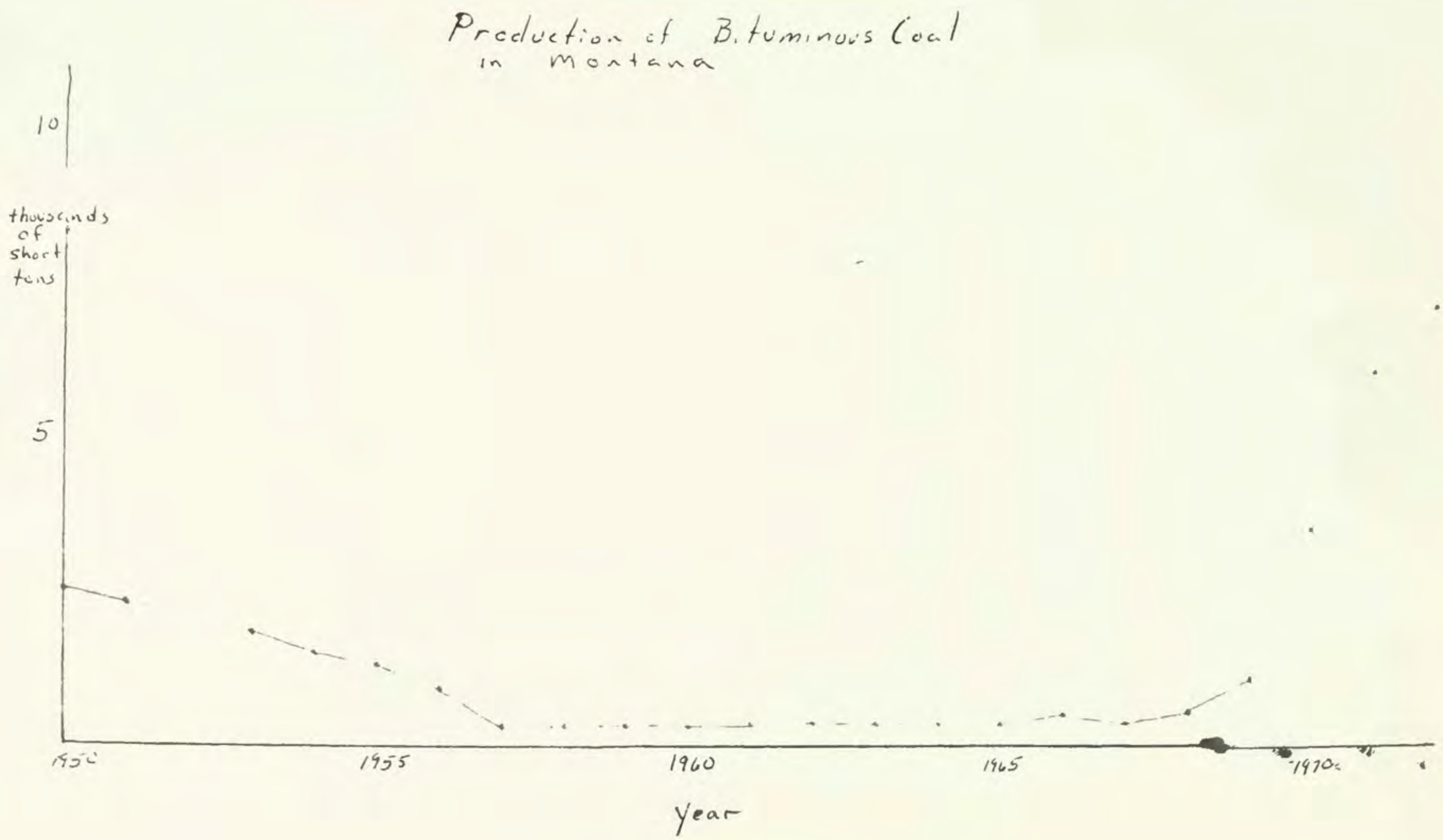
Export of Montana coal requires low transportation costs. The estimated cost of transporting coal 100 miles varies from 1.0-5.0 cents/ million Btu by slurry pipeline[8] to 3.6 cents/million Btu by railroad.[9]

Coal and water requirements for conversion processes

	Coal (tons/year)	Water (acre-feet/year)
Thermal electric plant (1,000 megawatts capacity: cooling water used)	5,000,000	9,500 - 17,000
Gasification (250 million cubic feet per day)	6,500,000	20,000 - 30,000
Hydrogenation (100,000 barrels synthetic crude oil per day)	15,000,000	20,000 - 65,000
Combined products (50,000 barrels crude per day; 250 million cubic feet gas per day; 1,000 megawatts electricity)	12,000,000 - 18,000,000	50,000 - 75,000

Source: Appraisal Report on Mont.-Wyo. Aqueducts (U.S. Dept. of the Interior)


Montana Coal
Trillion Btu
Production
Export
Consumption
Year
Source: 1971 Montana Data Book


Production of Bituminous Coal
in Montana
10
thousands of short tons
5
1950
1955
1960
1965
1970
Year

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ELECTRICITY

West power region

Most of Montana lies within the West Power Region which includes one third of the area of the United States (excluding Alaska and Hawaii). Characteristic of the region are large loads along the Pacific, long distances between load centers, and a variety and non uniform distribution natural resources.

Sales

Sales of electricity in the west region included 34.0 percent of the industrial sector, 30.3 percent for residential and rural, 20.3 percent for commercial, 5.4 percent for street and highway lighting, electrified transport and other uses, and 10 percent for losses.[1]

The utility load curve (power vs. time) for the west region shows annual peak power use in December and January and June, July and August.[2] Daily peaks occur midday and early evening.[3]

Fuel use for generation

Electricity is generated by a variety of fuels in the west region. Hydropower has been a major contribution in the past, but thermal generation will become more important as dam sites become scarcer and less environmentally desirable because of loss of wildlife habitats, relocation of people, and water and land use conflicts.

Coordination with the west power region

Montana's electricity generation plans are coordinated with those of other states through a number of coordinating committees. Interconnections between utilities have evolved due to the need for reliable and economic electric energy. For example, the Montana Power Company is a member of the Pacific Northwest Coordination Agreement (PNCA), Western Systems Coordinating Council (WSCC), Associated Mountain Power Systems (AMPS), Rocky Mountain Power Pool (RMPP), and the Northwest Power Pool (NWPP).[4]

Through subregionally coordinated planning for generation and transmission, west power region utilities jointly own large generating plants, use seasonal load diversity to share reserves, and coordinate construction of plants.

MONTANA ELECTRICITY

Capacity

Montana's capacity in kilowatts per capita is higher than per capita capacity in the U.S.

Capacity (Kw) per capita	1968
Montana	2.64
U.S.	1.55

Source: 1970 Montana Data Book (Planning and Economic Development Division, Department of Intergovernmental Relations)

Montana's electricity capacity in 1968 was about 23 percent of the Rocky Mountain States' capacity and .58 percent of the U.S. capacity.[5]

Generation

About 87 percent of Montana's electricity is generated by hydro-electric plants (less than 16 percent of U.S. electric power is produced by hydro-electric plants). Conventional steam plants produce 13 percent of the electricity for Montana (82 percent of U.S. electricity is produced by conventional steam plants, and 2 percent by nuclear and internal combustion plants).[6] The following 1970 figures show the breakdown of generation by prime mover for both the U.S. and Montana:

Generation by type of prime mover driving generation (1970) (million Kwh)

	U.S.	Percent	Montana	Percent
Hydro	247,456	16	8,745	87
Conventional Steam	1,256,294	82	1,281	13
Nuclear Steam	21,797	1	---	--
Internal Combustion	6,062	1	---	--
Total	1,530,609	100	10,026	100

Source: US Statistical Abstract (Dept. of Commerce)

Of the electricity generated by steam plants in Montana, 80 percent is generated by coal, 18 percent by natural gas, and 2 percent by fuel oil.[7] The following figures are for 1970:

Generation by fuel

(Million Kwh)	U.S.	Montana
Coal	706,102	966
Fuel Oil	182,488	14
Gas	372,884	228
Nuclear	21,979	---
Total thermal	1,283,271	1,208

Source: US Statistical Abstract (Dept. of Commerce)

Power Plants in Montana

Montana electricity comes from three sources, federal hydroelectric power plants, non-federal hydroelectric plants and conventional thermal electric plants.

1. Federal hydroelectric

Existing or under construction

Canyon Ferry

Fort Peck

Yellowtail

Hungry Horse

Libby

Big Creek

Authorized or Licensed

Allenspur

Under Consideration

Long Meadows

Kootenai Falls

Libby Rereg

Buffalo

Smoky Range

Spruce Park

Knowles

Quinn Springs

Quartz Creek

Ninemile Prairie

2. Non-federal hdyroelectric

Lake Creek 1

Lake Creek 2

Noxon Rapids

Cabinet Gorge

Big Fork

Thompson Falls

Milltown

Kerr

Milltown

Flint Creek

Madison

Holter

Hauser Lake

Mystic (w/pumped storage)

Hebgan (storage)

Black Eagle

Rainbow

Ryan

Cochrane

Morony

Buffalo 2 (under consideration)

3. Conventional thermal electric

Troy

J. E. Corette

Frank Bird

Colstrip

Miles City

Baker

Glendive

Lewis and Clark

Trident (under consideration)

Source: 1970 National Power Survey, Federal Power Commission.

Power Generation Resources 1970-71

	January peak mw	Energy average mw Critical period	Energy average mw Median average hydro	Ownership
Project--River				
Hungry Horse, South Fork	271	185	101	USBR
Kerr, Clark Fork	180	112	123	MPCo
Thompson Falls, Clark Fork	40	35	35	MPCo
Madison, Madison	9	7	8	MPCo
Canyon Ferry, Mo.	58	29	46	USBR
Hauser Lake, Mo.	16	12	14	MPCo
Holter, Mo.	49	24	29	MPCo
Black Eagle, Mo.	18	14	17	MPCo
Rainbow, Mo.	35	29	35	MPCo
Cochrane, Mo.	50	24	33	MPCo
Ryan, Mo.	60	42	53	MPCo
Morony, Mo.	49	25	33	MPCo
Ft. Peck, Mo.	200	97	100	Corps of E.
Mystic Lake, Rosebud	12	7	6	MPCo
Yellowtail, Big Horn	250	108	126	USBR
Minor plants	4	3	3	MPCo
Total hydro	1,301	753	762	
Steam Plants--Location				
Bird, Billings	66	60	60	MPCo
Billings Unit No. 2, Billings	180	144	144	MPCo
Total steam	246	204	204	
Total resources	1,547	957	966	

Source: 1970 National Power Survey (Federal Power Commission)

ELECTRIC UTILITY INSTALLED GENERATING CAPACITY
MONTANA
January 1, 1973

Owner or Operator	Plant Name	Location	Class of Ownership	MAXIMUM NAMEPLATE RATING - KW				Fuel Used 1/
				Hydro	Steam	Turbines	Int.Comb. Engines	
MDU	Glendive	Glendive	Private		7,000			Oil, gas
"	Lewis & Clark	Sidney	"		50,000			Lignite, gas
"	Baker	Baker	"				1,000	Gas
"	Miles City	Miles City	"			23,267		Gas, oil
Mont.Lt. & Pwr.	Lake Creek	Troy		4,500				
"	Troy	Troy	"		3,000			Wood Wastes
"	Libby	Libby	"		12,550			Wood Wastes
MPC	Black Eagle	Great Falls	"	16,800				
"	Cochrane	Great Falls	"	48,000				
"	Flint Creek	Philipsburg	"	1,100				
"	Hauser Lake	Helena	"	17,000				
"	Holter	Wolf Creek	"	38,400				
"	Kerr	Polson	"	168,000				
"	Madison	Norris	"	9,000				
"	Milltown	Milltown	"	3,040				
"	Morony	Great Falls	"	45,000				
"	Mystic Lake	Columbus	"	10,000				
"	Rainbow	Great Falls	"	35,600				
"	Ryan	Great Falls	"	48,000				
"	Thompson Falls	Thompson Falls	"	30,000				
"	J. E. Corette	Billings	"		172,800			Bit.coal, gas
"	Frank Bird	Billings	"		69,000			Oil, gas
PP&L	Big Fork	Big Fork	"	4,150				
"	Libby	Libby	"			26,600		Oil
Wn. Wtr. Pwr.	Noxon	Noxon	"	282,880				
U.S.B.R.	Hungry Horse	Hungry Horse	Federal	285,000				
"	Canyon Ferry	Canyon Ferry	"	50,000				
"	Yellowtail	Hardin	"	250,000				
US Ind. Irrig. Svc.	Big Creek	Polson	"	360				
US Army Engrs.	Fort Peck	Fort Peck	"	165,000				
TOTAL				1,511,830	314,350	49,867	1,000	

1/ Where multiple fuels are shown for steam plants, it does not necessarily imply that full capacity or continuous operation is possible with all fuels shown.

Source: Federal Power Commission, Bureau of Power Staff Report on Coal Burning Steam Electric Generating Plants in Montana, Wyoming, North Dakota and South Dakota 1973-2000.

Abbreviation explanation from preceding table.

MDU	Montana Dakota Utilities Company
Mont. Lt. & Pwr.	Montana Light and Power Company
MPC	Montana Power Company
PP&L	Pacific Power and Light Company
Wn. Wtr. Pwr.	Washington Water Power Company
U. S. B. R.	U. S. Bureau of Reclamation
US Ind. Irrig. Svc.	US Indian Irrigation Service
US Army Engrs.	US Army Engineers

PROJECTED ADDITIONS OF ELECTRIC GENERATING CAPACITY

Owner or Operator	Plant Name	Location	Class of Ownership	Capacity - (kw) Hydro	Steam	Fuel	Scheduled Operation
Montana Power Co.- Puget Sound	Colstrip #1	Colstrip, MT	Private		330,000	Coal	July 1975
Montana Power Co.	Colstrip #2	Colstrip, MT	"		330,000	Coal	July 1976
Montana Power Co.- and others	Colstrip #3	Colstrip, MT	"		700,000	Coal	July 1978
Montana Power Co.- and others	Colstrip #4	Colstrip, MT	"		700,000	Coal	July 1979
US Army Engrs.	Libby #1	Libby, MT	Federal	121,000			July 1975
US Army Engrs.	Libby #2	Libby, MT	"	121,000			October 1975
US Army Engrs.	Libby #3	Libby, MT	"	121,000			January 1976
US Army Engrs.	Libby #4	Libby, MT	"	121,000			April 1976
US Army Engrs.	Libby #5	Libby, MT	"	121,000			October 1982

Source: Regional Reliability Council Reports to the Federal Power Commission, Dated April 1, 1973.

The Montana Power Company and Puget Sound Power and Light Company are constructing a 700 mw mine-mouth power plant to be fueled with coal from the Western Energy Mine at Colstrip. Half of the power will go to Puget Sound's load and half to Montana Power's. The first 350 mw unit is expected to go on line in 1975. The other 350 mw unit will be operating by 1976.

The Montana Power Company and a group of Pacific Northwest utilities are planning two additional 700 mw mine-mouth power plants. To be approved by the Department of Natural Resources and Conservation's Plant Siting Division, the companies must demonstrate that no adverse environmental effects will result from the construction and/or operation of the plants.

Sales

About sixty-six percent of Montana's electricity sales goes to industry, seventeen percent to the residential and rural sectors, fourteen percent to commercial and the remaining three percent to street and highway lighting, other public authorities, railroads and interdepartmental uses.[8]

Electric Energy Sales (million Kwh)

	U.S.	Montana	Montana Investor Owned
Residential	479,080	1,614	1,145
Commercial & Industrial			
Small light and power	333,752	1,254	927
Large light and power	592,700	6,079	2,491
Street and highway lighting	11,673	53	52
Other public authorities	39,819	113	92
Railroad and railways	4,537	80	80
Interdepartmental	4,880	21	12
	1,466,441	9,214	4,799

Source: US Statistical Abstract (Dept. of Commerce)

The following data shows the growth trend in electricity sales, and REA power consumption.

Energy Sales by class of Service (million Kwh)

	Residential	Commercial	Industrial	Other	Total
1970	1,534	924	6,029		8,750
1965	1,216	654	3,938	272	6,080
1960	937	480	2,951	207	4,575

Source: 1970 Montana Data Book (Planning and Economic Development Div., Dept. of Intergovernmental Relations)

Rural Electrification Administration

Average monthly consumption	(Kwh) 1970	1971
All consumers	914	998
Residential consumer	687	711

Source: Thirty-third Annual Report of Energy Purchased by REA Borrowers, REA Bulletin III-2, December 1971.

Montana Power Company sales for resale customers include Washington Water Power Company (dump power; average monthly maximum demand of 42,500 kw; annual maximum demand 60,000 kw), Puget Sound Power and Light Company (firm power supplementing own generation or other purchases; 35,000 kw contract demand equals average monthly maximum demand equals annual maximum demand), Utah Power & Light Company (dump power; 84,000 kw average monthly maximum demand; 190,000 annual maximum demand), and Montana Rural Electric Co-ops (Beartooth Electric Co-op., Big Horn Electric Co-op., Fergus Electric Co-op., Hill County Electric Co-op., McCone County Electric Co-op.)[9]

Load Centers

The largest electricity load centers in Montana are Butte-Anaconda, Helena-Great Falls, Kalispell-Missoula, and Billings, with peak demands of 551, 260, 173, and 138 megawatts respectively.[10]

Exports

Montana is a net exporter of electricity:

	1970	1971
Electricity generated in Montana	10.026 billion Kwh	10.653 billion Kwh
Sold in Montana	9.091	9.214
Exported	.935	1.439

Source: 1971 Statistical Yearbook (Edison Electric Inst.)

There are two reasons Montana cannot use the exported electricity: (1) preference clauses of Federal legislation, and (2) the Washington Water Power Noxon Dam. The preference clauses:

> Hungry Horse Act - 25 percent of the power generated by Hungry Horse Dam must always be reserved for Montana. More than this actually stays in Montana, however; Montana Power Company purchases an average 40 mega watts and 50 mega watts during peaking and Anaconda Aluminum purchases power for the aluminum plant in Columbia Falls.

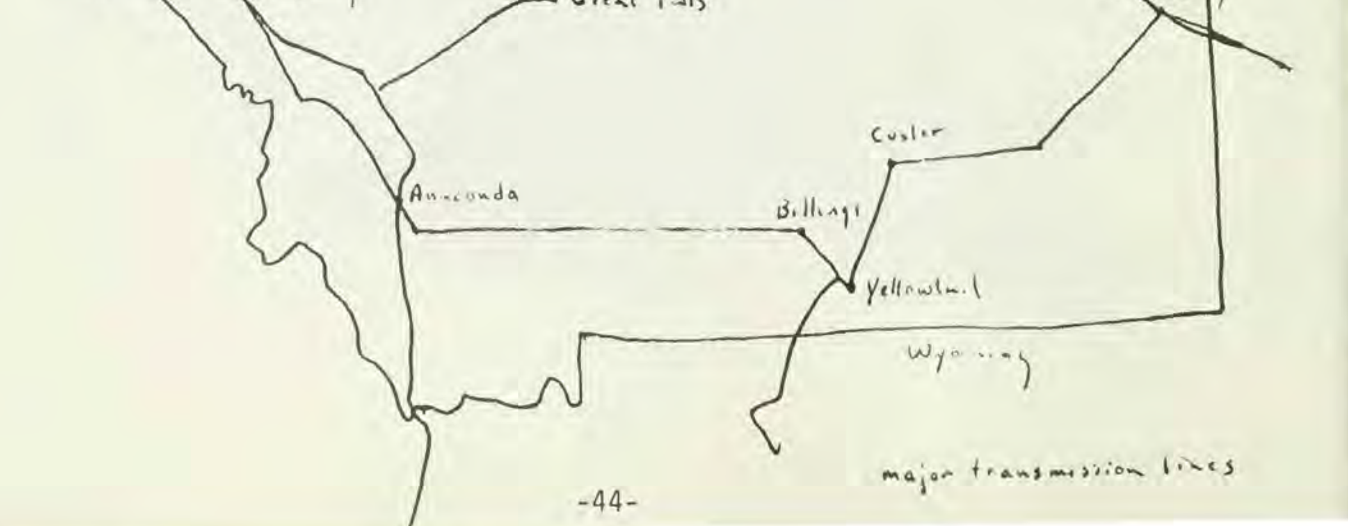
Pacific Northwest Preference Act (Public Act 88-552) All power marketed by Bonneville Power Administration is confined to the Pacific Northwest Region unless there is a surplus which can be sold outside of the Pacific Northwest. (Western Montana is included as a part of the Pacific Northwest, so this doesn't effect us much.)

Another Federal law states that any power generated by a federal installation has a preference list of customers. Government agencies, co-ops, PUD, municipalities, etc. are high priority, investor owned utilities are low priority. There are three federal plants east of the divide including Fort Peck, Canyon Ferry and Yellowtail. The power from these three installations is marketed by the Bureau of Reclamation. Much of the power from Yellowtail goes to rural electric co-ops in the Dakotas.

The main reason we are a power exporter, however, is the Washington Water Power Noxon Dam in western Montana. It's average annual generation of one and a half billion kilowatt hours is shipped to Washington. Montana cannot use this energy. Checking back to the Edison Electric Institute figures, the export of Noxon Dam's power accounts for the export. In fact, depending upon the amount of electricity imported, the Noxon export is sometimes larger than the net export. Most Montana utilities must import electricity. Montana Power imports 12-23 percent of its firm load annually.

Transmission

The following chart shows the present electricity transmission grid system for Montana.




Montana Electricity
Trillion Btu
Net generation
Sales in Montana
Net outflow
year
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
40
30
20
10
Source: 1971 Montana Data Book

Conservation Measures

Industry wide research program

In the past, there has been a lack of a well funded, industry-wide research effort. However, a recently established research corporation, established by the Electric Research Council (which has members from all parts of the electric utility industry), in addition to existing research programs, will help alleviate this need.

Combined cycle plants

These plants combine gas and steam turbines. The supposed advantages of combined cycle plants are that they have relatively high efficiencies, short construction times, and require less land than steam plants. However, they require gas or low sulfur distillate for fuel; both are expensive and in short supply. Also, the companies using such plants report no major operating or economic advantages compared to steam plants.

Advanced power cycle

The advanced power cycle is a combination of coal gasification and gas turbine-steam turbine power plant. Its advantages are low cost, little pollution, flexibility in plant size and sites, and high efficiency. The development of this system is contingent on the development of coal gasification.

Magnetohydrodynamics

Magnetohydrodynamics (MHD) power generation is accomplished by passing a hot ionized gas (plasma) through a magnetic field. The concept has been known for over 100 years but the technological advancements of the past twenty years have made it a promising method of power generation. The process is attractive because it is more efficient than the present fossil fired plants. However, there are still many technical difficulties to be resolved before it will be a viable method of power production

Coupling industries and towns with power plants

Much of the reject heat coming off a power plant could be sold to an adjoining industry or towns to be used for heating, air conditioning, etc.

Garbage as fuel

A possible partial solution to both Montana's solid waste problem and energy problem might be to use the solid waste as a supplementary fuel for coal-fired steam plants, or to provide heat for industrial processes. An advantage to using trash is that very little modification is required for boilers and material processing equipment.

It is possible that this could become Montana's primary means of disposing of solid waste (assuming that sufficient quantity of refuse was produced). An advantage is that it would replace the burning of some coal. (e.g. 600 megawatt plant could replace 500 tons of coal with 1,200 tons of waste a day (10 percent of the total fuel) an annual saving of about 2 acres of Montana strip mined coal, assuming a 50 ft. seam and 1,770 tons/acre foot.)

The City of St. Louis with cooperation from Union Electric Company and EPA has operated a prototype trash burning plant since May 1972. Metallic material is removed from the city's residential solid waste. The remaining material, about 300 tons a day, which has an energy content of 5,000 Btu per pound, is burned in a power plant to supply about 13 percent of the total heat energy.

Another prototype plant is to be completed in 1974 in Nashville, Tennessee. Three hundred sixty tons of trash per day will be burned to supply energy for heating air conditioning 27 office buildings. Included in the study is the potential use of reclaimed ash.

Both the Japanese and French are involved in using trash as fuel. All future solid waste disposal sites to be built by the Tokyo metropolitan government will burn garbage to provide heating and hot water to nearby homes. Paris for the past 50 years has been using the city's trash to generate electricity.

Goodyear Tire and Rubber Company uses old tires for heat for boilers. The tires are said to provide one and a half times more heat than coal. The company also is experimenting with a mixture of 4 parts oil to one part old tires to produce carbon black which is used to make new tires.

For Montana, however, burning garbage for fuel would probably serve more as a solution to the solid waste disposal problem than the fuel problem. The population is simply not large enough or concentrated enough to produce a quantity of solid waste large enough to replace a considerable amount of coal.

Rate restructive

The bulk user of electricity pays less per kilowatt hour than other customers. This served the purpose in the past to increase electricity consumption to increase efficiency of plants by bringing consumption up closer to plant capacity. However, this practice also encouraged wasteful and excessive energy use. The situation today is not that we have too much power; the electric utilities in the northwest are having problems meeting electricity demands due to low water levels this year. To encourage use of more low cost electricity is unwise.

Rate restructure of various fuels has been advocated to force industry and commercial establishments to conserve fuel in response to the increased price of fuel. The idea behind rate restructing is that the costlier the energy source, the more conservative industry will be using it. This, of course, depends upon the elasticity of the demand of the fuel or power with cost. The price of gas, electricity and oil will naturally rise to a high, level by 1980, simply because of the scarcity of fuels and incorporated external costs. If the price increases faster than real income, there may be a dampening effect on electricity demand. If the price increase is slower than income increases, there may be continued growth. A reversal or flattening of the rate structure would be a shock to the economy, if not implemented gradually and over a period of time to allow the economy to adjust. If the cost of Montana electricity were to become too high for Montana goods produced with electricity to be competitive with those from other states, industry would relocate, depending on:

1. amount electricity required by industry;
2. degree to which other factors more efficient machines, human labor, fossil fuels, etc. can replace electricity; this depends on the availability and cost of those factors;
3. extent to which industry competes with out-of-state firms for its sales;
4. dependency on resources available only in Montana.

Also, the effects of increasing the cost of the intermediate energy would increase the cost of the goods produced with that energy. The cost will ultimately be passed along to the consumer. Another factor to consider is the relative price of other fuels. (e.g. If the cost of gas increases demand for electricity if its price has not gone up as much.)

An alternative to rate restructing is to gradually add the gas or electricity price increases on to the industrial and commercial rates. This would be less trumatic to industry. (This was done with gas prices recently. When Montana Power's Canadian gas cost went up, it was reflected in the price of gas to the industrial and commercial sectors.)

Reduced rates for appliance peak-shaving devices

Reduced rates for the installation of devices to cut off washers and dryers during peak load periods is being tried in Vermont. Since our big problem is the peak load, this measure should be looked into by Montana utilities.

Insulation promotion for electric heated homes

Montana utilities might look into financing low cost loans for added insulation for electrically heated homes.

Change of advertising practices

The advertising of most utilities is beginning to change from promotional ads to conservation and off-peak promotional ads and customer service. For example, a recent pamphlet put out by the Montana Power Company is entitled "54 Household Hints on Conserving Energy". The Montana Power Company is also involved in a number of other public activities and public information programs promoting energy conservation, including individual contacts with customers with particular problems or inquiries.

Utilization of waste heat

Waste heat from electricity production does not have to be considered a "waste". There are many beneficial uses for the low grade heat. Steam can be sold for industrial use or for district heating and cooling. In a site such as Colstrip, some of the waste heat from the power plant could be used to heat the nearby town. Some of the heated water could be used to accelerate sewage processing and save energy to heat the sewage by some other means.

Another very promising use for waste heat from power plants is acquaculture. The Japanese in particular have been interested in acquaculture. In the United States, areas in the Pacific coast near power plants are supporting man-made colonies of oysters. There has been research in California on the growing of algae for livestock feed on the combination of heated power plant effluent and sewage. The result has been a nutritious and inexpensive source of animal feed. An added advantage is that the sales of the feed pays for the sewage treatment! The warm water algae or single cell protein can also be used for human food, although there is a problem with consumer acceptance. It is possible now, however, to flavor and texturize the product to make it more palatible and appealing. The growing of livestock feed using heated power plant water in Montana is a possibility which should be investigated.

A project sponsored by Portland General Electric Company, Pacific Power and Light Company, Boeing Company, and Eugene Water and Electric Board is looking into using waste heat from power plant water and examining two possibilities for upgrading the energy to a usable level: the steam-bleed off-system and heat pump system.

The Aluminum Company of America is testing a system using waste heat from power plant stacks to purify water and reduce contaminants to a solid fuel.

Research and development

A. Conversion Technology

Research and development is needed on the following:

1. Energy storage systems involving phase change materials, batteries, capacitors, pumped storage, flywheels, compressed gas, hydrogen.

   Hydrogen fuel economy

   Hydrogen could be used to multiply electrical power on the future through its use as a secondary fuel. It can be produced by the decomposition of water. Hydrogen can be substituted for petroleum or coal in most industrial uses requiring a reducing agent and can easily be converted into other fuel forms such as methanol, ammonia, and hydrazine.

2. More efficient power generation equipment. (Topping cycles such as gas turbines, magnetohydrodynamic, supercritical and potassium vapor systems; bottoming cycles using ammonia vapor for converting rejected heat into useful energy; fuel cells.)

   The first gas turbine driven generator in the Northwest was built by General Motors for the Pacific Power and Light Company at Libby, Montana. The plant went on line in October 1972 with a capacity of 28 mw. The gas turbine is capable of servicing the Libby area during a power shortage and is being used only temporarily in Libby until the Libby Dam is completed sometime in 1975. At that time, the generator will be relocated.

3. Solar energy systems for power generation. Specific research on photovotaic cells, properties and radiation stability of plastics, high temperature characteristics of selective optical coatings for solar energy converters, reduction of price and increase of reliability of solar converters.

B. Transmission

1. The Electric Research Council is sponsoring a project studying the feasibility of high capacity, long distance underground transmissions.

2. Compressed gas insulation systems for underground cables.

3. Niobium plated copper pipe as a superconductor.

4. Combination high voltage dc and cryogenic cable systems.

5. Ultra-high voltage alternating current systems.

6. High-voltage direct current transmission.

C. Generation

1. Locating suitable (environmentally sound) plant sites.

2. Development of materials to withstand higher temperatures and pressures.

3. Improved nuclear plant safety.

4. Geothermal, solar, wind.

Surcharge on electric power used during peak periods.

This would be effective in encouraging electricity conservation if the difference in non-peak and peak prices was significantly large. There would be some difficulty in changing electricity meters, but the measure is good in that it would discourage electricity use during the peak load period.

The Future

Montana cannot depend on hydropower for all of its electricity in the future as the number of hydroelectric sites is finite and the demand for electricity is steadily rising. As the power demands grow, hydropower will be reserved for peaking and other forms of power generation (coal, gas, solar, geothermal?) will meet base load demands.

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HYDROPOWER

Montana has many excellent hydroelectric sites, so the majority of our electricity has been and is generated by hydropower. However, this reliance upon hydropower sometimes causes problems as spring run-off is unreliable and unpredictable. This year for example, is a very bad year for hydroelectric plants as there is not enough water to run the generators at desired levels.

Developed water power capacity totalled 1,512 thousand kilowatts in 1968, which was 43.2 percent of the hydro capacity of the Rocky Mountain States, and 3.11 percent of the U.S. capacity. An estimated 7,781 thousand kilowatts is available for development. However, there is strong opposition in Montana for further hydropower development other than adding generators to already existing dams.

Source: U.S. Federal Power Commission, Hydroelectric Power Resources of the U.S., Developed and Undeveloped, Jan. 1, 1968; annual summaries and monthly reports (U.S. Statistical Abstract).

GEOTHERMAL ENERGY

Geothermal energy is natural heat from the earth's interior produced primarily by natural nuclear decay and friction. A hot water geothermal site occurs where rock heat is transferred to groundwater. If the water is sufficiently heated, steam can accumulate in porous rocks. This type of natural steam is used to produce power at geysers in California and Italy. More common types of geothermal energy source, however, are hot water fields (where reservoir pressures are higher and boiling does not occur underground) and dry heat fields. Geothermal power is actively being developed in Japan, Mexico and Russia.

Geothermal energy is a clean energy source and abundant. However, like hydropower sites, it is not evenly distributed; some areas are rich in geothermal energy sites; others have none.

A potential geothermal energy site was discovered near Marysville in 1966 by Professor David Blackwell (Geology Department, Southern Methodist University) while he was conducting heat flow surveys in the Rockies. The area has one of the highest geothermal gradients on the continent. Battelle Pacific Northwest laboratories has begun a three year study on the area under National Science Foundation funding. Another high heat gradient has been found at Butte. There are a number of hot springs in western Montana and hot groundwater is found in some eastern Montana wells.

There has been little exploration in the past of the potentially usable geothermal sites. Now, however, in addition to the Battelle study, the Montana Power Company is studying potential geothermal sites and Dr. S. L. Groff, State Geologist and Director of the Montana Bureau of Mines and Geology, has submitted a proposal to the Environmental Quality Council for a survey of Montana's geothermal resource potential. Professor Gary Crosby of the University of Montana is also studying Montana geothermal sites.

A 12,763 acre area in Montana near Yellowstone Park is classified as a known geothermal resource area.[1] Three million eight hundred thirty-four thousand additional acres are classified as prospective geothermal sites.[2]

According to Groff and Balster, Montana's geology is potentially suited for geothermal sites. The basic requirements for geothermal energy are present. Much of the state has evidence of tertiary volcanic instrusive activity. The western part of the state is faulted, the mountains in that area are fault block mountains and the state has high volume aquifers.

Balster and Groff mention the following as areas of geothermal heat (both wet and dry).

1. Upper Yellowstone River Valley - this area has thermal springs. Some (e.g. Chico) have been used for recreation facilities. Hot water escapes through faults probably from Tertiary intrusive body in the Beartooth Mountains or perhaps from volcanic activity in the Crazy Mountains.

2. Mocassin - Judith Mountain Area - Big Warm Springs a large thermal spring is on the north side of South Mocassin Mountains. Geothermally heated water comes through faults in the loccolithic Tertiary instrusions of the area.

3. Little Rocky Mountain Area - This area has several warm springs coming out of limestone of faults from Tertiary instrusive masses which comprise the core of the mountains.

4. White Sulphur Springs area - A major fault is thought to be under the city of White Sulphur Springs and might be the pathway for heat from Castle Mountain instrusive body or other nearby cooling body.

5. Boulder Batholith Area - Several thermal springs surface along fault lines in this area.

6. Idaho Batholith Area - The eastern part of this area lies in Montana and is a source of dry geothermal heat.

7. Beaverhead Area - This area, south of the Boulder and Idaho batholiths has thermal springs. Drilling for uranium has revealed warm water beneath Big Hole Valley.

8. Snowcrest - Gravelly Range Area - This area west of Yellowstone Park has a heat source probably from deep igneous instrusions.

9. Madison Group Area - Hot water wells.

Much more data must be collected to determine the feasibility of geothermal energy use.

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SOLAR ENERGY

"Solar energy is an essentially inexhaustible source potentially capable of meeting a significant portion of the nation's future energy needs with a minimum of adverse environmental consequences...The indications are that solar energy is the most promising of the unconventional energy sources..." (Testimony of Dr. A. Eggers of the National Science Foundation before the Senate Interior Committee on June 7, 1972.)

Solar energy has the potential of providing an almost unlimited supply of energy, provided we can develop the technology to use it economically. Approximately 2,000 Kwh (or two billion calories) per square meter of solar radiation fall on U.S. deserts annually.[1] Assuming five percent efficiency of collection and conversion of the sunlight, an 8,000 square mile plot of desert solar-energy-collectors would be required to supply the electrical energy consumption in 1970.[2]

One of the first recorded uses of solar energy was the Greek use of a "burning mirror" to ignite invading Roman warships around 200 B.C. Solar energy has been used to boil water, to operate a printing press in the 1800's, to heat water in South Africa, Israel and Australia, to power silicon cells in satellites, and to distill fresh water from saline water. Solar energy has never been developed on a large scale because of problems in gathering and storing solar energy. However, solar energy will become more attractive as the price of natural gas and fuel oil rises over the next few years. Other incentives for the development of solar power are that it is non-depletable and pollution-free.

Biological solar systems

Our existence depends upon the use of solar energy in photosynthetic processes. Plants supply us with food energy as well as an oxygen-rich atmosphere. Plants are also a potential energy source.

Biological systems are not as efficient as physical solar systems (which are expected to have efficiencies of ten percent or greater.) Chlorophyll utilizes only that solar energy which has a wavelength between 400 and 700 millimicrons[3] (this is only about half of the incident solar energy.) The maximum theoretical efficiency of plants is fifteen percent.[4]

However, when the energy content of harvested crops in intensive agriculture is divided by the energy content of incident solar radiation, a much smaller conversion efficiency is obtained (less than one percent.)[5]

Algal systems have variable conversion efficiencies, but the average is about five percent.[6] Higher efficiencies may be obtained if a cell extract containing enzymes for the photolysis (chemical decomposition by light) of water, can be isolated and stabilized. This process would produce hydrogen gas, a fuel.

Space solar system

The space solar system would consist of satellites covered with solar cells which convert the solar energy into electricity. The energy could then be transmitted to the earth as mocrowave beams.

Marine systems

Thermal gradients in the oceans might be tapped as an energy source in the future.[7] The temperature difference between surface waters and water at 2,000 feet is about 35° F in the Gulf Stream. A platform floating in the Gulf Stream would use the surface water heat to boil pressurized propane which would turn a turbine to generate electricity. The propane would then circulate 2,000 feet beneath the surface to be cooling and then returned to the surface to boil again.

Another proposed system,[8] consists of a free-floating ocean platform holding concentrating mirrors which would focus incident solar energy on a boiler system. The heat would drive a working fluid through a turbine generator. Deep sea water would serve as a coolant. The generated electricity would be used to produce hydrogen fuel from water. The advantages to produce hydrogen are that it is a versitile fuel. (It is suitable for fuel cells as well as direct heat application.) Water is the only combustion product.

Terrestrial systems

There are two types of terrestrial systems. Solar energy may be converted directly or by solar cells into electricity or solar energy may be absorbed as heat which can be used directly or converted into another energy form.

Solar cells were developed for the U.S. space program. The solar cells use silicon crystals and have an average efficiency of ten percent. At the present time an electricity generating system is too expensive ($100,000 per Kw)[9] to be practical. However, it might be possible to bring the cost down to a competitive level.

There is need for much more research on increasing the efficiency of solar cells by focusing sunlight on the cells by mirrors, developing a cadmium sulfide cells (which don't require the growth of large single crystals), and improving energy storage systems for cloudy weather.

Other solar energy terrestrial systems absorb solar energy as heat which is stored in insulated high heat capacity materials. The heat is then used directly or converted to electrical energy.

The use of solar energy is now limited primarily to heating, cooling, water heating, and/or power for individual homes. Solar roof-top water heaters are found in Japan and the Southwest and Southeast sections of the U.S. They consist of a solar absorber (a flat black pan holding pipes or black coated pipes) and an insulated storage tank to store heated water during bad weather. The heated water flows by natural convection from the absorber to the storage tank, so pumps are not needed.

Use of solar energy for individual homes in Montana is contingent upon the commercialization of moderate or low cost solar water or space-heating devices, the relative cost of competitive energy forms (gas, fuel oil, electricity), and the amount and reliability of sunshine in Montana. The architecture department of Montana State University is studying the feasibility of solar energy for Montana. Much more data (e.g. insolation rates) must be gathered before an accurate assessment of the availability and feasibility of solar energy for Montana can be made.

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WIND ENERGY

Like solar energy, wind energy has the advantages of being non-polluting and renewable and the disadvantages of being intermittent, unpredictable, and diffuse. However, some Montana ranches and farms have harnessed the wind for mechanical energy. (pumping water, lifting weight, etc.) Perhaps wind energy could be developed as an auxiliary energy source for Montana.

ENERGY CONSUMPTION & CONSERVATION

RESIDENTIAL SECTOR

Twenty percent of the U.S. total energy and thirty four percent of the U.S. electrical energy is consumed by the residential sector.[1] Space heating and cooling, cooking and refrigeration account for almost ninety percent of the residential energy use.[2] According to the Montana Power Company, the average annual use of electricity for all Montana homes (including cabins and summer homes) is 526 Kwh; the average use excluding cabins and summer homes is probably close to 700 Kwh.[3] Homes consume 17-20 percent of the total electricity sold in Montana and residential customers comprise 85 percent of the total number of customers.[4] Gas sales (including natural, manufactured, mixed and liquid petroleum gas) in the residential sector are 34 percent of the total gas sold in Montana; residential customers were 85-89 percent of the total number of gas customers.[5]

During the 1960-1968 period, U.S. residential energy use increased almost 5 percent (compared to a total energy use increase of about 4.5 percent).[6] A similar trend of increasing residential energy is found in Montana and is expected to continue. The following chart shows the U.S. residential consumption of energy in 1960-68 in trillions of Btu.

	Natural Gas	Petroleum Products	Electricity
1960	3212	2702	742
1961	3362	2721	785
1962	3756	2807	847
1963	3713	2801	910
1964	3917	2719	988
1965	4038	2944	1062
1966	4283	2966	1155
1967	4464	3022	1279
1968	4606	3192	1390

Source: Patterns of Energy Consumption in the U.S. (Stanford Research Institute)

"WE HAVE MET THE ENEMY AND HE IS US!"
Pogo

Collectively, consumers have the potential to realize a large energy savings if they are energy-aware and choose to conserve energy.

"Consumer education has ... the greatest potential for impact on the energy conservation needs of the nation. If consumers can be aware of the energy utilization characteristics of the appliances and equipment which they buy, they will consciously seek the more energy efficient items. Furthermore, if consumers become energy-wise in the way in which they operate their appliances and equipment, they can achieve substantial reductions in energy consumption. I would venture to say that the electrical bills for two identical houses, next to each other, but with different families in them can differ by as much as 50 to 100 percent, depending upon thermostat settings, how many times children may leave doors or windows open, whether or not kitchen exhaust fans are used, etc. A slight improvement in the efficiency of an air conditioner or an appliance will not make nearly this much difference.

Excerpt of a letter to the author, August 1973, from Herbert Bilkey, Asst. Managing Director, Air Conditioning and Refrigeration Institute.

Residential Energy, Consumption and Conservation

Space heating is the largest user of residential energy. By 1980, it will account for 2/3 of the total U.S. residential and commercial energy use.[7] Virtually all Montana homes have some form of heating equipment. Over two-thirds of the heaters burned utility gas for fuel.[8]

Type of Heating Equipment	Number of Households
Steam or hot air	27,106
Warm-air furnace	123,529
Built-in electric units	7,317
Floor, wall, or pipeless furnace	22,602
Room heaters with flue	42,095
Room heaters without flue	5,532
Fireplaces, stoves or portable heaters	11,831
None	743

Source: Detailed Housing Characteristics (Bureau of Census, Dept. of Commerce)

Type of heating fuel	Number of Households	Percent
Utility gas	151,104	70
fuel oil, kerosene, etc.	29,850	14
coal or coke	4,531	greater than 2
Wood	4,113	less than 2
Electricity	8,464	less than 4
Bottled, tank,or LP gas	18,503	8
Other fuel	720	1
None	19	

Source: Detailed Housing Characteristics. (Bureau Of Census, Dept. of Commerce)

Alternatives for Heating

Electricity

Electrical resistance heating efficiency is only about 30 percent. 33 percent conversion in power plants x 91 percent transmission and distributing losses x 100 percent end-use efficiency of electrical resistance heating = 30 percent. However, at the point of use, electricity is "clean" and non-polluting.

Gas or oil

Gas or oil-burning heating systems have efficiencies of forty to eighty percent. Drawbacks are that it is essential to clean the furnace regularly to maintain high efficiency, and that gas and fuel oil are getting scarcer and more expensive.

Solar energy

Solar energy is the most abundant form of energy, is non-polluting and renewable. However, due to its diffuse and intermittant nature, large areas are required to collect and store sufficient amounts of energy. It's present use is limited to water heaters and space heating and the technology for widespread commercial use is unavailable. It is possible to build solar homes now, but expensive. However, if gas and electricity costs keep rising, solar energy may become competitive. Montana solar homes would probably need back up systems using conventional fuels for extended periods of bad weather. Also, there might be problems with consumer acceptance because of higher initial cost of solar equipment. (A tax incentive however, might make solar homes more attractive). The fragmented building industry is slowly beginning to accept solar and geothermal heating systems.

Geothermal

A clean, renewable, non-polluting heating energy source, geothermal energy geothermal energy still has many technical problems to solve (e.g. scaling, water disposal). However, at least one rancher in eastern Montana is using hot water from the earth to heat his home.

Waste heat from lighting, or air conditioning

Heat from lighting, air conditioning, and refrigeration can be reclaimed to use for space heating. Waste heat in the form of hot water or steam from power plant (common district heating). Most energy required by buildings is low energy heat (space heating requires air temperature 28°C and water heating temperature of 60-65°, which is less than the temperature of cooling water or steam of steam power plants). It therefore makes more sense to use low energy (e.g. solar energy) for such uses if it is economically and technically feasible rather than high energy heat.

Electrical heat pump

The heat pump delivers 2 units heat energy for every unit electric energy consumed. Its overall efficiency is 60 percent - about the same as gas fueled furnaces and is not initially expensive when installed in conjunction with central air conditioning. The same equipment is used for both heating and cooling.

Waste heat from refrigerations units

Supermarkets could make use of waste heat from their large refrigeration units for heating purposes during the winter.

<u>Additional conservation measures</u>

<u>Insulation</u>

tighten up control on FHA insulation standards;
include insulation standards in state building codes;
enact income tax revisions to allow tax deductions for home energy

conservation measures (trees for weather and shade breaks; insulation in older homes, purchases of storm windows, etc.)

<u>Consumer tips</u> (to be given during utility ads, cooperative extension service workshops, etc.)

- leave thermostat at 70° or lower during day
- turn heat down at night
- replace pilot light with electric sparker (there is some question as to the relative safety of an electric sparker however)
- turn heater off during vacations
- clean filters periodically

close doors to unused rooms
close damper when chimney not in use
caulk and weather strip crack
draw curtains

Water heating is a second major residential energy user. In 1968, ninety-two percent of all U.S. households had gas or electric water heaters (only 74 percent had them in 1960).[9] About 70 percent of the water heaters were gas, 25 percent electric.[10]

Saturation of Water Heaters in U.S. Residences

	Households	% Saturation	
		Gas	Electric
1960	53.0 million	54	20
1968	60.4 million	68	24

Source: 1970 census of Housing. (Dept. of Commerce).

In Montana, 97 percent of all homes had water heaters in 1970, over 60 percent were gas and 30 percent were electric.[11]

Water Heating Fuel	Number of Households	Percent
Utility gas	134,503	62
Fuel oil, kerosene, etc.	726	
Coal or coke	124	1
Wood	652	
Electricity	64,323	30
Bottled, tank, or LP gas	10,704	5
Other fuel	145	less than .1
None	6,127	3

Source: 1970 Census Of Housing (Dept. of Commerce)

The per unit energy consumption for water heating has gone up from 4272 Kwh in 1960 to 4490 Kwh in 1968 for electric water heaters and from 25.5 million Btu in 1960 to 27.2 million Btu in 1968 for gas water heaters.[12] The reason for the increase is probably the increased use of dish washers and automatic washing machines.

Conservation measures include running washers and dryers with full loads, fixing leaky faucets, showering rather than bathing, using alternative water heating (solar, geothermal), replacing washers on leaky faucets, installing the water heater as near the point of use as possible, and lowering the water temperature setting.

Space cooling accounted for about 30 percent of U.S. residential energy use in 1968.[13] The energy consumed by air conditioners in 1960 had tripled by 1968.[14] The 1970 market saturation of air conditioners was only 40 percent so energy consumption for air conditioners will probably continue to rise, as the saturation increases. Most air conditioners in Montana are electric.[16]

Number of U.S. households with air conditioning (1968)

Type	Number of Households
Room units	18,154,000
Central system	5,654,000
Electric	5,494,000
Gas	160,000

Source: Patterns of Energy Consumption in the U.S. (Stanford Research Institute)

Number of Montana Households with air conditioners

Type	Number of Households	%
Room unit	15,049	6
Central system	6,929	2
None	240,753	91

Source: 1970 Census of Housing (Dept. of Commerce)

Total U.S. energy consumption for air conditioning (1968) was 426 trillion Btu. The following is Montana Power information on computing electricity consumption of residential air conditioners:

To estimate KWH used in average residential installation:

1. Determine size in KW from listing.
2. Multiply by number of hours for month and locality from chart.

Central		Window of Built In	
3 Ton 36,000 BTU/HR	5.5 KW	6,000 BTU/HR	0.19 KW
2 Ton 24,000 BTU/HR	3.5 KW	8,000 BTU/HR	1.35 KW
1 1/2 Ton 18,000 BTU/HR	2.6 KW	10,000 BTU/HR	1.6 KW
		12,000 BTU/HR	1.85 KW
		15,000 BTU/HR	2.3 KW

Average Number of Hours of Operation

Area	May	June	July	August	Sept.	Season Total
Billings	40	100	230	240	90	700
Bozeman	--	45	135	140	20	340
Butte	--	40	110	125	15	290
Great Falls	15	65	160	180	45	465
Havre	25	8-	175	195	55	530
Helena	10	60	160	170	30	430
Lewistown 3.)	5	30	110	160	40	345
Missoula	10	75	165	180	35	465

There are about 1,400 models of air conditioners sold under 52 brand names.18 Efficiency ranges from 41.7 to 12.2 Btu/watt-hour (the least efficient air conditioner would consume 2 1/2 times as much electricity as the most efficient one, and both would achieve the same cooling). The energy efficiency rating (EER) for most central compression type air conditioning systems is 8-9 Btu/watt-hour.

Conservation suggestions include the following:

1. require prominent labelling of efficiency (Btu/watt-hr.) and cooling capacity

2. require information advertising including efficiency and cooling capacity

3. require units coming into state after 1975 to meet minimum efficiency level and be thermostatically controlled

4. give tax incentive for planting and trees for shade around home

5. public education as part of utility advertising program

6. raise thermostat to 78° F

7. close doors to unused rooms

8. close windows

9. turn off unnecessary lights

10. keep condenser coils on air conditioner clean

11. improved insulation (see section on heating)

The U.S. had 60.4 million ranges in 1968; about 30 percent were electric, 70 percent gas.[19] In Montana, the cooking fuel was 65 percent electric, 25 percent gas.[20]

Cooking fuel	Number of Households	Percent
Utility Gas	54,447	25
Electricity	142,739	66
Bottled, Tank, or LP gas	14,329	7
Fuel oil, kerosene, etc.	2,862	1
wood	563	
coal or coke	895	1
Other fuel	184	
None	1,285	1

Source: 1970 Census of Housing(Dept. of Commerce)

The average per unit electric energy consumption of electric range (surface units and ovens) decreased from 1960-68 by 45 Kwh per year. Gas range per unit consumption remained about the same.[21] During this time self-cleaning ovens, built-in clocks or timers were being added. A partial answer is the Microwave oven (they use 96.5 percent fewer Btu than gas ovens and 71.4 percent fewer Btu than electric).[22] The high price of microwave ovens and safety considerations prevent wider spread use hovever.

The following is a list of estimated power consumption of electic cooking appliances:

Appliance	Average wattage	Estimated Use	Consumed Annually
Broiler	1,436	80 min/wk	100 Kwh
Frying pan	1,196	26 min/day	186 Kwh
Hot plate	1,257	12 min/day	90 Kwh
Range	12,207	16 min/day	1,175 Kwh
Roaster	1,333	25 min/day	205 Kwh

Source: Patterns of Energy Consumption in the U.S. (Stanford Research Institute)

Cooking dinner contributes to the peak load, therefore cooking meals before or after the daily peak period should be encouraged. Other conservation measures include covering pots and pans while cooking, turning the oven or range off slightly before food is done and allowing the food to cook with the remaining heat, thawing frozen foods before cooking and baking other foods while baking main dishes. Microwave ovens, electric fondues, waffle irons, electric fry pans and grills are often more efficient than range or over cooking. Another energy savings would be accomplished by using lower thermal conductive components and better insulation in the construction of ovens.

Refrigerators were found in ninety six percent of U.S. homes in 1968 and consumed 692 trillion Btu. Six hundred eighty seven of the Btu were consumed by electric refrigerators.

The following chart gives estimated per unit annual electricity consumption for refrigeration:

Appliance	Average wattate	Estimated Use	Est. Annual KWH consumption
Food freezer (15 cu. ft.)	341	40% of the time	1,195
food freezer (12 cu. ft.)	440	46% of the time	1,761
Refrigerator (12 cu. ft.)	241	34% of the time	728
Refrigerator (frostless 12 cu. ft.)	321	43% of the time	1,217
Refrigerator-freezer (14 cu. ft.)	326	40% of the time	1,137
Refrigerator-freezer (14 cu. ft. frostless)	615	34% of the time	1,829

Source: Edison Electric Institute

The following figures from <u>Patterns of Energy Consumption in the United States</u> are on kilowatt hour consumption by food freezers:

	Average wattage	Annual Kwh consumption
Food freezer (15 cu. ft.)	341	1195
Food freezer (15 cu. ft. frost less)	440	1761
Average		1478

Freezer sales in the U.S. increased at an annual rate of 1.7 percent from 1960 to 1969.[24]

Montana's 1970 census lists ninety four percent of Montana homes with complete kitchen facilities (range or cookstove, installed sink and piped water, mechanical refrigerator - not including portable cooking equipment or ice boxes).[25] It is difficult to determine how many of the incomplete kitchens have mechanical refrigeration. About 50 percent of Montana households have home food freezers.[26]

Conservation suggestions include the following:

1. don't open refrigerator and freezer doors more than necessary, close door immediately.
2. use chest-type freezers rather than refrigerator type (they lose less cold air when opened)
3. buy refrigerator without automatic defrosting and automatic ice cube maker
4. require refrigerator labelling for efficiency, wattage, and other energy consumption data.

It is estimated that 40 percent of all U.S. households had clothes dryers in 1969. Two thirds of the dryers are electric and one third are gas. Clothes dryers consumed 207 trillion Btu (1.7 percent of total residential energy consumption) in 1968.[27]

About 55 percent of Montana households have clothes dryers; 94 percent of the dryers are electric.[28]

Conservation measures include the following:

1. Use clothes line except in bad weather
2. dry full load
3. require appliance labelling

Dishwashers were found in twenty percent of U.S. homes in 1969 and consumed 36 trillion Btu.[29] Twenty three percent of Montana homes had dishwashers in 1970.[30]

The average annual energy consumption for a dishwasher is 364 Kwh. Eighteen million Kwh of electricity is consumed annually by Montana dishwashers. Energy conservation for dishwashers includes washing only a full load of dishes using proper detergent and requiring appliance labelling.

Ninety percent of U.S. households have at least one television set.[32] Thirty percent of the homes have color sets which use thirty to forty percent more energy than black and white sets.[33] The U.S. television energy consumption in 1968 was 352 trillion Btu. About ninety-two percent of Montana households have at least one television set.[34]

Conservation measures include using black and white televisions instead of color sets and turning off the set when it is not in use.

Lighting consumes twenty-four percent of all U.S. electricity sold and accounts for one and a half percent of the national energy consumption.[35]

Suggested conservation measures:

1. change current design philosophy of maintaining uniformly high light levels to a more conservative approach of directing most light to the work area. This measure may reduce lighting energy consumption by 50 percent.
2. design building to make better use of natural lighting and to allow for optional use of artificial light
3. use more fluorescent lights which are three to five times as efficient as incandescent bulbs based on bare bulb comparisons.[36]
4. choose lighting fixtures to optimize lighting
5. turn lights off when not in use
6. lower illumination if possible (except in work area)

Incorporating an energy consumption awareness into building design could do much to conserve energy. Listed below are several building design conservation ideals:

1. Area to volume ratio
   A house with smallest exposed surface to heated usable volume ration loses less heat during winter and requires less cooling during summer. For the same floor area, two story houses are more energy efficient than one story--e.g. two story home of 1200 to 1800 ft^3 of floor area has 20-25 percent less surface area than single story home with same floor area and would require 20-25 percent less surface area .than single story home with same floor area and would require 20-25 percent less energy.

2. Building Shape
   A roung building has less surface area and therefore less heat gain or loss than any other shape with same floor area; a square building has less surface area than rectangular.

3. Shape and orientation relative to path of sun.

    a. Minimize amount of sunlight coming through south and west walls and windows

    b. Rectangular building with short axis north and south for less solar heat gain in summer.

    c. Increased reflectivity of surfaces exposed to sun

4. Shade windows from direct sunlight by awnings, overhanging eaves, porches.
5. Good insulation -- high initial cost but fuel savings for heating and cooling.
6. Use two layers of heat absorbing glass (separated by circulating air gap) for windows exposed to sunlight to reradiate as much as forty-five percent of the solar heat.
7. Solar homes
    a. Solar water heating would be good during sunny weather. But an auxilliary system is also needed in Montana for periods of bad weather.
    b. Solar space heating works even in Boston and New York with cloudy winters. Solar space heating reduces other fuel consumption for space heating.
    c. There is a need for an incentive for builders to incorporate solar features into homes.
8. Ventilation improvements
    a. Use natural air circulation
    b. Use exhausted air from buildings in winter to melt snow on sidewalks, driveways, and ramps by circulating exhaust warm air through tiles under the outdoor surface.
9. Use more low energy or recycle material like Envirite stone and wood instead of high energy materials such as aluminum and brick.

10. Prefab modular homes take less energy to put together, because their assembly is more efficient.

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COMMERCIAL SECTOR

The commercial sector consumes 15 percent of the total U.S. energy budget; over 50 percent of this energy is for space heating and cooling.[1] Commercial lighting alone consumes 1/10 of the U.S. electricity.[2] In Montana, the commercial sector consumes 14 percent of the total Montana electricity.[3]

The energy use and efficiency patterns are difficult to determine for the commercial sector which includes so many different types of establishments. Conservation suggestions, however, can still be made. Conservation suggestions include the following:

1. Building design and construction (offices, stores, etc.)
   Builders should have an economic incentive for considering energy conservation measures such as using less building material to meet safety standards, installing proper insulation, using openable windows for natural ventilation, situating building advantageously with regard to sun and climate factors (wind, sun, etc.), using trees and shrubs to cut down on summer sun and winter wind effects, installing efficient heating and cooling equipment, re-evaluation of lighting standards (direct the light to work area rather than having a uniformly high light level unnecessarily throughout the building), using less glass or using mirrored glass, and using less energy-intensive materials for construction.

2. Building maintenance
   There are several energy conservation opportunities in this area: opening windows and doors for natural ventilation, reducing air conditioning use (most restaurants, for example, are too cold during the summer due to excessive air conditioning,) burning building refuse for heat, using heat of lighting systems, heat wheels, heat pumps, and using total energy systems.

3. Outdoor electrical advertising
   An energy savings would be realized by the elimination of electrical advertising after business hours or restrictions on the amount of energy consumed for advertising purposes. The governor of Oregon has recently banned electric advertising. The Montana Public Service Commission has ordered all jurisdictional utilities to discontinue furnishing electricity for outside display and advertising after business hours effective January 1, 1974. It also ordered utilities to refuse requests for new electrical service to light outside billboards after September 1973.

4. Business hours
Many businesses (especially grocery stores) stay open late at night to compete with others for business. During an electricity shortage business could be curtailed. However, the financial repercussions of such curtailment on store owners and customers must be considered.

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TRANSPORTATION SECTOR

Transportation of people and freight consumes one fourth of our national energy.[1] Including secondary transport activities such as fuel refining and manufacturing transportation equipment, the energy consumed is over a third of the national energy.[2] Since 1950 there has been a forty percent increase in per capita energy consumption for transportation and since 1960, the total U.S. consumption for transportation has increased 52 percent.[3] People want to be transported more places faster, more conveniently and confortably, and all at the expense of efficiency. During the past decade, there has been a decrease in overall transportation efficiency (as measured in Btu per ton miles or Btu per passenger miles). This is due primarily to the shift from waterway and railroad to airplane and truck transportation of freight, the shift from buses and trains to automobiles to airplanes for passenger inter-city travel, and the shift from mass transit systems to private automobiles for passenger intra-city travel. The following tables from Eric Hirst's report[4] show the comparison of efficiencies for the different modes of transportation (taking into account load factors):

Freight-Inter-city

Mode	Btu/ton mile
pipeline	450
waterway	680
railroad	670
truck	2,800
airplane	42,000

Passenger-Inter-city

Mode	Btu/passenger-mile
bus	1,600
railroad	2,900
automobile	3,400
airplane	8,400

Passenger-Inter-City

Mode	Btu/passenger miles
bicycling	200
walking	300
bus	3,800
automobile	8,100

Referring to the tables, the most efficient transportation of freight is by pipeline, waterway or railroad, but the least efficient modes are being used because of the greater speed and flexibility of truck and air freight. The faster, more convenient automobile and airplane are used primarily for inter-city travel rather than the more energy-efficient modes such as trains and buses. For intra-city travel, people prefer to drive in automobiles instead of using the more efficient modes such as mass transit, walking or bicycling. To compound the problem, the average number of passengers is low: 2.4 per car for inter-city travel, 1.4 for intra-city travel and 1.2 during rush hour.[5]

The leading fuel consumers are automobiles consuming 55 percent of the transportation energy, trucks consuming 21 percent, and aircraft consuming 7.5 percent.[6] Including energy uses such as manufacturing of automobiles, gasoline refining, tire manufacturing, and oil refining, the energy consumption of U.S. automobiles is 21 percent of the U.S. energy budget.[7]

Petroleum accounts for 96 percent of the total transportation fuel use.[8] This amount is greater than half of the total U.S. petroleum consumption. Current U.S. transportation fuel consumption is 6.8 million barrels per day of gasoline.[9] Electric power accounts for 0.1 percent of the transportation energy[9] (or .019 percent if secondary electricity consuming activities are included).[10]

By 1985, it is projected that autos and aircraft will use 73 percent of the total transportation energy (the total transportation energy consumption itself is also growing. Due to the increasing demand for petroleum products and the dwindling domestic supplies, much of our transportation fuel will probably come from foreign sources.

Transportation Energy Consumption in Montana

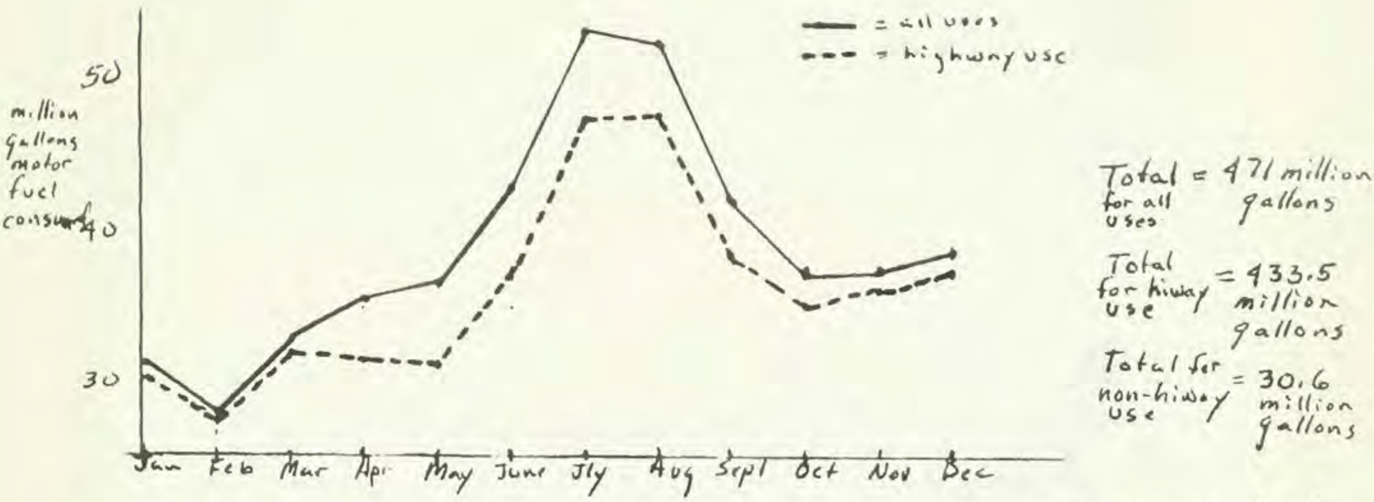
According to the Federal Highway Administration, Montana had the nation's largest percentage increase of registered vehicles during 1972. The total number of motor vehicles in 1972 was 14.4 percent above the 1971 figure. According to the Montana Department of Law Enforcement and Public Safety, Motor Vehicle Registration Division, 286,100 passenger cars, 171,100 trucks and 25,692 motorcycles were registered in 1973.

The following data from the Motor Fuel Tax Division of Montana Department of Revenue, lists the motor fuel consumption in Montana.

Motor Fuel Consumption in Montana (1972)

Total gasoline gallons	454,284,322
Gasoline - gallons tax was refunded on (off highway use)	34,789,141
Diesel fuel gallons taxes	72,618,863
Aviation gasoline gallons	31,193,430
LPG (liquid petroleum gases) taxes	822,189

(Information on off highway use of diesel and LPG fuels on farms is found in the industrial sector section of this report).



1971 Motor Fuel Consumption - Montana

Sourse: U.S. Dept. Transportation Highway Statistics 1971

Other motor fuel uses for 1971 included 24.3 million gallons for agriculture, 1 million gallons for aviation, 2.7 million gallons for marine purposes (pleasure boats, etc.) according to the U.S. Department of Transportation 1971 Highway Statistics.

Montana has six railroad carriers, Butte, Anaconda, and Pacific Railway (BA&P), Burlington Northern, Inc. (BN Inc), Chicago, Milwaukee, St. Paul and Pacific Railroad (CM ST P&P), Soo Line Railroad (Soo Line), Union Pacific Railroad (UP), and White Sulphur Springs and Yellowstone Park Railroad (WSS & YP). Fuel consumption data is from the Carriers 1971 Report to the Public Service Commission.

(1) Passenger Service

Carrier	Amount and type of fuel
BN Inc.	145,808 gal. diesel
UP	9,886 gal. diesel
Total	155,694 gal. diesel

(2) Freight Service

Carrier	Amount and type of fuel or power
BA & P	236,787 gal. diesel
BN Inc.	3,920,760 gal. diesel
CM ST P&P	11,827,216 gal. diesel
	66,170,193 Kwh. electricity
Soo Line	3,801 gal. diesel
UP	1,436,376 gal. diesel
WSS & YP	5,129 gal. diesel
Total diesel fuel	17,430,069
Total electric	66,170,193

(3) Switch 3,417,050 gal. diesel

Note: Fuel consumption for all except BA & P and WSS & YP are computed on the percentage of Montana traffic to U.S. Traffic. Fuel consumption for BA & P and WSS & YP are exact because they are within the state.

Conservation measures

Perhaps one of the most important measures for transportation energy conservation is increasing citizen awareness. Citizens can be informed by pamphlets (handed out at gas stations) on conservation means such as the following:

1. keep car tuned up properly and regularly; be sure your tires are properly inflated:

2. slow down (at 50 mph a car uses about 4/5 the fuel used at 75-88 mph):

3. improve driving habits-don't accelerate like a jack rabbit and don't constantly accelerate and decelerate;

4. warm up engine on cool mornings;

5. don't race the engine;

6. plan daily schedule to include a number of errands in one car trip instead of making many small trips in the car during the day - don't idle while waiting for a passenger;

7. car pool if possible;

8. replace driving with walking or bicycling for short trips (side benefit of health);

9. use the city bus service;

10. don't use air conditioner or fan unless necessary; accessories lower gas mileage by as much as 2-3 miles per gallon in cities and 1-2 miles per gallon on open highways.

It is important that citizens are stimulated to participate in transportation planning and development. An example of an activity in which citizens got involved in the transportation planning process in Montana is the Missoula Bikeway Plan.

Carpools

During rush hour, the average occupancy of automobiles is only 1.2. This is obviously very inefficient. If it is necessary work, carpools are a much more efficient means of transportation than one person per car. To set a good example, the state government should encourage and facilitate setting up carpools among its employees. Another action to encourage carpooling is the setting aside of existing street facilities for the exclusive use of buses and carpools during rush hours. Because this would be difficult to enforce, it would depend upon the voluntary participation of drivers.

Parking

Decreasing the number of parking facilities (by limiting future development and decreasing the number of existing ones) and/or placing a surcharge on allday parking would discourage automobile travel to downtown areas and hopefully provide an incentive to take the bus or use carpools. This measure however, unless carefully done, might have the effect of shifting business from downtown to shopping centers.

Traffic flow

The traffic signal systems of Montana cities should be examined and their coordination improved if necessary to reduce inefficient stop-short driving. The cities should also look into revisions for their transportation plans to facilitate (e.g. conversion of two-way streets to one-way, elimination of parking on one side of the street, development of special bicycle lanes).

Special Bike and Pedestrian Paths

Attractive and maintained bike and pedestrian paths would make it more enjoyable and safe for people to use these two modes. There is a need in most Montana cities for such pathways. (Have you ever pedaled down Helena's Broadway or Billings' Grand Avenue on a bicycle?) A Montana bill similar to the Oregon (House Bill 1700) which requires one percent of the state highway funds revenue received by county, city or the commission be used for the development of city and statewide bike paths.

Graduated automobile excise tax on the purchase of new vehicles

Another conservation measure is to tax new vehicles sold in Montana (starting in 1975) based on fuel consumption. This would encourage consumers to buy high gas mileage compacts. The lower the fuel mileage the higher the tax. This however may be inequitable because some one may buy a car with low gas mileage, not use it much and consequently consume less total gas than a person driving a high gas mileage car. A caution is that if it is implemented nationwide it should be done gradually over a period of time to allow U.S. manufacturers to be able to compete effectively with foreign cars (otherwise we get into a balance of payments problem).

Increased tax on gas

The high cost of gas (due to an increased tax on it) would provide a disincentive for waste or inefficient use of fuel. It would be fairer than the tax on automobiles as the biggest user of fuel would pay a corresponding tax. A problem with this measure is that its effectiveness is dependent upon the elasticity of demand with respect to price. The measure would only be effective if it acted as a brake on gas consumption. Another problem with this measure is that low income and fixed income persons might have problems being able to buy gasoline.

Reduction of speed limits

This measure will undoubtedly meet with opposition in Montana! The reasoning behind this proposal is that an automobile uses less gas at lower speeds. (at 50 mph a car uses about 20 percent less gas than a car going 70 mph) "The Emergency Petroleum Allocation Act of 1973" passed by the Senate has a provision urging federal, state and local governments to reduce speed limits. This measure would involve a trade off between convenience and speed and safety and gas conservation. Just how much gasoline would be saved is difficult to determine. If there is a relatively small number of cars driving over 55 or 60 on inter-city trips, the gas saved by slowing them down might not be so great. Another drawback is the increased travelling time and cost for the trucking industry.

Electric vans

Electric vans might be a partial solution to the energy problem, assuming a clean and renewable method for generating electricity is used (e.g. solar or geothermal). First, they are clean (there is a single pollution source at central power plant as opposed to emissions by each individual auto) and require little maintenance. Second, they do not idle (the engine supply shuts off when the vehicle is not moving) so energy is not being used at those times. There are, however, drawbacks. Electric vehicles are slow (30 mph) and need to be recharged often (about every 30-50 miles), therefore they aren't suitable for inter-city travel. However, using them for Montana's postal service or for mail deliveries is a possibility.

The efficiency of electric cars depends upon the efficiency of the power plant supplying the power. The vehicle control system, according to Grimmer and Luszczynski is 90 percent efficient, the battery 80 percent, transmission 90 percent, for a net efficiency of 65 percent for the vehicle. Assuming the electricity comes from coal the efficiency of producing, transporting and converting coal to electricity is about 30 percent for a total efficiency of about 20 percent for the car. However, the total efficiency would not be so low if the electricity were generated by hydropower or another more efficient method.

An article in the Electric Vehicle News, February 1973 issue reports that the Cupertino, California U.S. Postal Service uses electric postal vans. It takes about 14 Kwh to power the vehicle for a normal mail route - about 13 miles. The vehicles are recharged at night during off-peak electricity consumption times. The cost to run an electric van is less than 1/5 the cost for the conventional quarter ton Jeep used for a similar route. The drawbacks of the electric vans are low power, low speed, and some difficulty in maneuverability. The advantages are no direct pollution (although the power plant producing the power may be polluting), no engine vibration or noise, no heat from the engine, and no fuel consumption when idling.

Electric Railroads

There is only one electric rail line in Montana at the present time (a Milwaukee Railroad line) and it is to be discontinued soon due to cost of replacing old cables.

Railway Magazine reports that in 1971, U.S. railroads bought about 1/2 as much fuel as highway diesels (including buses) bought, while carrying about 75 percent more ton-miles of freight.

Urban Planning

Ultimately we must learn to coordinate urban planning and transportation planning. One concept of a well planned city is to have clusters of homes connected to working areas by a good bus, railroad or other mass transit system, auto free downtown and shopping centers (linked to residential area by mass transit), attractive and safe bike paths and pedestrian trails.

Air Travel

A reduction of the number of flights and a corresponding increase in flight distances (eliminate milk run flights) would fill planes to greater capacity for more efficient transportation of passengers. (However, short haul trips, 250 miles or less, account for only 3.8 percent of total passenger miles, so perhaps the savings would not be so great.)

Recycling Oil

About 50 percent of the new oil sold for industrial and automotive uses is disposed of as waste each year. Waste oil can be re-refined into lubricating or fuel oils. In 1971 the American Petroleum Institute reported that the capacity of reprocessing plants was 1/2 of what it was in 1965-66. There are several reasons for this decline:

1. Additives in "high performance" lube oils complicate and reduce the efficiency of the re-refining process.

2. Some state laws and military regulations prohibit the use of recovered oil.

3. The Excise Tax Reduction Act of 1965 exempted new lube oil used in off-highway operations from taxes, but not re-refined oil.

Research at Villanova University indicated that re-refining using the present processes was not economically feasible.

It is possible to use a mixture of waste and new oil to fuel power plants, but there are problems. The cost of recovering the waste fuel may exceed the price of new oil. Additives in the used oil may cause boiler problems.

Recycling of oil will probably not be possible until the legal and economic restrictions are removed.

Containerized freight and computerized yard and interchange control

Both of these developments greatly increase freight movement efficiency and should be encouraged.

Improved engines

The development of lightweight diesel, stratified charge, gas turbine, Rankine, and/or starting engine may improve the efficiency of engines.

Novel fuels

With the shortage of petroleum, novel fuels such as methane, methanol, propane, and ethanol from coal, hydrogen from nuclear energy (as in a hydrogen fuel economy), and magnesium hydride, ammonia and hydrazine as chemically stored hydrogen have become attractive substitutes for petroleum-based fuels. The most serious problems with these types of fuel is the bulk of the fuel and storage tank, fire and explosion hazards, and highly toxic combustion products. The Transportation Energy R & D Panel of the Department of Transportation rate ethanol second as automotive fuel next to gasoline and related petroleum derivatives, third is propane, then methanol, and liquid methane, in that order. The other novel fuels are not so attractive.

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INDUSTRIAL SECTOR

Industrial energy accounted for 42 percent of total U.S. energy in 1969.[1] The principle consumers, accounting for over half the industrial energy use, were primary metal industries, chemicals and allied products and petroleum refining and related industries.[2] Forty-six and a half percent of the energy used was natural gas, 26.0 percent was coal, 16.8 percent petroleum, and 10.6 percent electricity.[3]

Efficiency

All of the industrial sector (except for four industries-tabacco manufactures, apparel and other finished fabric products, lumber and wood products, and printing, publishing and allied-industries; which consume only 2 percent of the industrial energy) has had an increase in efficiency in the past ten years (i.e., a decrease in energy used per unit output).[4] In theory, the design of electric power generation and chemical plants incorporates energy effectiveness by considering both initial and operating costs. However, in some industries (especially small ones) energy is not adequately added in to the cost of production since it is only a small fraction of the total cost. Sometimes it is less expensive to leak energy than to replace or repair machines causing the leak. With the expected rise in fuel prices efficient use of energy by industry should increase. Anaconda Copper Company is involved in an energy efficiency study analyzing the efficiency of current energy use and possible conservation measures, including new production processes.[5]

A fuel quota is another incentive for effective and efficient energy use. If industry has only a certain amount of fuel available, it will try to make the best possible use of the energy, it cannot afford not to. Already because of the uncertainty of Canadian gas imports, some Montana industries may have gas quotas, causing them to increase their energy use efficiency.

Montana Industry and Economy

Montana's economy is sluggish. The per capita income has fallen from 8 percent above the national average in 1950 to 12 percent below the national average in 1970.[6] Montana has relatively high unemployment and a net migration of residents out of the state. This situation is partially the result of the type of industries found in Montana. The industries providing for growth are primarily the export industries: agriculture, mining, forest products and other manufacturing, railroads, federal government and tourism. Examination of these industries explains the economic lag.

Agricultural employment has declined over the past twenty years from 25 percent of the labor force in 1950 to about 13 percent in 1970.[7] Part of the reason for the decline was the increase in farm production efficiency (output per manhour) with the increased use of technology.

PRIMARY EMPLOYMENT IN MONTANA

	Annual Average			Percent change		
	1950	1960	1970	1950-1960	1960-1970	1950-1970
Agriculture	52,800	39,200	34,800	-26	-11	-34
Mining	10,200	7,900	6,600	-23	-16	-35
Manufacturing	18,000	20,600	23,900	14	16	33
Lumber, wood products, and paper	5,400	7,400	8,700	37	18	61
All other manufacturing	12,600	13,200	15,200	5	15	21
Railroads	14,000	9,000	6,600	-36	-27	-53
Federal Government, civilian	8,300	9,900	11,900	19	20	43
Total primary employment	103,300	86,600	83,800	-16	- 3	-19

Source: Wood Production in Montana, Maxine Johnson

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It is important to remember, however, that although the number of people running farms has decreased, the number of farm-supporting industries has increased. Farms are becoming industrialized themselves. Land is treated in an assembly-line like manner - straight, uniformly plowed and planted rows of crops, mechanized (and in some instances self-propelled) irrigation systems, and complicated, expensive equipment.

Although the number of acres farmed in the U.S. and Montana has remained fairly constant the last 30 years, both the number of farms and farmers has decreased drastically. The result is fewer but larger farms.

Year	Average size of farms (U.S)
1940	161 acres
1960	297 acres
1970	400 acres

Source: 1971 Statistical Abstract of the United States (Department of Commerce)

The mineral industries (mining, smelting and refining) have also experienced a decline in employment, although this was slightly offset by the aluminum plant at Columbia Falls and the petroleum industry in eastern Montana.

Manufacturing industries in Montana are based primarily upon the processing of raw materials. Wood products industries provide about 1/3 of the manufacturing jobs.[8] Employment in wood products and related industries has increased over the last 20 years. Railroad employment has declined over the same period of time because of increased automation and the shift from steam to diesel engines. Federal government employment increased over the twenty year period.

The gains in employment in Federal government, wood products and other manufacturing was less than the losses in agriculture, mineral industries and railroads. The net loss from 1950 to 1970 was 19,500 jobs.[9] Although per capita income is low and unemployment relatively high, Montanans have a wealth shared by few other states - a relatively unspoiled environment. There must be a balance reached between exploiting our energy resources and preserving Montana's environment.

Copper Smelting and Refining

The copper smelting process consists of reverberatory furnacing and converting (roasting may precede these steps). The reverberatory furnace is fueled by oil, gas, or pulverized coal. (Coke was used in older furnaces and electric furnaces are planned for some of the newer smelters.) A 35-45 percent copper matte is formed by the process. An average fuel requirement for smelting (although it varies widely) is 375 Kwh of electricity and 32,000 cubic feet of natural gas per ton of anode copper.[10] The crude copper matte is then refined to remove impurities. One method of refining copper is electrolytically depositing cathodes. The copper cathodes are then melted in electric arc or fuel-fire reverberatory or shaft furnaces to obtain ninety-nine percent pure copper. Fire refining, another method, consists only of furnace processing. An estimate for energy requirements for electrolytic refining is 615 Kwh of electricity and 4,700 cubic feet of natural gas per ton of refined copper.[11] Energy consumption for smelting (33.3 million Btu) and electrolytic refining (6.8 million Btu) amounts to 40.1 million Btu per ton of anode copper.[12] This is a very rough estimate as there is no typical energy use factor for the copper industry.

With increased pollution control demands placed upon the industry, the processes are likely to change. Lower smelting costs, improved pollution control and lower energy consumption would result from:

1. bypassing the reverberatory step

2. flash smelting

3. autogenous smelting (with oxygen and enrichment)

4. implementation of the arbiter process

Suggested conservation measures for copper include recycling (recycling of copper scrap uses less energy than producing copper from ore), and use of more efficient equipment. The Anaconda Copper Company, which consumes a large amount of Montana energy, is studying the possibility of implementing processes which are more energy efficient than existing ones.[13]

Aluminum

Aluminum production uses more electrical energy per ton than any other primary metal. Alumina is electrolysised in a molten cryolite bath. Within the carbon-lined still reduction cell is a pact of molten aluminum which acts as the cathode, a carbon anode; and an electolyte of molten cryolite in which alumina is dissolved. The reduced alumina is found as aluminum at the cathode and the oxidized carbon is found as carbon dioxide at the anode. The aluminum ingot formed is 99.5 percent pure. Most of the energy consumed in the process is electrical. The amount of power in electrolytic smelting of aluminum varies but the average use is 46.7 million Btu per ton (3.413 Btu per Kwh). Primary producers use about 4.7 million Btu of fuel to melt one ton of aluminum ingot and scrap. Process power, steam and other energy use amounts to about 3.6 million Btu per ton. The total consumption of power and fuel in aluminum production is about 55 million Btu per ton (including cartonaceous material like petroleum, coke, coal tar pitch, carbon for anodes, pot linings, etc.). To produce secondary aluminum from aluminum scrap requires 8.5 million Btu per ton; processing wrought aluminum consumes 12 million Btu per ton.[14]

The American Aluminum Company has recently announced a method which will decrease energy consumption by 30 percent. This is of particular interest to Montana, since the Anaconda Aluminum Company consumes a large amount of the BPA electricity generated in Montana. However, the environmental impact of any new processes should be evaluated before implementing them.

Pulp and Paper Industry

A major consumer of electricity in Montana is the pulp and paper industry (e.g. Hoerner Waldorf in Missoula). Paper and pulp industries consume 5 percent of the U.S. industrial energy; of this energy, 10 percent is used for mechanical drive and 90 percent for heat.[15] The average U.S. efficiency of energy conversion in this type of industry is about 60 percent.[16] Suggestions for energy conservation include tax incentives for purchasing new, efficient equipment or repairing old equipment and the establishment of a statewide paper recycling program.

Power to clean up pollution

Power is also used to clean up the environment. The Anaconda Company, for example, uses energy equivalent, the energy required by 100,000 homes for pollution control devices.[17] The secondary sewage treatment plants under construction in Great Falls and Billings will use energy equivalent to that required by a town of 10,000. Tertiary treatment plants, requiring two to three times the energy of secondary plants will soon be needed.[18]

Petroleum refining

Energy is required to produce the more than 200 different crude oils and the more than 1,000 petroleum products necessary for our mobile society. The energy used in refining processes varies with each plant (there are more than 100 different refining processes). The average energy use, however, is about 710,000 to 715,000 Btu per barrel of crude oil run to stills, or about 11 percent of the total energy input to refineries (including crude oil and auxiliary fuels).[19] The major energy sources used in petroleum refining are listed below:

Energy source	Percentage of total energy used	Amount of energy used per barrel of crude
Natural gas	38 percent	.26 Mcf/barrel crude
Refinery gas	34 percent	.25 Mcf/barrel crude
Petroleum coke	13 percent	.003 tons/barrel crude
Fuel oil	10 percent	.01 barrel/barrel crude

Source: Patterns of Energy Consumption in the U.S. (Stanford Research Institute)

About 60 percent of the energy used in petroleum refining is for direct heat, 34 percent for a process steam, and 6 percent for electrical generation.[20] Direct heat is produced by the burning of oil and gas in direct fired heaters.

Some fuel is burned in mechanically driven compressors in catalylitic cracking. The use of process steam depends on the type of crude processed, processes used, and products turned out. In general, a central steam boiler produces high pressure steam for heat exchangers and mechanical drive systems. The exhaust steam is used for stripping steam or as an inert carrier to facilitate separation of petroleum factions. Montana refineries purchase their electricity.[21] However, some U.S. refineries generate their own electric power when it is more expensive to purchase electricity than to use steam from the central steam supply or boiler plant to power a generator. The exhaust generator steam powers mechanical drives or is used as process heat or steam in the refinery. Most of the electricity in refineries is used for air conditioning, spaceheating, lighting and cathodic protection of equipment. Energy could be conserved in petroleum refining by the installment of efficient equipment and by the use of waste heat.

Agriculture

The latest Census of Agriculture [22] showed 24,953 farms in Montana with an average size of 2,521.4 acres (considerably larger than the U.S. average), and covering a total land area of 62,918,253 (almost 70 percent of the land area of Montana.) A total of 1,841,420 acres was irrigated on over 9,000 farms.[23]

Energy use in agriculture includes the manufacturing and operation of farm equipment, the manufacturing and application of fertilizers and other chemicals, irrigation, and photosynthesis (which uses "free" solar energy).

1. Energy was used to manufacture and spread the 150,579 tons of commercial fertilizers used on Montana farms in 1969.[24] Composting with manure, sewage sludge, and food processing wastes is an excellent use of material which would probably otherwise be disposed of (perhaps adding to water pollution) or chemically, physically, and/or biologically treated (at an energy cost). In addition, composting reduces the use of manufactured fertilizers which require large amounts of energy to produce.

2. The manufacture and operation of the following equipment on Montana farms required energy.

20,606	Automobiles
58,329	Motor trucks (incl. pickups)
58,729	Tractors
1,923	Riding Garden Tractors (7 horse power & greater)
11,687	Grain & bean combines self-propelled
468	Cornpickers, corn heads & picker-shellers
11,059	Pickup balers

Source: 1971 Census of Agriculture (Dept. of Commerce)

The following data shows the delivery of fuel to farms and ranches and the amount consumed by various equipment: Tank, truck, car deliveries of fuel to farms/ranches (1,000 gallons) - 1970.

Fuel type	Number of Farms	Amount of Fuel (1,000 gallons)
Gasoline	20,290	19,827
Diesel	12,712	7,471
LP gas	5,168	1,297
Butane	5,168	1,297
Propane	5,168	1,297
Motor oils	20,522	2,858
Grease	20,522	2,858
Piped gas	20,522	2,858
Kerosene	20,522	2,858
Fuel oil	20,522	2,858

Source: C. Meyer, Montana Department of Agriculture

1969 Farm and Ranch Fuel Consumption in Montana (thousand gallons).

Farm vehicles	Diesel	Gasoline
Wheel tractors	20,400	17,900
Crawlers	4,000	760
Trucks (farm)	240	23,900
Self propelled combines	130	6,400
Autos on farms and misc.	170	17,100
Total	24,940	66,060

Source: C. Meyer, Montana Department of Agriculture

Because electricity has been plentiful and inexpensive for Montana in the past, electricity intensive industries have been attracted to the state. This trend can't continue indefinitely, however. In the future, it will become increasingly important to analyze the energy demand as well as the environmental impact of new industries on the local and state regions.

The following questions should be answered concerning existing and future industrial development:

1. What are the major industrial energy consumers and how much of what type of energy do they consume?

2. How does the industrial energy use affect the environment?

3. To what extent do the various industries provide direct employment and income as well as secondary contributions?

The following is a list of the major electricity consuming industries in Montana (listed in the order of magnitude of consumption):

Company	Electricity Purchased From:
Anaconda Aluminum	Bonneville Power Administration
Anaconda Copper (note: this includes 282,608 MWH for a zinc contract which was terminated in August 1972)	Montana Power Company
Stauffer Chemical	Bonneville Power Administration
Humble Oil	Montana Power Company
Hoerner-Walforf	"
Ideal Cement	"
Kaiser Cement	"

Source: Montana Power figures from Montana Public Service Commission; Bonneville Power figures from Bonneville Power Administration; U.S. Department of Interior.

4. How are the industries interdependent?

5. What would be the best industrial energy policy to minimize the economic impact due to energy cutbacks?

Further suggestions for industry include the following:

1. Reschedule for off-peak periods

Industry should look into rescheduling work hours, production or any other operations to off-peak period. Examples are starting refrigeration equipment an hour or two earlier than usual, lowering the temperature lower than normal and resetting the water chiller thermostat higher than normal, so that the power usage during peak load times will be lower. Another suggestion is turning off the chiller an hour or so before the end of the working day. Chilled water will remain in the pipes for a while for the air conditioners and the space temperature probably will not increase much.

2. Reduce maximum load

Current may be reduced or interrupted to some electric heating equipment without much loss of heat or to motor-driven air compressors without much pressure loss. These and other load reducing options should be examined by industry. Other load reduction ideas are adjusting belting and eliminating unnecessary shafting.

3. Use standby generators

During critical peak periods, industries might use emergency standby generators.

4. Use photo cell switches

Photo cell control switches for exterior lighting (parking lots, building lighting, security lights) would eliminate unnecessary exterior lighting. Also time clock controls to reduce lighting after certain hours would help.

5. Reduce ventilating air and cooling

Unoccupied areas shouldn't be ventilated or cooled unless necessary. Levels of ventilation and/or cooling in occupied areas might be reduced in some cases.

6. Reduce lighting

Elimination of unnecessary lighting and reduction of excessive lighting would save power directly as well as reducing the air conditioning load. In the winter, heat of light units might be used.

7. Reset thermostats

Lower temperature settings in the winter and higher settings in the summer might be possible and would reduce energy consumption.

8. Maintain equipment

Industry should routinely check for leaks, keep heat transfer surfaces clean, clean furnaces and air conditioning units, check to see motors are operated at proper voltages and check for any inefficient machinery.

9. Use of power plant or industry waste heat or a total energy system

This item was covered in the electricity generation section.

10. Proper insulation

Insulation in a climate like Montana will greatly save energy.

11. Using own waste heat

An industry may be able to use its own waste heat for heating, cooling, water treatment, industrial processes, etc.

12. Local balanced ventilation system

Use local exhaust ventilation instead of general ventilation. Handle ventilation at source. Use a balanced system for maximum efficiency; size ducts instead of using dampers (unbalanced systems).

13. Use air curtains

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THE RESOURCES DEVELOPMENT INTERNSHIP PROGRAM

The preceding report was completed by a WICHE intern during the summer of 1973 This intern's project was part of the Resources Development Internship Program administered by the Western Interstate Commission for Higher Education (WICHE).

The purpose of the internship program is to bring organizations involved in community and economic development, environmental problems and the humanities together with institutions of higher education and their students in the West for the benefit of all.

For these organizations, the intern program provides the problem-solving talents of student manpower while making the resources of universities and colleges more available. For institutions of higher education, the program provides relevant field education for their students while building their capacity for problem-solving.

WICHE is an organization in the West uniquely suited for sponsoring such a program. It is an interstate agency formed by the thirteen western states for the specific purpose of relating the resources of higher education to the needs of western citizens. WICHE has been concerned with a broad range of community needs in the West for some time, insofar as they bear directly on the well-being of western peoples and the future of higher education in the West. WICHE feels that the internship program is one method for meeting its obligations within the thirteen western states. In its efforts to achieve these objectives, WICHE appreciates having received the generous support and assistance of the Economic Development Administration, the Jessie Smith Noyes Foundation, the National Endowment for the Humanities, the National Science Foundation, and of innumerable local leaders and community organizations, including the agency that sponsored this intern project.

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