The Joint AAPG-AIPG Liaison Committee has been charged to "consider all matters of mutual concern to the two organizations and to recommend possible action to the two executive committees." The major question of mutual concern brought to the committee's attention has been the issue of divided effort among geologists in matters of professionalism—especially as these bear upon professional certification. The joint committee has considered these problems at length and submits the following recommendations for consideration by the two societies.

**Recommendation 1.** That AAPG and AIPG accept the principle of a single professional program for the majority of geological scientists.

**Recommendation 2.** That, as the largest societies involved, AAPG and the Division of Professional Affairs of AIPG agree to merge those aspects of professional activity that are adversely affected by a continued divided effort.

These two recommendations encompass the major findings of the joint committee. It is implicit in the committee's recommendations that "professional activities" include professional certification; inter-profession discussion and arbitration (as between geologists and civil engineers, for example); political action at the international, national, and local levels, and advancement of the profession.

Formal acceptance of items 1 and 2 is the paramount issue placed before the societies. Agreement on these matters would pave the way for consideration of the following:

**Recommendation 3.** That, whatever the structure and identity of the unified agency recommended above, all current members of the Professional Affairs Division of AAPG and AIPG shall be admitted to full membership in any new, expanded, or revised listing of certified geologists without further review.

Careful study of the requirements for membership in either present group shows that these requirements are substantially equivalent and that no change in essential standards would result from merger of AAPG Division of Professional Affairs and AIPG membership lists.

**Recommendation 4.** That close consideration be given to the fees required for support of the combined effort in view of the greater efficiency deriving from unification and in view of possible separation of professional activities from the umbrella of a major society.

There is a widespread feeling that AIPG fees are too high. Geologists certified by AAPG are reluctant to become members of another organization that requires twice as much in annual dues.

**Recommendation 5.** That the publication media of the two societies institute a strong educational program directed toward members whose understandable pride in one organization may outweigh the advantages of unification, especially if the latter were not clearly stated and widely disseminated.

**Recommendation 6.** That provision be made for appropriate identification of professional specialties such as petroleum geologists, mining geologists, ground-water geologists, etc.

At present, AIPG recognizes no specialties while AAPG identifies only petroleum geologists. The vigor with which specialty identification is defended by many practitioners and the equal fervor with which other geologists reject specialty identification are indicative of the degree of flexibility required in this regard.

**Recommendation 7A (offered by committee majority).** That AAPG be designated the agency for professionalism and professional activities for its own membership and for the AAPG Division of Professional Affairs members.
REPORT OF LIAISON COMMITTEE (continued)

This recommendation is clearly the most controversial. It is offered as one mechanism through which early unification of effort can be achieved. The joint committee is itself divided on this recommendation but the majority asks that it be placed before the two societies for consideration without prejudice to action on the preceding recommendations.

Acceptance of this recommendation in the context of the foregoing paragraphs would bring about the eventual merger of the AAPG Division of Professional Affairs into AIPG. AAPG is a scientific society dedicated to the practice of geology in the discovery and exploitation of mineral resources with current emphasis on oil and gas. AIPG is wholly dedicated to professionalism; it includes all branches of professional earth science; it is not concerned with science and technology except where these influence professional activities. Thus, AIPG seems to constitute the model for the organization required for unification of professional activity among geologists.

Recommendation 7B (offered by committee minority). That both AIPG and the AAPG Division of Professional Affairs continue as separate but coordinated entities, cooperating and closely associated by joint agreement in all mutually pertinent areas of professional activity.

A committee minority of one point out that (1) acceptance of Recommendation 7A is tantamount to elimination of the Division of Professional Affairs of AAPG; (2) it would be an error to designate either AAPG or AIPG as the exclusive agency for the professional activities of both organizations; (3) implementation of the recommendation would be resisted by the AAPG membership and would be considered a divisive act by that membership.

Minority Recommendation 7B is introduced as an integral part of the committee report in order that the full spectrum of committee opinion be represented.

Recommendation 8. That, with receipt of this report by the two societies, the Joint AAPG-AIPG Liaison Committee be discharged, and be replaced by working committees charged with the implementation of those recommendations accepted by the two organizations.
THE PRESIDENT'S COLUMN

CHANGING TIMES

In 1962, when I became aware of the organizational stirrings to form the AIPG, I was hesitant at first to acknowledge the validity of any group that was attempting (as I thought) to form geologists into a political action group. I suppose my geological individualism was asserting itself, but I decided that if anyone was going to tamper with my profession, I had best be a part of the group, if only for self-interest.

I was pleasantly surprised, therefore, to find the discussion at the organizational meeting of quite different tenor than I had expected. The founding members of AIPG were unanimously opposed to regulation of professional geologic practice by statute. But at the same time they knew of the attempts that had been made to license geologists—without asking their opinions—by generally uninformed but supposedly well-intentioned legislators.

They also knew of the inroads being made upon the practice of geology by those who were untrained or by the poorly trained, or by outright frauds. They knew that for protection of the investing public, and for geologists themselves, some group had to act in a concerted manner.

The problems of geologists, however, were recognized long before 1963. In fact, part of the enthusiasm for a strong AGI arose from the fact that one of its initial aims was to deal in the realm of professional matters. Under the aegis of AGI a Model Law for registration of geologists was drawn up for just such emergencies as had arisen in the past, a law that could be put forth when proposals for licensing appeared to be immediate threats to the freedom of geological practice (Geotimes, February, 1965).

The failure of AGI to act further in professional affairs was probably due to many factors—prosperity in the profession, few immediate threats to freedom of practice—but some are of the opinion that this failure was due mostly to lack of leadership. There are many who will remember the presidential address of a distinguished scientist and former president of AGI who, from his eminent position, denigrated the efforts of geologists who would attempt to form a "trade union." Unfortunately, this man never had to sell a prospect, to defend a client, to face the public, nor in fact, rely upon the practice of geology for his livelihood.

Nevertheless, the dangers of the profession were recognized by many others, foresighted men who were equally distinguished in both the science and practice of geology. Had it not been for the action of the founders of AIPG, many of us would now be supplicant to the engineering boards of several states.

Some early AIPG efforts were directed at discouraging regulatory legislation—mostly hasty and intemperate efforts put forth by disgruntled legislators or citizens.

Then came the California affair. In self-defense the engineering geologists proposed to be registered as engineers, and this effort threatened to impinge upon the practice of all geologists. It was then that members of the Institute stepped forward to act in the interest of the entire profession in order to promote an equitable regulatory bill and to guide its safe passage into law. It was a hard fight, and at times a wild one, but their efforts saved the practice of geology for geologists. The California law is not a "Model Law," but as statutory regulation, it is one that all geologists can live with.

After California—what? Most of us probably wish that the subject of statutory regulation will lie dormant in other states. Many view any regulation as a hindrance to practice, rather than a help.

There are some who seem to feel that we should take more positive action. Why wait for another crisis like that faced by California and then be forced to act defensively? Why not take the offensive and see that an ideal bill is introduced first, before having to fight the unfair ones?

These questions seemed to reflect the growing mood among the assembled representatives of the Western States (The Professional Geologist, July-August, 1970). This conference resulted in resolutions favoring the registration of geologists by legislative action. It also appears that the time for action is near, if not for direct action for legislation then in preparation for future action. It will be a long tough road, one that needs a plan for informing the public as well as other geologists of our professional problems, and it is a road that is not without its special hazards.

The time to prepare for any battle is before, not after, the fighting begins. It is only during the prelude that sound and moderate plans can be made. The state sections of AIPG must lead, as they have in the past, in any effort that affects the entire profession. I am convinced that now is the time to prepare for what may be inevitable, that is, statutory regulation of geologic practice.

Robert R. Berg

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LETTERS TO THE EDITOR

Sir:

In a recent letter to the editor, Mr. E. L. Krinitzsky took a shot at the American Medical Association for alleged "controlling" the number of students in its profession. As the father of a medical student I submit that if Mr. Krinitzsky separates fact from casual rumor he will find the number of students in medicine are strictly and directly controlled by available vacancies in freshman classes at each school. There simply is not enough money available to increase enrollment until the public, through private donations or general taxation, recognizes the obligation to expand medical schools in proportion to population increase. The AMA may not be populated by saints, but Mr. Krinitzsky's criticism in this area is unfair.

Vincent L. White, AIPG

Sir:

Mr. Robert Hall's letter to the editor (TPG, November 1970) asks many questions yet answers few. Let me state at the outset that I am opposed to registration, but only because the legal certificate has come to be tantamount to a statement of credentials. The tail has come to wag the dog. This is a ridiculous situation, but it exists and must be faced up to.

Will registration be required in many states—is it necessary or desirable? The answer to these questions is YES; the reasons for this are sad indeed. Registration of engineering geologists is required simply to enable the engineering geologist to practice his own profession. Some of the incompetents and charlatans from which protection is needed include licensed Professional Engineers who poach in interfacing professions by virtue of their licenses and consequent legal protection (and, to be fair, liability). This malady is not confined to California, but exists on a national scale.

The problem of legal competence among specialties has existed in engineering (and geology) for many years. Registration brings the problem under the control of the profession, a situation infinitely more desirable than rampant interprofessional privateering. As far as the professional image is concerned, you can bet that it's important. Our professional image has got us where we were 50 years ago.

Professional certification is certainly more desirable than registration in individual states, and would neatly avoid some of the problems brought out by Mr. Hall; however, this amounts to talking to yourself. If the authority remains within the profession, it is useless. You must be recognized before you can be heard. This can be accomplished either by getting within the power structure and working outward (i.e., registering as P.E. and trying to change the situation from within) or assaulting the existing power structure with one of your own. If you want to join in the game you must abide by the rules of the game in progress. Legal recognition is the name of the game and registration is king of the hill. Starting your own game is folly, since there is only one team.

I'd rather beat 'em than join 'em.

Mr. Fred L. Fox, AIPG

Sir:

It has been brought to my attention that the members of the Wyoming Geological Association are attempting to write a bill for the State's legislative body concerning the ground-water resources of the State of Wyoming.

The following is a quote from a letter dated December 2, 1970 to all W.G.A. members by Mr. Robert W. Riedel: "Concerned people become alarmed that the State Engineer, in his primary concern over the ground-water resources of the State, might support legislation which could be an unnecessary economic burden on explorationists (uranium, coal, trona, bentonite, etc.) and not really advance his cause of shepherding the ground-water resources. The W.G.A. was asked to draft and sponsor, if possible, a bill which its members could ethically support as an effective tool in maintaining the ground-water environment and one which operating explorationists could live with, without undue financial burden or bureaucratic harassment." A proposed bill was drafted and discussed by members present at the December 11 meeting of the Wyoming Geological Association.

I believe it could conceivably help the W.G.A.'s position if the entire Wyoming Section of the A.I.P.G. could review W.G.A.'s proposed bill and, if so inclined, help champion this type of legislation.

I would like to point out that three of the twelve members of the committee set up to make the initial W.G.A. draft are members of the A.I.P.G.

I thought perhaps, through our monthly publication, we would be able to alert all responsible members on the action presently being taken within their state.

I. W. Mathiesen, AIPG

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FUELS AND PEOPLE

SPEECH BY D. A. McGEE TO AIPG, OKLAHOMA CITY, OCTOBER 1970

It is a pleasure to be here today and to have this opportunity to discuss with you some of the unusual developments that are emerging as the energy businesses enter the 1970’s.

As the decade begins the industries that supply the fuels that power our society are confronted with a set of circumstances that is unique in the history of energy in this country. For the first time in the memory of those here, demand for oil, gas, and coal is threatening in peacetime to exceed the currently available supply.

At the same time concern over this country’s physical environment is rising. Almost everyone is joining in the dialogue about pollution of our air and water, the despolling of our land, the noise and blight of our cities. Laws and regulations are being demanded and enacted at all levels of government. The national mood is building up to one of urgency about the quality of life in this country and the current fashion seems to be the prediction of ecological disaster. Unfortunately, the development and production of the energy raw materials, oil, gas, coal, uranium, hydropower, and edible energy through agriculture, the conversion of these materials into convenient, usable forms of energy and their consumption, disturb and pollute the environment to varying degrees. As a result the decade of the 1970’s promises to be very difficult for the energy businesses as the people of the United States demand the attainment of two vital national goals that are not entirely compatible—a clean environment and an abundant supply of low-cost energy.

Since the availability of low-cost energy is crucial to our future way and quality of life on this planet and existing technology does not permit immediate elimination of all the undesirable environmental effects of producing and using energy fuels, the people of the United States will soon need to decide how they wish to reconcile energy supply with environmental objectives.

A brief look at the role energy has played in the molding and shaping of our civilization and especially its importance to our highly industrialized and affluent society will provide background for speculating about whether the people of this country will wish to continue to have an expanding supply of low-cost power that permits a rising per capita consumption or whether they will accept a leveling off of supply which means a decrease in per capita use as the population increases. Voices are now questioning whether we really need all the energy we use and whether making more energy available to each person in this nation is desirable.

No resources won from the earth have had more influence on the destiny of man than the energy fuels. Alone among all the living creatures on this planet man turned to converting energy fuels into usable power for his survival. How many men can live on earth at once and how long and well they can live depend on man’s ability to control energy. Those qualities of mind and spirit that give human life its sense of value cannot be developed until each of us has obtained certain minimum standards of living, and the evolution of the human race shows that increased ability to control energy and matter is what enables man to improve his environment. The development of sources of energy, of techniques for using that energy and for conversion of energy from one form into another is the main thread along which the history of the human race is stretched.

Man himself has always been an energy-converting device, the source being energy from sunlight stored in plants. The end product was man’s ability to stay alive and to do work with his muscles. This was, to all intents and purposes, the only source of energy available to primitive man, and consequently, he lived a primitive existence. His time was completely occupied with an unending search for food.

Man existed in this manner on earth for hundreds of thousands of years. Then, about 10,000 years ago, an efficient method of utilizing the conversion of energy from sunlight into food was developed. This occurred with the “invention” of agriculture, a major milepost in the history of our civilization. Agriculture made it possible for one man to produce enough food in the form of plants to feed a number of men, thereby creating a surplus of energy. When there is a surplus of energy, society can support intellectual activity. The next significant technological event in the story of energy and of mankind was the utilization of wind power to propel ships and windmills.

Then the water wheel laid the groundwork for converting energy to manufacturing purposes.

Up to the 18th century, wood was the only major fuel. By the end of the 18th century, the vast forests of England and Europe were almost destroyed by the prolific use of wood as fuel.

Coal could not become important commercially until man learned how to generate power from fuel to use in the procurement and transportation of more fuel. This became a reality with the development of James Watt’s steam engine for which the first patent was issued in 1769. The steam engine initiated the industrial revolution—a new epoch in human history marked by a change in the energy pattern of society. With machine power provided by the steam engine, it was possible to produce fuel and to transport it more efficiently.

Then a more practical method of converting and transmitting energy from one place to another was discovered. By 1882, Edison was converting coal into electrical energy and distributing it in New York City and a whole new industry was born.

About the same time, another major technological advance in energy conversion occurred with the development of the internal combustion engine.

Then in 1942, a major new source of energy, the nucleus of the atom, and a new energy fuel, uranium, became a reality. Unlike the fossil fuels where energy is released by the molecular interaction of fuel and oxygen, nuclear energy is produced by the interactions within the nucleus of the atom. Now nuclear energy has been harnessed for peaceful uses and is filling an increasingly vital role in this country.
The per capita consumption of energy has increased explosively as each new energy fuel and the technology for converting it to usable energy forms have become available. In the early history of man the per capita consumption of energy was only that represented by the food he ate, probably an average of about 3.4 million Btu per year. At the beginning of this 20th century, per capita consumption of energy was about 126 million Btu per year. Today, it is about 327 million and by 1980, it is expected to reach 368 million per year. It has been estimated that the United States with 6% of the world’s people has consumed more than 1/3 of the world’s commercial energy supplied during the last decade. If this per capita growth rate in energy demand is superimposed on the projected population increase, it is apparent that a continuing massive growth in total energy demand is inevitable.

New fuels and new technologies, and resulting new and better energy sources have provided mankind higher levels of production and the potential to effect much higher standards of living. This is especially apparent, today, within the advanced nations of the world, and particularly so in the United States where the ready availability of the primary energy fuels has resulted in abundant quantities of low-cost energy. This energy has been the key to this nation’s record economic growth and unparalleled degree of prosperity.

Since energy is so fundamental to man’s existence and makes life itself possible, a sustained effort is needed to make the continuing and expanding use of energy compatible with an improved and healthy environment. To accomplish this will require voices of reason and not just of alarm. The answer will undoubtedly be more and lower cost energy rather than lesser amounts of higher cost energy. Dr. Glenn Seaborg, chairman of the United States Atomic Energy Commission, recently said, "Ultimately it is going to be very large amounts of very cheap energy, used in conjunction with highly systematized technologies, that will move us from a wasteful and polluted world to a more efficient and healthier one."

In view of the probability that the people of this country will decide to reach a realistic balance between energy use and environment protection and repair that will require a growing supply, a brief look at the history and future of each of the primary fuels and the alternatives available, if there is a shortfall of these sources, may be of interest.

At the turn of the century, the total U.S. energy demand was about 10 quadillion \(10^{15}\) Btu per year. Today, it is equivalent to about 67 quadillion per year, and by 1980, just a short 10 years away, total U.S. energy demand is expected to increase by nearly 40% to 92 quadillion Btu per year. To meet this spiraling demand, this country will need to exploit fully every energy fuel—liquid petroleum, gas, coal, and uranium.

At the present time, more than three quarters of the energy we utilize in this country comes from petroleum products. Almost half of our current energy consumption is supplied by oil, and 32 percent by natural gas. Coal supplies 21 percent and water power, with 4 percent, essentially represents a constant supply which will be a diminishing percentage of the growing total energy picture. Uranium, of course, has not yet become a significant contributor to the overall energy picture, but it will rapidly emerge as such between now and the end of this century.

Fuelwood dominated the energy picture in America until almost the turn of the century. Coal then displaced fuelwood only to yield to the petroleum industry in 1947. Just as fuelwood set the stage for the coal industry, and coal, the petroleum industry, the fossil fuels have set the stage for the nuclear fuel era.

Even though fuelwood dominated the energy market during the early period, the total energy consumption was insignificant compared with consumption today, and consumption today is small compared with what is projected for 1980. The sharp decline in percentage participation of coal is not so much the result of a decrease in coal usage as it is an increase in demand for other energy fuels. It is apparent that petroleum did reverse the coal industry’s growth in the early 1900’s. The impact from dieselization of the railroads and from stepped-up construction of natural gas transmission lines in the late 1940’s is also evident. The coal industry recovered in 1950, four years after electric power generation became the principal end use for coal.

Energy fuels in the U.S. were utilized predominantly for residential heating until industrialization at the turn of the century placed heavy demand on both wood and coal for manufacturing purposes. Energy for transportation was supplied, in large part, by muscle power until the full impact of the automobile was felt in the early 1900’s.

The acceptance of the automobile in the early years carried the transportation sector to an all-time peak of about 30% of the energy fuels used in the mid-1920’s. The percentage then gradually decreased to the current 24 percent.

Electricity began to appear as a significant consumer of primary energy fuels around 1920. Electric energy growth has long outpaced total energy consumption and now is the fastest growing sector of the total energy industry. Demand for electric energy is doubling about every 10 years, a growth rate which is roughly twice that of total energy.

The rapid growth of the electrical industry is creating an economic paradox. Energy fuels are being converted into electricity which then competes on a large scale with the original energy fuels for the ultimate markets. This is adding a new dimension to the changing end use patterns. The greatest impact is on the residential and commercial sector of energy consumption. An increasing percentage of energy fuels is being converted into electricity for use in residential and commercial buildings for space heating and other purposes. This is reflected in a smaller percentage of the original energy fuels being used for this end use category.

Despite the inroads of electricity, consumption of primary energy fuels by all sectors is rising sharply, and the nation is going to need all the fuels it can get in the coming decade and beyond. But, we might add, an increasingly higher percentage of energy fuels will be converted into electricity before use.

Historically, coal has been the dominant source of energy for power generation in this country. In the early history of
the electric utility business, hydropower was almost as important as coal, but it has gradually yielded to coal and natural gas.

Since electric power generation is the only significant commercial application for nuclear energy for the foreseeable future, electric power growth will, to a large measure, determine the demand for uranium. Technologically, as well as historically, the commercial utilization of nuclear energy is still in the early stage of development.

Fifteen nuclear generating plants are now in service in this country with a total capacity of more than 5,000 megawatts, and there is a total of 113 power plants—representing some 90,000 electric megawatts of capacity—which are now operable, under construction, or on order. Through 1980, nuclear capacity is expected to approximate 150,000 megawatts, about 12 percent of the nation's total energy consumption as compared to its current insignificant share of less than 2 percent, and by 1990 it is predicted that at least half of all electric energy will be derived from nuclear fuel.

At this point, brief comments on each of the four major energy fuels—coal, oil, natural gas, and uranium—should be helpful in placing the whole energy picture in perspective.

For the long term, coal will most certainly grow in importance in the energy picture. U.S. coal reserves, mineable at near present costs, are estimated to be 824 billion tons, sufficient at the current consumption rate to last for centuries. Total U.S. reserves in place have been estimated at 1.5 trillion tons. Because of the potential for development of technology for liquefaction and gasification, this large reserve of fossil energy should soon enjoy an additional market as a supplier of synthetic liquid and gaseous petroleum products.

Following coal, liquid petroleum became established as an energy fuel in the United States in the mid-1800's. By 1862, kerosene had captured almost the entire coal-oil market and demand for kerosene grew rapidly. Fuel oils became significant commodities around the turn of the century when their availability as cheap by-products and their greater convenience began to give coal its first serious competition since the fuel-wood era.

Although substantial quantities of gasoline were produced as a co-product with kerosene, the gasoline fraction of crude oil remained relatively unimportant. It was largely sold as cleaning solvent until about 1915 when the full impact of the automobile began to be felt. By 1930, the automobile pushed gasoline into first place as the most important liquid petroleum product.

LPG and jet fuels have entered the picture as significant energy fuels in fairly recent years. These still represent a small fraction of the petroleum barrel, but demand for them is growing rapidly.

Total domestic demand for all liquid petroleum products was 5.1 billion barrels in 1969. By 1980, the U.S. is forecast to consume about 7.5 billion barrels annually.

Natural gas in the beginning was a by-product of crude oil production, and it continues to be treated by government regulation as such today, although for several decades it has been an important primary fuel. The limited consumption of gas prior to 1900 was for lighting, for field use, and for some other industrial purposes. Carbon black became an important end use for natural gas by 1925. Demand for this purpose reached a peak in the 1940's and then rapidly declined. The effective utilization of large proven reserves of natural gas occurred when the technology for fabricating and laying large diameter cross-country transmission lines was developed.

The projected U.S. demand for natural gas will approach approximately 30 trillion cubic feet in 1980, but an even more recent forecast by the Future Requirements Committee for Natural Gas has estimated 1980 demand at 34.7 trillion cubic feet. As with liquid petroleum, demand for natural gas is outpacing the additions to reserves.

Current concern over adequacy of supply of oil and gas is well founded. Reasonable economic incentives must prevail if the petroleum industry is to mount the massive exploration effort required to supply fully the available market.

A brief word is in order about uranium demand which has triggered the intensified interest in exploration for this fuel. The AEC procurement program for weapons reached a peak of almost 35,000 tons in 1960, but in that year only 16,600 tons, less than half, was domestically produced. AEC procurement began dropping after 1960 and is scheduled to phase out in 1971.

This year, only about 8,800 tons of uranium will be purchased commercially in the U.S. The significant commercial demand lies ahead. The AEC presently estimates that installed nuclear capacity in 1980 will require a cumulative total of about 208,000 tons of uranium, and an annual requirement by that time of about 34,000 tons. The industry will start the period of growth with proven reserves in this country of almost 300,000 tons of U3O8, or yellow cake, which includes both AEC reserve stocks and uranium recoverable at prices up to $10 per pound. These reserves amount to about a 12-year supply. The industry currently has an annual production capacity of about 14,000 tons; this can be expanded to 20,000 tons over a period of several years.

Now for a look at the period beyond 1980. Undoubtedly, additional major reserves of oil and gas will be found. A larger percentage of oil-in-place will be recovered from presently producing reservoirs, and importation of both oil and liquefied natural gas will increase. But, when liquid petroleum and natural gas begin to fall short of meeting requirements, there are three hydrogen deficient alternative sources—shale oil, coal, and tar sands that can be developed. Also, gas from coal can supplement the natural gas supply when needed.

In the 1960's there was a great public as well as petroleum industry interest in the shale oil lands of Colorado, Utah and Wyoming. There have been suggestions that this reserve of synthetic liquid petroleum can supply our future domestic needs. However, the reserves of economic interest under prevailing technology appear to total about 80 billion barrels. The development of this reserve faces many political, economic, technical and environmental obstacles. However, a technological breakthrough such as the proposed underground nuclear explosion to induce in situ retorting could change the economics of this energy source.

(continued on back page)
The liquefaction and gasification of coal seem to offer, long range, the most certain available domestic supply of both liquid petroleum and pipeline gas. Technology for converting coal into both liquid and gaseous fuels has been known since 1924, but the economics have not been commercially attractive. In the case of coal, as compared to oil shale, very large reserves are physically accessible at reasonable production costs. Furthermore, there is already an existing, well capitalized, experienced, and knowledgeable coal mining industry.

Presently, we have learned the secret of economic control of the energy released by the splitting--or fission--of the atoms of the material known as U-235, a form of uranium which is present in natural uranium to the extent of only seven-tenths of one percent.

The reactors, which are currently being used by the industry for the generation of nuclear electric power, are inefficient in the utilization of uranium--only one to two percent of the total available energy is released--and their thermal efficiency is lower than that of up-to-date fossil plants.

Development work, by both government and industry, is under way, both in the United States and abroad, on reactor types which will more efficiently use the energy inherent in uranium. By far, the more attractive of these programs are those which are aimed at utilizing uranium in reactor systems which, in the course of their operation, convert the 99.3% non-fissile portions of the uranium--U-238--to fissile plutonium which can be used as a fuel for the nuclear chain reaction. Technical feasibility of such systems (known as fast breeders) has been demonstrated, and it remains for the industry, with fairly extensive government assistance, to build the prototype plants which will demonstrate the economic feasibility of the concept. The current government-industry effort should result in operation of demonstration plants in the early 1980's and a commercial breeder program near the end of that decade.

When breeders come into commercial operation, then, thorium will constitute another potential long-range fuel resource.

The next generation of nuclear power plants beyond breeder reactors could be fusion reactors. These reactors will use the atoms of heavy hydrogen for fuel. If the energy in these atoms can be converted through controlled thermonuclear fusion--a technology being pursued today--the atoms of heavy hydrogen in the oceans contain enough energy to generate an unlimited supply of low-cost electricity.

It appears that existing and potential energy resources are adequate, with advances in technology, to supply a growing energy demand if the people of this country choose to achieve a responsible balance between the production and use of energy and the protection of the environment.

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