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Energy Choices and Environmental Constraints

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ABSTRACT

This paper acknowledges the fact that there is no such thing as a free lunch - energy used is waste made. The paper reviews the environmental problems associated with two distinct classes of emerging energy technologies—solar and synfuels. Although the recent push towards synfuels has raised serious environmental concerns, it will be shown that developing the "clean" solar technologies also will demand sound environmental management practices. While changes in technology-use projections based on environmental constraints are not developed in this paper, it will be seen that some impacts could be quite significant; and still others could very well be "show-stoppers". Finally, the Federal regulatory scene is reviewed to determine what steps are being taken to prevent environmental damage without unnecessarily constraining development of new energy technologies.

INTRODUCTION

Production of energy historically has been an issue of great environmental concern in the United States. As shown on Figure 1 energy usage has shifted from one source to another, driven partly by environmental concerns. Early on, the heating of homes through individual wooden stoves and coal furnaces created air pollution problems in urban areas. The switch to large central coal-fired generating stations also eventually caused significant adverse environmental effects bringing on a switch to the use of low-sulfur oil in homes and utilities. The consequences of this shift in strategy have become only too obvious.

But what of the energy future? Which technologies can we rely on as being most environmentally sound? Coal, nuclear, synfuels and hydroelectric technologies have all for one reason or another received bad reputations for the land use, air or water quality degradation they can cause. Solar on the other hand has been hailed by many including the heralded Energy Project at the Harvard Business School. Yet, it is not commonly known that one of the more prevalent solar technologies, cadmium-sulfide cells, would result in 20-40 percent more cadmium being emitted to the atmosphere than an equivalent coal-based system. Since cadmium is especially toxic and known to cause acute pulmonary edema and chronic emphysema, solar technologies in perspective, are not as environmentally pure as is commonly believed.

Presented below is an environmental review of solar and synfuels, two technologies receiving considerable attention as we enter into an era of great uncertainty and, potentially, great international energy interdependence.

SOLAR TECHNOLOGIES

"Solar energy" has become one of the most popular solutions to the nation's energy problems. Unfortunately many people espousing this point of view are unaware of the technical and environmental constraints that will affect its commercial penetration into the market place. There are five technologies currently under development that are based on the energy of the sun that, in the aggregate, are expected to contribute about five to ten percent of the nation's energy supply by the year 2000. These are discussed below followed by a review of the potential environmental problems.

Solar Thermal Technology

Solar thermal technologies refer to commercial solar hot water and space heating systems. These systems have been available since 1976 and it is projected that by 1985 there will be over 1.7 million solar hot water and space heating systems in operation in the U.S. By 2000 over 16 million solar heating and cooling systems are expected to result in 1.6 quads of energy, only about 30 percent of their total potential market penetration.

The theory behind a solar thermal system is straightforward. A solar heating or hot water system converts the thermal radiation from the sun into heat which may be used directly for heating building space or potable water. Typically in these processes the sun's radiation heats an absorber plate which is framed with a double layer of glass or plastic which is insulated and covered to reduce heat losses. A heat transfer medium, either liquid or air, flows over, under, or through the absorber plate and is heated. The heated transfer medium can be used to meet an immediate heating or cooling demand or else it is routed to a storage device for later use.

While these systems are used primarily in residential and commercial buildings, solar thermal systems can also be used for industrial process heat applications. Some of the most likely solar process heat applications include crop and lumber drying, canning, textiles, cement block curing, washing operations, plastic curing and metal finishing.

Photovoltaic Systems (PV)

Photovoltaic energy conversion is a non-thermal process in which electricity is produced directly from sunlight using a solar cell comprised mainly of a semi-conductor material such as silicon. In general, there are two major PV types: (1) flat plate arrays, that operate on direct sunlight at normal intensity; and (2) concentrators, that increase the intensity of the sunlight as much as 2,000 times. "Concentrating" photovoltaic systems will function most efficiently in the Southwest. Photovoltaic flat systems, which make more effective use of diffuse sunlight would be more effective across the south central and southeastern regions of the country. In either system the basic principle is that when light energy from the sun, in the form of photons, strikes the semi-conductor material, internal voltages are created.

Residential communities, industrial applications, and connection of large arrays of photovoltaic cells to a central power station are the major applications of this technology. PV systems are already being manufactured commercially on a limited scale in the U.S. In fact, an array of 20 photovoltaic panels was used to provide electricity for critical communications links along the 4,800 ft. high Whiteface Mountain during ski events at the Winter Olympics in Lake Placid, New York. Significant reductions in the costs of the arrays will be needed before this technology can contribute several thousands of megawatts to the national energy needs.

Ocean Thermal Energy Conversion Systems (OTEC)

Ocean thermal energy conversion uses the temperature difference between solar warmed surface ocean waters and cold deep ocean waters to produce electricity. The ocean acts as both a solar energy collector and as a storage medium.

OTEC systems are envisioned as large plants (about the size of large ocean going vessels) located in warm ocean waters. Warm sea water at the surface is used to evaporate a working fluid such as ammonia or propane. This would drive a turbine which in turn will drive an electric generator. The vaporized working fluid will then be cooled by the colder deeper sea water in the condensor, returning it to the liquid state. The electricity produced by the system could be delivered by cable to a power grid on shore or could be used on the platform to produce energy intensive products such as ammonia or aluminum.

OTEC will be best suited along the Gulf Coast and in Puerto Rico and Hawaii where ample sites are available within the required distance of land.

An assessment of the impact of OTEC on national energy use in the future is difficult, since the technology is still in the developmental stage. Technical feasibility is still being investigated through laboratory and field experiments. The first demonstration plant is expected to begin operation in 1985, and the first commercial plant in the early 1990's.

Wind Energy Conversion Systems

Wind energy systems, composed of individual or arrayed machines convert the kinetic energy of wind into mechanical motion. Although a broad variety of options exist for harnessing the wind's energy, the machine that appears to be the most feasible at this time is a double bladed wind turbine whose mechanical power is used to drive an electric generator. Wind power may be used directly, integrated into an electric utility grid, or stored. Potential applications of wind systems range from rural farms to large scale industries.

The first commercial systems are expected to begin operation in the early 1980's. Commercial applications will be most applicable in regions that have the best combinations of high wind velocity and maximum number of days of availability. In general, wind power is greatest in the coastal northwest, the Northeast, and the high Central Plains. Although its contribution to total energy use in the future is expected to be low, the potential market for this technology is high. General

Electric has indicated that 157,000 sq. miles of U.S. territory would have winds high enough to support wind systems. Siting, legal, and institutional barriers will have to be overcome before this technology makes a bigger impact on natural energy needs.

Biomass

Trees represent the most obvious and plentiful source of biomass. Of the 400 million acres of trees in the U.S., roughly 20 percent are commercial forests which are potentially available for harvesting. Wood wastes from silvicultural operations, moreover, represent an even more readily available source of wood. This potential energy source is not being overlooked by industry nor private citizens; the forest products industry currently relies on wood waste for 45 percent of its energy needs, while growing numbers of Americans are turning to wood burning stoves as a source of supplemental or even primary fuel.

A second source of biomass is agricultural residues. According to one study conducted for the Energy Research and Development Administration, 277 million tons of agricultural waste could be collected annually, along with 26 million tons of animal waste. Most notable among these agricultural waste products are corn, sugar cane, and sweet sorghum. Corn products alone would produce up to one quad of energy in the midwest according to one estimate, and thereby reduce the need for large quantities of liquified gas to fuel farm equipment. In addition to crops grown on the land, furthermore, aquatic vegetation offers considerable biomass potential. Water hyacinths, algae, and kelp have all been suggested as easily cultivated energy sources, and research on methods of conversion is underway.

Municipal waste, better known as sewage and rubbish, is yet another readily available form of biomass. The quantities of wastes produced by our "throwaway" society are staggering. We discard over 125 million tons of solid waste per year. In addition, sewage from private houses and industries contain large quantities of organic materials that can be converted into fuel. Clearly, the potential of these sources is vast as suggested by the U.S. Environmental Protection Agency which has estimated that the energy potential of the daily refuse of 70 percent of the U.S. population contains the energy equivant of 500,000 barrels of oil per day.

Wood, agricultural refuse, and municipal waste can be converted into energy via three principal means: direct combustion, liquefaction, or gasification. Through these processes a range of fuels can be produced, including ethanol, methanol, medium Btu fuel gas, synthetic natural gas, ammonia, and fuel oil.

Solar Based Technologies and the Environment

In addition to technical and market constraints there are some significant environmental issues associated with solar based technologies which must be addressed before large-scale commercial application of these systems occurs.

Solar thermal and photovoltaic systems have similar environmental effects. Large amounts of land are required for the collector system and disturbances to local ecological communities are likely as are changes to the microclimate resulting from solar central power systems operations. The working fluids in these systems require additives that could result also in ground water contamination with chromates and nitrates if the systems fail.

The principal concerns however with these technologies are occupational and environmental health issues. There are several hazardous substances associated with the preparation and operation of semi-conductor materials and photo voltaic cells. Workers may be exposed to silicon dust that can cause respiratory disease. Cadmium compounds and arsenic compounds also are hazardous substances associated with these systems which can contribute to lung cancer, kidney damage and, if discharges are not carefully controlled, the effects can be lethal.

The potential environmental impacts of wind energy systems on the other hand are limited. These systems produce no major air or water pollutants or solid waste products. Principal environmental concerns are structural safety and electromagnetic radiation interference. Although extensive tracts of land would be needed for an array of wind machines, the land in between the machines can be utilized for other purposes. Ecological concerns are limited to the potential interference with migratory bird populations due to collision with towers or moving blades.

The major environmental issues associated with implementing ocean thermal systems (OTEC) are centered on the potential effects to marine life. Some of these include chemical releases and metal discharges resulting from the corrosion of heat exchangers. These substances may be toxic to indigenous marine species. Also, use of chlorine as a biocide and ammonia as a working fluid may be toxic to marine species or may have adverse effects on marine ecosystems. Another concern is that marine species may be trapped against the screens covering the cold and warm water intakes. They may also be swept along through the system and subjected to rapid pressure and temperature changes. Finally, there is some concern that mixing ocean layers may alter the air to surface water temperature ratio, thus affecting the micro climate by influencing winds and currents.

The environmental impacts of increased use of biomass fall into two distinct categories: (1) impacts resulting from wood harvesting, and (2) impacts of wood burning. Water pollution can be severe in cases of large scale timber harvesting operations where clearcutting is employed. Runoff of chemicals and fertilizers can contribute to stream pollution, in addition to soil erosion and subsequent stream sedimentation. In addition, increased cutting of wood by nonprofessionals could lead to damage to residual timber stands or the loss of commercially valuable trees. Despite the adverse effects of wood harvesting, increased cutting can have beneficial results. Wildlife habitat can be enhanced, forest productivity can be greatly increased, and overall forest management can be significantly improved.

Increased reliance on wood as fuel can also result in direct environmental impacts if wood is burned. Wood burning emits greater amounts of particulates than either oil or gas. Chemical emissions are especially troubling, especially in light of the fact that wood (and other forms of biomass) contain quantities of a number of toxic substances such as cadmium, mercury, and zinc. Potential problems relating to the production of polycyclic aromatic compounds have also been suggested.

While the scientific literature on the environmental impacts of increased fuel wood burning is insufficiently developed to allow definite conclusions to be drawn, empirical evidence suggests that wood burning can cause severe, localized problems. In low lying areas of Vermont, and in areas of Colorado subject to constrained air circulation, severe air pollution problems have been linked directly to residential wood burning stoves. Such problems have led to the imposition of local controls on the number of wood burning stoves and furnaces that can be installed. It is clear that these problems will be localized, and will depend largely on such factors as climate, population density, the presence of industry, as well as the type of wood burned and the characteristics of the combustion process. While precise impacts cannot be predicted, therefore, some localized problems have already occurred, and others will undoubtedly develop.

None of these environmental concerns for any of the solar technologies appear to be "show stoppers" in that they will prevent the technologies from advancing to commercial application. However, they do need to be addressed through research and development activities so that their full implications can be understood and appropriate mitigating measures can be developed if necessary.

SYNTHETIC FUEL TECHNOLOGIES

The synthetic fuels (synfuels) industry is here to stay. There has been a great deal of interest (and money) generated by government and industry for plans to design and build synthetic fuel plants around the country. Synfuels are now considered our best short-term solution to help the U.S. decrease its dependence on imported oil, which currently accounts for half of our total oil requirements.

The FY81 Federal budget for developing new coal, oil and natural gas technologies could top one billion dollars. The bulk of this funding will be dedicated to developing new cleaner ways to produce and use coal. A good portion of these dollars is earmarked for construction of major demonstration facilities for converting coal into synthetic liquid gases and solids.

There are a few small scale synthetic fuel plants in operation today but industry and state governments are gearing up for an expansion of these facilities. Interestingly, coal gasification plants once were commonplace in the U.S. with more than 11,000 plants operating in the 1920's. By 1950, all but a few of these plants had been shut down, due to the availability of low cost natural gas and fuel oil. Attaining the level of commercial application again that existed in 1920 is not going to be easy. There are many significant institutional and environmental issues that need to be addressed first and these are highlighted below. But first— a brief description of synthetic fuels technology.

Coal Based Fuels

Coal can be converted to either a synthetic gas (gasification) or a synthetic liquid (liquefaction). It can be converted in place to produce a combustible gas (in situ) or mined and then processed at the surface into a gas or liquid. In both cases the basic process involves the chemical addition of hydrogen to the carbon in the coal. Water in the form of steam, is the common source of hydrogen. In coal gasification processes, the gas produced is either a low BTU (100-200 BTU/SCF) or medium BTU (300-650 BTU/SCF) gas depending on whether air or pure oxygen is used in the combustion process. A high BTU gas (950-1050 BTU/SCF) which is comparable to natural gas can be produced only by further processing steps such as methanation. The gaseous products can be either directly combusted in a boiler, used as a chemical feedstock, or used as an intermediate product that can be converted into liquid fuels.

The low-BTU gas (or "town gas" as it is

sometimes called) can only be transported one to two miles because of its low quality and therefore would be used primarily by local industries that can accommodate its lower flame temperature and higher nitrogen content. Medium BTU gas can substitute for natural gas in almost any industrial application. The industries showing the greatest potential for use of synthetic gas are the steel and chemical industries. The aluminum, glass, metal fabrication and refining industries also show good potential.

The early adopters of coal gasification technology, in addition to being concentrated in a few industries, are likely to be concentrated in a few regions of the country as well. In general these regions fall into two categories: areas with low coal prices relative to fuel oil and natural gas prices, and areas with historical fuel supply problems and/or special institutional problems.

Oil Shale Fuels

The other major non renewable resource that can be used for synthetic fuels is oil shale. This is simply a rock structure that has kerogen (organic substance) imbedded in it. When heated, an oil is produced which is referred to as "oil shale". Large areas of the U.S. contain oil shale deposits; however, the richest deposits are found in Colorado, Utah and Wyoming. The Federal government holds the mineral rights to most of the western oil shale and also owns about 70 percent of the associated land surface. To date four Federal tracts have been leased and several experimental or demonstration projects are in progress on private and State lands. Also, about 20 other oil shale development projects are now being contemplated, mostly on private land.

Basically there are two major techniques for converting raw shale to shale oil—surface retorting, and in situ processes. Surface retorting requires mining of the shale by either underground or surface methods and crushing and sizing the material. This material will yield shale oil when heated to a temperature of 900^{o}F in a closed vessel. This process is referred to as surface retorting, and using a high grade shale, 35 gallons of oil can be obtained per ton of shale. In situ oil shale processes involve fracturing the oil shale underground, introducing heat to liquefy the Kerogen, and recovering the oil through wells.

Following product recovery, crude shale oil (from any process) requires further treatment to remove nitrogen, oxygen, and sulfur compounds, and to reduce viscosity and pour points to allow pipeline or tanker transport. Removel of the nitrogen compounds requires a special refinery process.

Synthetic Fuels Technologies and the Environment

There are several major environmental concerns associated with the development of the synthetic fuels industry. Currently there is a substantial amount of environmental and health related research and development activity being performed by government and industry in an effort to obtain a fuller understanding of the magnitude and significance of these problems. It is not clear at this point if some of these concerns may turn out to be "show stoppers", meaning the environmental and health related problems could prevent or limit the commercial penetration of synfuels.

Water Resources Effects—The development of a synthetic fuels industry will mean that large quantities of water will be necessary. This becomes a critical issue in the West, where many coal conversion and all oil shale plants are likely to be located. Two recent major water-for-energy assessments in the Upper Missouri and Upper Colorado River Basins prepared for the Water Resources Council have addressed the question of water availability for large-scale synfuel industries in the West. These studies suggest that sufficient water physically exists to support a significant-sized synfuel industry. However, institutional issues surrounding acquisition of water rights by energy developers must be recognized as a further, and potentially severe, constraint on water availability for synthetic fuel development.

Commercialized coal conversion facilities will probably use maximum water recycle and recirculation systems to conserve water and control pollutant discharges. Although treatment options resulting in maximum water reuse will ameliorate water quality problems at the plant site, the generation of solid sludges may result and solid waste disposal. These wastes may be defined as toxic or hazardous under Federal regulations.

Oil shale effluent could contaminate aquifers and surface waters by leaching from spent shale piles, evaporative and lagoon concentrates, or from burned-out in situ retorts. Problems with in situ processes concerning backflood water and fugitive gas emissions may result in contamination of groundwater aquifers. Groundwater supplies and surface water supplies fed by groundwater aquifers might be affected for very long periods of time (e.g., 50 years) thereby creating difficulties in securing adequate water supplies for retort operations.

Acid Precipitation—Emissions from coal conversion facilities that can affect the air quality of the area include sulfur oxides, particulate matter, nitrogen polynuclear aromatic hydrocarbons, nitrogen and sulfur-containing heterocyclic compounds, and trace elements. Appropriate use of available control technology should control source emissions to levels complying with applicable current regulations.

There is a related problem that poses significant environmental concern that is not fully understood or controlled—the acid precipitation problem. Emissions of sulfur and nitrogen oxides from boilers and synfuel facilities act as precursors to sulfate and nitrate formation, the two most prevalent chemicals found in acid precipitation. U.S. sulfur oxide and nitrogen oxide emissions have been steadily increasing since 1940. National emissions of these pollutants are expected to increase over 1975 levels by 1 percent and 20 percent, respectively, by 1990 (MITRE Corporation, December 1978). These increases may exacerbate the acid precipitation problem that is already prevalent, especially in the northeastern region of the country. Recent studies indicate that acid precipitation is also occurring in certain regions of the Rocky Mountains and the far West.

Historical records of acid precipitation indicate that several lakes with low buffering dissolved solids, particularly in the Eastern United States, now contain drastically reduced fish populations as compared with previous periods. Increased soil acidity, which can retard the growth of forests and reduce crop yields, has been shown to be caused by acid precipitation in laboratory and greenhouse experiments. This phenomenon has not yet been demonstrated in monitoring studies of natural conditions, however. Other studies indicate that the deterioration of buildings and monuments is being accelerated by acid rain, which slowly dissolves cement and stone.

Spent Shale Disposal/Reclamation—Major uncertainties exist with surface retorting concerning large volumes of spent shale. Disposal of spent shale and storage of raw shale could create land disturbances of large magnitudes, potential accumulation of toxic substances in vegetation, and contamination of groundwaters and surface waters from runoff. For example, for every 50,000 barrels of surface retorted shale oil produced, there will be enough spent shale to occupy a volume of almost two million cubic feet, or about a two-foot depth over a square mile every month of operation. Aboveground retorted shale from modified in situ operations would have considerably less solid waste to be disposed of. Large areas are required for the storage of raw shale and the disposal of retorted shale. The resulting potential loss of habitat for plant and animal communities and natural erosion of the disposal piles by wind and water may not be fully mitigated by vegetating or physically stabilizing the disposal piles. Problems and uncertainties related to the vegetation of retorted shale include water requirements, accumulation toxic trace substances in the vegetation, and long-term stability.

Environmental control systems to mitigate these impacts should, in most cases, be available; however, potential problems with stability of waste piles will require several years to emerge and uncertainties will remain for 10 to 20 years. Spent shale can either be returned to the mine or stockpiled aboveground, in which case it will be compacted and vegetated or otherwise stabilized to prevent erosion by wind or water. Dust control will be accomplished by application of water or chemical wetting agents. Surface disposal options include filling valleys and recontouring surfaces. The major consideration is to ensure that the large quantities of spent shale can be economically disposed of with minimum environmental damage.

CLOSURE: REGULATORY TRENDS AFFECTING ENERGY TECHNOLOGIES

Emerging energy technologies likely will continue to receive stringent environmental reviews before widescale commercialization is approved. Although the recent emphasis is on increased development of domestic energy supplies, there is an ever present concern that this be accomplished so as to avoid ex post facto hazardous situations like those occurring with the nuclear technologies. Nonetheless, much will be done to streamline a presently cumbersome regulatory setting which, as an example, requires more than 50 permits and approvals of an oil shale company prior to initiation of a proposed project. Based on the most recent happenings in the regulatory arena there are four separate developments worth mentioning here; two address the streamlining issue and two the stringency issue.

The Energy Mobilization Board (EMB)

The overall purpose of the Energy Mobilization

Board is to facilitate the development of critical energy projects by eliminating undue delays in facility siting and operation. As originally proposed by the Carter Administration in 1979, the EMB would be empowered to eliminate or modify procedural impediments to the construction of critical energy facilities. However, several Congressional proposals would empower the EMB to eliminate or modify substantive environmental requirements as well. Despite the fact that the authority of the EMB is therefore uncertain at this writing, it is essential to understand that it is likely to pass in some form and will do much towards streamlining energy technology development.

The Consolidated Permit Program

As shown on Table 1, EPA administers five major permit programs to control the disposal of various waste materials into the environment. After studying the relationships of these programs, EPA concluded that management economies and environmental benefits could be realized through greater coordination of the various permitting activities. Thus, the Agency has developed a consolidated permit encompassing, to the extent possible, regulations under the five programs. Much like the EMB this new program will help to streamline regulatory procedures for new energy facilities.

Substantive Regulatory Trends

Procedural streamlining of the regulatory process is one issue that appears to have inherent merit. Where this might compromise stringency is a related issue fraught with controversy. In fact, recent developments indicate that if anything, there will be tighter future control of industries likely to emit hazardous or toxic wastes. Regulations being promulgated under the Clean Water Act and Resource Conservation and Recovery Act will emphasize control over hazardous pollutants in liquid and solid waste streams. Unfortunately, many metals and organics considered toxic can be found in energy technology wastes, including those generated by some solar technologies. Thus, high costs due to control of these pollutants may inhibit development of some systems. Prevention of Significant Deterioration (PSD) requirements under the Clean Air Act also may constrain energy development in the pristine, energy abundant areas of the west. PSD regulations, when issued in final form, will require that source emissions not cause significant deterioration of air quality in any attainment area.

The Hazards of Forcasting—The Case of Acid Rain

Finally, it is important to recognize that there will always be environmental and regulatory issues that simply cannot be forecast—the future is marvelously unpredictable. One such unforeseen issue now of significant concern is acid rain. Several actions in this area are presently underway.

The President has established a Federal Acid Rain Coordination Committee in his Environmental Message of August 2, 1979 in order to further assess the deleterious effects of acid rain and to determine what types of control measures would best mitigate the problems caused by acid rain. The purpose of the committee is to plan and manage a comprehensive Federal ten-year acid rain assessment program. Futhermore, a bill titled "The Acid Precipitation Act of 1979" was introduced to the Senate Committee on Environment and Public Works on September 14, 1979. This proposed legislation also seeks to expand the knowledge base of the acid rain problem by increasing the scope and intensity of research on the causes and effects of acid rain. A similar bill (HR 605) was introduced in the House of Representatives. The Federal acid rain research program will be coordinated through the Department of State with similar efforts by Canada and Mexico, as well as with other nations. As a result of this increased research on acid rain and its effects, new regulatory measures may be proposed in the future.

* * * *

In closing, it should be emphasized that examining any new energy technology for environmental pollution potential, no matter how apparently clean the technology, is an exercise well worth conducting. Although it is certainly in the best interests of the nation to become energy independent, this independence should not be attained at the expense of undermining the environment we all live in and share, especially since most technologies can be developed consistent with environmental standards, albeit with increased costs.

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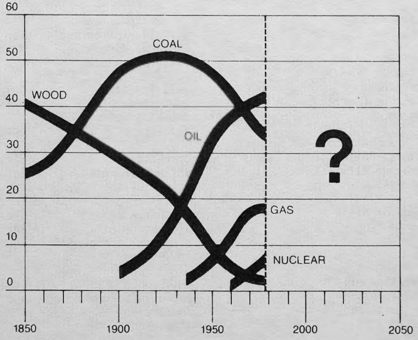
FIGURE 1
Historical U.S. Energy Usage



Source: Energy Research and Development Administration (now the U.S. Department of Energy); *The Energy Research, Development, and Demonstration Plan;* 1977

TABLE I

EPA Consolidated Permit Program

Name	Abbrev	Coverage	Act
Hazardous Waste Management Program	HWM	generation, transportation, treatment, storage, disposal of hazardous waste	Resource Conservation & Recovery Act
Underground Injection Control Program	UIC	well injection/ protection of drinking water aquifers	Safe Drinking Water Act
National Pollutant Discharge Elimination System	NPDES	discharge of wastewater into waters of the U.S.	Clean Water Act
Dredge or Fill Program	404	discharge of dredged or fill material, often in wetlands	Clean Water Act
Prevention of Significant Deterioration	PSD	emission of pollutants from sources in attainment areas	Clean Air Act

Source: U.S. EPA, "A Guide to the Proposed Consolidated Permit Regulations," undated.