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COAL LIQUEFACTION: ISSUES PRESENTED BY A DEVELOPING TECHNOLOGY

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As the energy crisis continues, we rely more and more on technology to provide answers to the question of how best to derive energy from the world's resources. At the same time, we rely more and more on the Federal Government to supply answers to the questions of how to manage, encourage, and direct the activities of an expanding technology.

Expectations of immediate technological resolution of energy problems generate a number of pressures, not only on the technology itself, but on the nation's legal, economic, and social systems. There are also inevitable environmental concerns and a multitude of unanswered questions about the use of natural resources. As pressures beget counterpressures, inevitably public policy issues begin to emerge, and the capabilities and potentialities of technology must be balanced against their costs.

The dynamics of energy constraints and energy demands must be worked out within the context of governmental and private enterprise systems, and as this process goes forward, both the public and private sectors experience perceptible change. To assist in keeping expectations within reasonable limits and to further understand changes which are taking place, it is useful to identify some of the public policy issues which are gaining new intensity with each technological development and nearly every governmental action. At the same time, it is desirable to examine the new relationships which are developing between law and technology.

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This article offers a case study of one specific developing technology, coal liquefaction, notes some of the more pressing public policy issues which liquefaction presents and, finally, offers a few brief observations about the implications for our legal system of this new legal-technical interdependence.

Overview of the Development of the Liquefaction Process

In its most generic sense, liquefaction is simply the process of converting coal into liquid fuels. It is obviously not within the ambit of this work to detail the development of liquefaction technology; however, it is instructive to call attention to some of the developmental high points.

Liquefaction has been the stepchild of economics. When cost was no object, it fueled the German war machine. When cost was everything, liquefaction faded to obscurity. As energy supply stress again intensified, the cost considerations of liquefaction were submerged in a sea of energy demand.

E. L. Clark, Chief for Gaseous Fuels Project Management at the Energy Research and Development Administration (ERDA), observed in describing early coal gasification developments that "[t]he light oils, obtained as a byproduct of these gases [sic] producing systems, were probably the first liquids obtained from coal."[1] Since these early efforts to derive gas from coal date back to at least 1792,[2] it is likely that the physical possibilities for liquefaction were also known at that time. Although industrial development of gasification processes continued throughout the nineteenth century, liquids apparently continued to be thought of as a byproduct,[3] and it was not until the early twentieth century that liquid-from-coal was developed and thought of as a desirable and useful process.

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1. Address by Energy Research and Development Administration Official Ezekial Clark, to representatives of the Iron and Steel Industry, Pittsburgh, Pa. (September, 1976).

ERDA was abolished on October 1, 1977 and its functions were transferred to the U.S. Department of Energy. This reorganization was effected by the Department of Energy Organization Act, 42 U.S.C. § 7101 *et seq.* (1977). Liquefaction research will be under the Assistant Secretary for Energy Technology, while commercial demonstration, if carried forward, will be under the Assistant Secretary for Resource Applications.

2. *Id.*
3. *Id.*

The most significant point in the development of liquefaction occurred in 1914 when a German inventor, Friedrich Karl Rudolph Bergius, disclosed the results of his work by submitting a number of patent applications in Britain and Germany.

> Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is: A process of manufacturing liquid organic compounds as set forth in Specification No. 18,232 of 1914, applied to the solid or liquid products of destructive distillation at the high temperature of coking and gas retorts of coal or other substances produced by natural or artifical carbonization or vegetable matter and carried through at pressures of more than 20 atmospheres.[4]

Translated into less technical and formalized language, the Bergius process requires that "[c]oal is first ground to a fine size and mixed with a process-derived hydrocarbon liquid and a catalyst. This mixture is reacted with hydrogen (produced by the gasification of coal) at pressures of up to 10,000 p.s.i."[5] For all practical purposes, the product derived from this process is petroleum. The conversion is effected by using pressure, elevated temperatures, and it occurs because "[t]he important chemical differences between coal and petroleum are the higher hydrogen and much lower oxygen and nitrogen content of petroleum. Processes that increase the hydrogen content of coal appreciably usually remove most of the oxygen and nitrogen."[6] It was this type of basic knowledge that enabled early inventors like Bergius to conduct the basic pioneering work that set the stage for continued development after World War I.

In fact, it was the realities of World War I and the demands it imposed upon fuel supplies that spurred post-war development of the Bergius process, especially in oil-poor Germany. Work in liquefaction was carried forward in that country by the I. G. Farben cartel and "[b]y September, 1939, seven hydrogenation plants had been erected in Germany, with a total capacity of 1.4 million tons of oil and liquefied gas a year."[7] The German production was so extensive that the bulk of its 1939-1945 war effort was sustained by liquefied coal. One

4. F. FISCHER, THE CONVERSION OF COAL INTO OILS 171-72 (1925).

5. I. HOWARD-SMITH & G. WERNER, COAL CONVERSION TECHNOLOGY: A REVIEW § 1, at 1 (NP Pub. No. 20,814 (1975) [hereinafter cited as CONVERSION TECHNOLOGY].

6. COMMITTEE ON CHEMICAL UTILIZATION OF COAL, DIVISION OF CHEMISTRY AND CHEMISTRY TECHNOLOGY, NATIONAL RESEARCH COUNCIL, II CHEMISTRY OF COAL UTILIZATION 1750 (1947).

7. CONVERSION TECHNOLOGY, *supra* note 5.

source says that Germany's liquefaction system provided "about 85 percent of the wartime needs for gasoline and diesel fuels."[8] Another writer says that "practically the entire production of aviation fuel in 1944 was from these hydrogenation plants."[9] Although no Bergius plants are in operation today, the processes developed in Germany and elsewhere[10] laid the groundwork for postwar liquefaction research.

The research effort in the United States in the late 1940's was undertaken because "there was an oil shortage."[11] The research program was mandated by Congress when it created the Office of Synthetic Liquid Fuels in 1944, which in the ensuing eleven years spent 87.6 million dollars

> investigating the production of liquid fuels from a number of resources from coal to corn waste. Coal research liquefaction plants were built in what are now the Pittsburgh and Bruceton Energy Stations. Additional research was done at the Morgantown and Grand Forks Stations. At Louisiana, Mo., a large government ammonia plant was converted into two liquefaction demonstration plants one of which utilized the Berguis process to produce about 200 barrels per day of gasoline.[12]

Interest then declined because "[t]he development of the major oil resources of the Middle East had begun. By 1955, the availability of low-cost, imported oil eliminated almost all interest in continuation of a major effort to develop synthetic fuels from coal."[13]

Even though there was very little general public interest in liquefaction, the government continued to fund small scale research projects which, in the last three to four years, have begun to mature and look like wise investments. For example, the Char-Oil Energy Development (COED) project was first funded in 1962; the Solvent Refined Coal (SRC) program was also started in 1962; first work in Synthoil

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8. Energy Research and Development Administration, Synthetic Fuels Commercialization Program; An Overview 3 (1976) (unpublished pamphlet) [hereinafter cited as Synthetic Fuels].

9. CONVERSION TECHNOLOGY, *supra* note 5.

10. *Id.* This source notes a Japanese plant at Fusan, Manchuria in 1928, a British Fuel Research Station in London, England in the 1930s, a plant in Billingham, England with a production capacity of 150,000 tons annually, and a plant in Korea in 1942 capable of producing "110,000 tons of gasoline and diesel fuel annually."

11. CONVERSION TECHNOLOGY, *supra* note 5.

12. *Id.*

13. Address by Energy Research and Development Administration Official, Ezekial Clark, to representatives of the Iron and Steel Industry, Pittsburg, Pa. (September, 1976).

began in 1964; and early work in H-Coal began in 1963.[14] All have been the subject of recent attention by the Federal Government.

While the American interest was directed totally toward research, at least one other country not completely beguiled by the availability of Mid-East oil turned to developing a production capability. In the early 1950s the Union of South Africa built a "coal to liquids plant . . . (which) produces synthetic gasoline and other motor fuels, along with pipeline gas, amonia, and other products."[15] This Sasolburg, South Africa facility produces "liquid hydrocarbons from coal-derived synthesis gas via Fischer-Tropsch Synthesis, [and the] current output is 2.5 million tons per year of petrochemicals which includes 1.68 million tons per year of gasoline."[16] Recently the South Africans announced plans for another larger liquefaction plant which should produce 10 million tons of gasoline per year.[17] Translated into barrels this "larger Fischer-Tropsch plant (will be) capable of producing the equivalent of about 40,000 barrels a day—nearly a size that could be considered a commercial facility in the United States."[18]

Absent the Mideast war of 1973 and the ensuing Arab embargo on oil exports, the liquefaction story would be complete. Because of that embargo and its consequences, both real and imagined, liquefaction has received renewed attention and is considered to be an important part of the technological effort to drive away the spectre of energy shortages.

The Present State of Liquefaction

Even considering the present energy crisis, the future development of liquefaction is still unclear. This is perhaps best illustrated by comparing two current and conflicting views of the art.

> Of the various approaches for converting coal into an improved nonpolluting energy source, liquefaction appears to be the most favored in terms of economics and confidence in reliable commercial operability.[19]

14. Energy Research and Development Administration, ERDA Pub. No. 76-33-4, Coal Liquefaction Quarterly Report 9, 12, 19, 28 (Dec. 1975) [hereinafter cited as Quarterly Report].
15. A Hammond, 193 *Science: Coal Research III: Liquefaction Has Far to Go* 873 (1976) [hereinafter cited as *Coal Research III*].
16. Conversion Technology, *supra* note 5, at 15, 16.
17. *Id.* at 16.
18. *Coal Research III, supra* note 15, at 874.
19. Synthetic Fuels, *supra* note 8, at 1.

> Liquefaction is perhaps the most difficult of coal conversion techniques . . . The process is inherently inefficient.[20]

Aside from the positional biases of these two "authorities," the conflict in opinion over the viability of liquefaction technology typifies the split within the scientific-governmental community over the present state of the art.

The points of disagreement are further accentuated by the fact that liquefaction was only one of ten different activities which competed for funds in the Fossil Energy Program at ERDA. For fiscal year 1977, liquefaction was scheduled to receive some 15.5 percent of the fossil energy funds.[21] Because Congress closely controls energy authorizations, important decisions affecting the further development of liquefication will be made as much on political grounds as for scientific reasons.

As if competition with its sister technologies were not enough, liquefaction development is beset by uncertainty over which process is the most desirable for extended development. Research efforts by ERDA were concentrated in four areas: direct hydrogenation; solvent extraction; pyrolysis; and indirect liquefaction. The agency's plan was to go forward "in parallel from laboratory scale, through process development unit (PDU), to pilot plant stage."[22] The plan was to then go forward with fewer projects by selecting the best features of the pilot plants and continuing them in the demonstration phase. ERDA said that "[c]urrent emphasis is being placed on the development of fuels suitable for firing industrial and electric utility boilers and gas turbines. Modern improvements are providing better catalysts, better reactor designs, and better construction material . . . ."[23]

As we view the present state of the art of liquefaction, it is interesting to note that the broadly scaled research effort seems to be paying off because the technology is developing greater efficiency. One authority estimates that the rate of efficiency of Bergius plants has been approximately 35 percent[24] while presently projected estimates of the thermal efficiencies of developing technologies range from 73.5 per-

20. *Coal Research III*, *supra* note 15, at 873.
21. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, ERDA PUB. NO. 76-63, FOSSIL ENERGY RESEARCH PROGRAM OF THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION 2 (1976).
22. *Id.* at 21.
23. QUARTERLY REPORT, *supra* note 14, at 1.
24. Synthetic Fuels, *supra* note 8, at 3.

cent of the H-Coal process using Illinois coal to 62.2 percent for the same process adapted to Wyodak coal.[25]

An attendant feature of the greater efficiencies of the new processes is a proliferation of projects for the overall liquefaction program. Within the four board categories mentioned above, which were the definitions by ERDA of its liquefaction program, there were no fewer than 15 individual projects in varying stages of development. There were four in direct hydrogenation; five in solvent extraction; five in pyrolysis; and one in direct liquefaction.[26]

Cost of the liquefaction research program has risen from 10.4 million dillars in Fiscal Year 1973 to 89.9 million for Fiscal Year 1976 with 73.9 million planned for the Fiscal Year 1977. When the 26.4 million transition quarter funding is included, a total of 340.8 million is reached for the five-year period 1973 through 1977.[27] The decline in funding from the high of 94.7 million in Fiscal Year 1975 to 73.9 in Fiscal Year 1977 is transitory since a number of costly pilot plant projects either are near completion or have been completed. Thus, the lower cost figure for Fiscal Year 1977 reflects a transition from the relatively high cost of construction to the lower costs of operation and data gathering. Moreover, there is little doubt that the next level of development will require even greater funding.

The above figures do not reflect the full cost of the program since many of the projects are joint efforts by government and private industry. The industry share tends to be about 30 percent for pilot plant projects, and will rise to a 50 percent share at the demonstration plant stage. An illustrative example might be the H-Coal project which is in the direct hydrogenation program. Budget authority for the project in Fiscal Year 1977 is 21 million dollars, and the total since 1975, including the 1977 authorization, is 72 million. However, "ERDA is providing two-thirds of the funds and the industry consortium, one-third."[28] Obviously the development of a liquefaction technology is, and promises to continue to be, a very expensive endeavor. The realization is now growing that the costs are so great that they may prohibit liquefaction development by private funding.

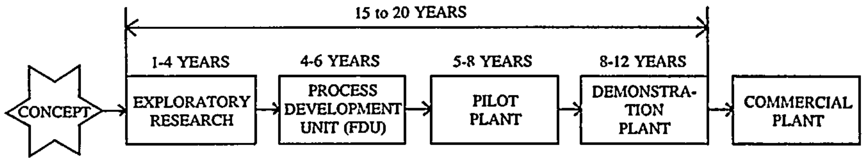
25. U.S. Department of the Interior, Preliminary Economic Analysis of H-Coal Process Producing 50,000 Barrels Per Day of Liquid Fuels From Two Coal Seams: Wyodak and Illinois (ERDA Pub. Nos. 76-56, 76-1-2, 76-2-1, 1976).

26. Energy Research and Development Administration, ERDA Pub. No. 76-63, Rossil Energy Research Program of the Energy Research and Development Administration 24 (1976).

27. *Id.* at 3.

28. *Id.* at 26.

The "Typical Process Development Sequence"[29] generally used by ERDA is illustrated as follows:



TYPICAL PROCESS DEVELOPMENT SEQUENCE

Applying this diagram to the 15 projects funded entirely or in part by ERDA, none has yet been carried through the demonstration stage. Only one, the COED, has completed the pilot plant phase; four others are in operation or planned as pilot plants; and the remainder are in various stages of development as PDU's, laboratory models, or are in the design phase.[30] It is clear that from the perspective of the federal government, liquefaction is an adolescent technology still suffering growing pains and is probably 10 to 20 years from maturity as a commercial operation.

PUBLIC POLICY AND THE LEGAL SYSTEM

The development of a coal-to-liquid fuel technology is creating a multitude of public policy issues which call for attention. Specifically, these issues relate to economic, environmental, and social concerns.

Economic Issues

The major economic issue is whether the development of coal liquefaction technology ever will be cost justified. Most liquefication technology cost estimates are expressed in terms of the costs to build conversion plants and the costs per barrel of liquid derived therefrom.

The President of the National Coal Association estimated the cost of a commercial-scale coal-based synthetic fuel plant at $1 billion and the cost of the oil produced in a range of $14 to $24 per barrel.[31] ERDA studies place the cost per barrel of oil produced by existing coal liquefication on the high side of the coal industry's estimates.[32]

29. *Id.* at 10.
30. QUARTERLY REPORT, *supra* note 14, at 2.
31. Address by Carl E. Bagge to the World Coal Conference, London, England (September 11, 1975).
32. For example, the H-Coal process with wyodak coal is estimated to be capable of producing oil for $21.95 per barrel and with Illinois coal for $19.45 per barrel.

Another way of analyzing the economics of coal liquefaction is to compare its energy output per dollar expended to that produced by direct combustion of coal. One such comparison estimated that the energy output per capital invested of the liquefication process was approximately eighty-seven percent below that produced by direct combustion.[33] Given these high estimates, cost/benefit analyses suggest that it will take 25 to 45 years for the synthetic liquids program to become commercially competitive with other fuel sources.[34] Not only are the known costs very high, but uncertainties and risks associated with the market prices of competing products, regulatory delays, environmental concerns, and social problems translate into costs which are nearly impossible to estimate.[35] Therefore, it is not surprising that the cost/benefit analyses of government planners produce confusing results. For example:

> Based upon presently available information concerning future expected U.S. demand and domestic production, the expected cost of synthetic fuels, and assuming the oil cartel has a 50-50 chance of remaining strong, then the expected costs exceed the expected benefits. The 350,000 B/D program could be expected to cost the nation on the order of $1.6 billion in discounted 1975 dollars. However, there is a 10 percent chance the 350,000 B/D could result in a net benefit to the nation of more than $7 billion while there is a 10 percent chance it could result in more than a $9 billion cost. The 1,000,000 B/D program could be expected to cost the nation on the order of $5 billion. However, there is a 10 percent chance the 1,000,000 B/D program could result in a net benefit of more than $15 billion or a 10 percent chance of a net cost of more than $26 billion.[36]

Given the high losses and risks involved in developing coal liquefiiciation technology, it is understandable why many backers of govern-

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33. Commoner, *A Reporter at Large*, NEW YORKER, Feb. 2, 1976, *reprinted in Hearings on 1977 ERDA Authorization Before the Subcomm. on Energy Research Development and Demonstration of the House Comm on Science and Technology*, 94th Cong. 2d Sess. 1667 (1976).

34. HUDSON INSTITUTE, INC., RESEARCH STUDY OF ISSUES RELATIVE TO THE DEVELOPMENT AND COMMERCIALIZATION OF A COAL-DERIVED SYNTHETIC LIQUIDS INDUSTRY, QUARTERLY REPORT FOR THE PERIOD OCTOBER 1975-DECEMBER 1975, at 3 (FE Pub. No. 1752-11, 1976).

35. Division of Industrial and Engineering Chemistry, American Chemical Society, *Proceedings of a Symposium on Commercialization of Synthetic Fuels* 5 (Feb. 1-3, 1976).

36. SYNFUELS INTERAGENCY TASK FORCE TO THE PRESIDENT'S ENERGY RESOURCES COUNCIL, RECOMMENDATIONS FOR A SYNTHETIC FUELS COMMERCIALIZATION PROGRAM: A BRIEF SUMMARY 15 (undated report).

ment-sponsored liquefication development programs proceed on the assumption that private enterprise will not invest capital in coal liquefication without government participation.[37] However, this cost and risk sharing by government and private enterprise may reorder the relationships between government and the private sector which could greatly distort the marketplace's resource allocation function. For example, the loan guarantee is a politically attractive method of providing government aid to high risk ventures. "For politicians caught between the need to point with pride to how they save money for their constituents and how they *get* money for their constitutents, loan guarantees are looking like an increasingly attractive way out. After all, the taxpayer loses money only if the guaranteed project fails."[38]

Additional attractions of the loan guarantee approach to financing high cost and high risk projects are that the fact that the government aid being given is not highly visible to the public and any embarrassing defaults usually do not occur until years later. But even though the loan guarantees seem attractive, they are receiving critical scrutiny by Congress. The Senate Committee on the Budget recently published a staff study which notes that

> [l]oan guarantees have consequences for both Government decision making and the private sector. Such guarantees may result in Federal outlays although neither the timing nor the magnitude of those outlays can be forecast. . . . Consequences for the private sector may include increasing the probability of default and of premature shutdowns and higher interest rates for borrowers who do not benefit from the guarantees.[39]

Other frequently discussed incentives which could be offered to industry to induce them to risk their capital in liquefaction facilities include price guarantees and project guarantees. Both of these are defined and discussed in the Budget Committee Staff Report. Their proposed use and the proposed use of loan guarantees for the promotion of liquefaction, as for any technology, presents fundamental public policy issues relating to the allocation of resources. "The private market allocates resources according to calculations of the risks and the

37. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, ERDA PUB. NO. 76-1, I A NATIONAL PLAN FOR ENERGY RESEARCH DEVELOPMENT AND DEMONSTRATION: CREATING ENERGY CHOICES FOR THE FUTURE 56 (1976).

38. Blustein, *The Bottomless Pork Barrel?*, FORBES, July 15, 1976, at 21.

39. SENATE COMM. ON THE BUDGET, 94TH CONG., 2D SESS., FEDERAL ENERGY FINANCING: FINANCIAL AND BUDGETARY IMPLICATIONS OF GOVERNMENT GUARANTEES IX (Comm. Print Aug. 30, 1976).

potential returns attributed to alternative projects. Because these calculations focus on the flow of funds to private investors, outcomes of market decisions may not conform with perception of the national interest."[40]

What the staff report, cited above, is necessarily implying is that decisions of whether to allocate available resources to support a technology such as liquefaction will be based upon such non-economic factors as social, political, and environmental considerations. To put it another way broad public interests may require the development of liquefaction even though it would not occur if the decision rested on the normal operation of the marketplace. This, of course, interposes an economic artificiality into the developmental process.

The scale of the proposed liquefaction program is another economic issue. Most planning estimates have been expressed in terms of the production goals of a total synthetic fuels program, and projections have varied from a 350,000 B/D effort to one producing over 1,000,000 B/D. The actual size of the liquefaction system developed will depend in part on the success of other technologies such as gasification of coal, solar, geothermal and, in part, on world supplies and world consumption of petroleum.

One study done for ERDA by the Hudson Institute discusses scale in terms of risk, available capital, and the presence or absence of government support: "However in the absence of government guarantees (that is, assuming investors to feel that they are taking the program's risks upon themselves), a small-scale program might require 11 percent capital, and a crash program about 12 to 12.5 percent or above."[41]

Environmental Issues

Obviously, in-depth and comprehensive treatment of all environmental issues presented by liquefaction is not possible here. Accordingly, the controlling theme herein will be an effort to develop and discuss only illustrative policy issues which relate directly to coal liquefaction technology.

Environmental issues are the most highly charged of all the questions which arise with the siting or announcement of plans to site any

40. *Id.* at 7.

41. HUDSON INSTITUTE, INC., RESEARCH STUDY OF ISSUES RELATIVE TO THE DEVELOPMENT AND COMMERCIALIZATION OF A COAL-DERIVED SYNTHETIC LIQUIDS INDUSTRY, QUARTERLY REPORT FOR THE PERIOD OCTOBER 1975-DECEMBER 1975, at 18 (FE Pub. No. 1752-11, 1976).

large plant in a given area. The various stages of the process itself suggest a panoply of environmental concerns.

> The basic steps in the process . . . consist of slurring the coal in a solvent, hydrogen addition, heating and dissolving, separation of the untreated carbon and mineral matter, fractionation to recover the solvent and fuel values, and production of reducing gas (or hydrogen) from the residue and additional coal as required.[42]

While the process itself encompasses nearly every environmental concern imaginable, further complication is added by the fact that different kinds of coal present different environmental problems. "There are major differences in the properties of the regional coals. For example, moisture content ranges from 3 percent to 37 percent while heating value ranges from 13,000 Btu/lb. to 7,000 Btu/lb."[43] The environmental problems vary with the variation in coal because lower Btu content necessarily implies a larger mining effort to produce a given quantity of liquid, and mining efforts present quite different problems for different parts of the country.

Some of the major problems presented by the mining of coal to supply conversion plants include the possibility that "particulates generated by coal mining could give rise to local or regional climactic changes."[44] This becomes a serious issue, especially in the western arid regions.

> One possibility is that changes in atmosphere particulate loading [will or could] result in a slight decrease in precipitation. The disturbance of large areas of land and natural surface characteristics from intensive strip mining could alter surface temperature patterns as well. Together these changes could have an effect on agricultural productivity and water supplies.[45]

Water pollution issues attend the mining of eastern coal, including the pollution by acids and "mine discharges and runoff (which) result in increased suspended and total dissolved solids loading of streams and rivers near coal mines."[46]

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42. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, ENVIRONMENT EFFECTS, IMPACTS AND ISSUES RELATED TO LARGE SCALE COAL REFINING COMPLEXES, R & D REPORT No. 101, INTERIM REPORT No. 2 at 10 (FE Pub. No. 1508-T2, 1975).
43. *Id.* at 22.
44. SYNFUELS INTERAGENCY TASK FORCE TO THE PRESIDENT'S ENERGY RESOURCES COUNCIL, RECOMMENDATIONS FOR A SYNTHETIC FUELS COMMERCIALIZATION PROGRAM, IV PRELIMINARY DRAFT ENVIRONMENTAL IMPACT STATEMENT V-4 (1975).
45. *Id.*
46. *Id.* at V-8.

An issue of intense public interest in the west is the loss of water for agricultural purposes when mining operations interdict ground water supplies. This occurs when aquifers are cut or disturbed by large strip mines, which in turn could lead to shortages with resulting severe impacts upon agricultural and ranching operations.[47]

Though not exhaustive, this discussion suffices to illustrate the spectrum of environmental issues raised by mining operations which are adjunct to liquefaction facilities. It is clear that environmental issues are so compelling that a showing of something more than strong public interest will be required to justify a commitment to liquefaction. Environmental concerns may require a showing of public necessity merely to justify the large scale mining operations which would result from large scale liquefaction.

Even more serious environmental issues may arise from the operation of liquefaction facilities. Perhaps the most significant of the facilities-related concerns arises from the anticipated effect of the plants on air quality.

> A unit plant's emissions would result in ambient concentrations considerably below Federal standards for sulphur dioxide and hydrocarbons in all regions for all classes of atmospheric stability; however the concentration of particulates may exceed the Federal standards during unstable weather conditions in all regions except the Powder River Region . . . . Even if all standards were met, some adverse health effects could occur to susceptible individuals.[48]

A more frightening public policy issue concerns the carcinogenic potential of the coal liqueficiation process.

> Coal liquefaction processes may produce substances that have considerable carcinogenic potential; some may produce mutagenic or teratogenic effects. The products of hydrogenation, the higher boiling point distillates, the centrifuged oils, the char, the centrifuged coke residues from hydrodesulfurization processing, and the recycled solvent oil used by the SRC process are all potentially hazardous materials.
>
> The liquefaction process breaks the connecting bridges of linkages between aromatic clusters of the coal molecule. Typical products of this mechanism would include polycyclic aromatic hydrocarbons (Lowell and Schwitzgebel, 1974).

47. *Id.* at V-10.
48. *Id.* at IV-78. A "unit plant" as used in this statement is a facility defined at IV-2 as a plant that produces the same amount of synthetic fuel regardless of the quality of feedstock, *i.e.*, oil or shale.

> Some of these substances are suspected carcinogenic agents. Accidental dermal or respiratory exposure to plant employees could lead to detrimental health effects.
>
> Coal liquefaction plants would emit unknown amounts of hydrocarbons of unknown composition, hydrogen sulfide and ammonia (Yavorski and Akhtar, 1974). The hydrocarbons could act as carcinogenic, mutagenic or teratogenic agent. The hydrogen sulfide and ammonia, as discussed above, can both act as respiratory irritants. It is felt that releases of such gaseous effluents would be minor; however, even low-level inhalation or dermal exposure to some of the polycyclic aromatics over long periods might induce carcinogenic activity in the general population.[49]

Yet another issue involves the continuous accumulations of waste materials emanating from a liquefaction plant.

> The total solid wastes to be disposed of at a unit-sized plant would be about 1,000 to 4,500 tons per day for a Fischer-Tropsch plant; 1,200 to 2,800 tons per day for other liquefaction plants; and 1,000 to 2,500 tons per day for a unit SRC plant. Disposal of these wastes from a Fischer-Tropsch plant would cover approximately 250 to 1,125 acres to a depth of 10 feet over a 20-year period; 300 to 700 acres would be covered by wastes from other liquefaction plants' and 250 to 625 acres would be needed to dispose of wastes from a unit SRC plant. This acreage would first be cleared of vegetation and revegetation may be difficult in the Western regions. In addition, improper disposal of liquefaction or SRC wastes would affect water quality and aquatic biota. Toxic substances and trace elements in the wastes could find their way into food webs and be biologically accumulated by some species with the result that higher life forms would be detrimentally affected.[50]

In addition to the environmental disturbances occasioned by mining and by the liquefaction facility itself, there is a significant problem associated with the transport and transmission operations of the liquificiation process. In fact, one study makes the claim that

> [i]n terms of the potential land disturbance, the facilities rerequired for the transportation and transmission of products, by-products and raw materials from the refinery complex can involve far greater areas that the complex and mining operation . . . .
>
> The principal products and typical quantities that will be pro-

49. *Id.*
50. *Id.* at IV-86.

duced by a large coal refinery and which must be transported daily from single refineries are. . . .
Solvent Refined Coal or Liquids
40,000 tons
By-Products and Water
50,000-100,000 tons[51]

Related transport problems include not only construction of new facilities, but maintenance and expansion of existing roads, railways and waterways. Transmission facilities encompass both pipelines and electric lines. The well known Alaskan pipeline is but one example of environmental impacts which arise from the transmission of energy.

These are but a few of the environmental and environmentally related problems which would be presented by the development of liquefaction technology. We have seen that there are environmental issues raised not only by the plant itself, but by supporting efforts of mining and transportation, and that the specifics of many issues vary from one region of the nation to another, from one kind of coal to another, and from one liquefaction process to another. In all cases the issues involve the preservation or deterioration of the quality of public health, water, soil, and air.

Social Issues

It is perhaps not entirely possible to typify the effects which a liquefaction facility would have on people and their social, political and cultural institutions in any given areas or regions. However, looking at a construct of a model liquefaction facility planned for a particular site is a useful exercise for identifying many of the problem areas and in developing the issues which warrant further study. With these goals in mind, ERDA financed a study by the University of Denver Research Institute of a "hypothetical large-scale, coal processing complex . . . coal-oil-gas (COG)"[52] facility to be built in the Fort Union region of Wyoming, Montana, or one of the Dakotas.

The study noted that among the more obvious results of such a project would be an infusion of new people, mostly construction

51. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, ENVIRONMENTAL EFFECTS, IMPACTS AND ISSUES RELATED TO LARGE SCALE COAL REFINING COMPLEXES, R & D REPORT No. 101, INTERIM REPORT No. 2 30-31 (Fe Pub. No. 1508-T2, 1975).

52. UNIVERSITY OF DENVER RESEARCH INSTITUTE, FACTORS INFLUENCING AN AREA'S ABILITY TO ABSORB A LARGE-SCALE COMMERCIAL COAL-PROCESSING COMPLEX—A CASE STUDY OF THE FORT UNION LIGNITE REGION 1 (FE Pub. No. 1526-2, 1975) [hereinafter cited as FORT UNION LIGNITE].

workers, into the area, a need for additional housing and social services, and a disruption of existing life styles and patterns in the immediate vicinity. The study also noted some specific effects that might be anticipated such as

> the presently very low drop-out rate among high school students is likely to increase as high paying construction jobs are available. Church attendance and membership might increase, but the presently high proportion of residents involved in religious activities may decrease . . . . Political control at the state and local level might, over time, shift away from agricultural interests.[53]

These are illustrative of types of social changes that might be expected to occur in such an area. One common theme that pervades such observations is change—usually swift and disruptive change. This, no doubt, is due to the abrupt appearance in a rural society of an industrial complex. The depth of concern over the extent and type of change in rural life styles is evidenced by the questions asked about coal development by the residents of one state which now faces dramatic change as liquefaction plants are tentatively planned there. In a work done at the University of Montana, these questions were listed as being among those most frequently asked by people in the affected area:

(1) Who will get the new jobs?
(2) Will coal development benefit current residents?
(3) Will coal development lead to an influx of newcomers?
(4) How will coal development affect agriculture?[54]

These questions reflect specific concerns and specific issues, but they also reflect basic social issues which would attend the countruction of any large liquefaction development.

Accepting the proposition that in almost every case a liquefaction complex would have the effect of changing the social context into which it is placed, and further that the change is fundamental and pervasive, it is necessary that a word be offered about the nature of these changes. The previously mentioned University of Denver study was careful to point out that the sum of social change can be either positive or negative.

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53. *Id.* at 9.
54. Water Resources Research Center, *Water Use and Coal Development in Eastern Montana: Water Availability, Water Demands and Economic Impact*, Report No. 57 at 177, 179, 181, 189 (Bozeman Mt. 1974).

In that study, in addition to the hypothetical facility, seven areas were examined which had experienced sudden large-scale development. For example, Idaho Falls, Idaho was considered as a case study because of the location there in the early 1950s of a National Reactor Testing Station.[55] Langdon, North Dakota was included as one of the seven because of the missile sites that were built there in the period 1969-1974.[56] One conclusion of the Denver University study was that the character of the change which occurs under such circumstances is largely dependent upon the type of planning and ongoing management which are brought to bear on the problems. "While public and private officials in Langdon were reasonably well informed of the magnitude of the project, the pace of construction activity and development was extremely rapid. Consequently, major problems resulted from the inability of the local area to respond quickly enough to the new demand placed upon it."[57] Although this is fairly representative of the comments made about the seven areas studied, and even though it does strongly imply a generally negative effect, positive results were also listed for each of the affected areas.

Closely allied with the issue of how to control change and optimize positive effects is the question of who shall finance the adjustments which these communities and states must make.

> As the case studies revealed, one of the most common areas for communities impacted by large-scale development is the inability of both the private and public sectors to respond with adequate educational, housing, shopping, medical, and other services . . . Locally generated funds would be expected to generate on the order of less than one quarter of the required amount. This indicates the need for substantial amounts of outside capital to satisfy the needs of new people moving to the area.[58]

The issues thus squarely presented are not only how much outside funding will be required, but of equal import, who shall provide it, to whom shall it go, what form shall it take, and what shall be the basis for allocation.

Perhaps the greatest obstacle to assessing the social impacts of a liquefaction facility on any given area is the absence of useful in-depth studies and data. A frequently used approach in studies and reports

55. FORT UNION LIGNITE, *supra* note 52, at 165.
56. *Id.* at 182.
57. *Id.*
58. *Id.* at 7.

is to categorize social problems as "socio-economic" problems or to place them under a heading with environmental issues. Although these study areas are undoubtedly interrelated, more direct information on specific technology-social problems would be helpful. This deficiency has been recognized and it has been suggested that social scientists be brought more into the decision-making process through the use of environmental impact reports.[59]

Legislative Context

Because liquefaction of coal is still a developing technology in terms of the maximization of efficiency of operation and in terms of the attainment of economical large-scale operation, only in the last four years has a unified and in-depth effort been made in the United States to bring liquefaction from the inefficient Bergius process to a modern, economically feasible, program capable of playing a significant role as part of the nation's energy supply. Confronted with a strong public need and an inefficient technology, lawmakers first reacted with uncertainty, then, as resolve began to bring a degree of firmness to the energy problem, they reacted with an excess of zeal which created a fragmented energy policy. The advance of the law that pertains to liquefaction technology, therefore, has not been significant as yet, nor does it seem to hold great promise for a desirable evolution in the near future.

The Bergius process sparked interest in many parts of the world. The United States was no exception and it began looking at the technology forty years ago. Congress dabbled in liquefaction in the 1930s and again in the post World War II period. ERDA's liquefication program had its genesis from programs of two predecessor agencies, the Bureau of Mines in the 1930s and the Office of Coal Research (OCR) in 1962.[60] These were not substantial efforts and, by the early 1970s, governmental interest in liquefication had greatly dissipated.

The turning point for interest and activity with respect to liquefication for the technology, the public, and the law was the imposition in October of 1973 of an embargo by a number of Arab oil producing nations on oil being shipped to the United States. The almost instinctive reaction to this crisis was the creation of a new bureaucratic entity.

59. Catalano, Simmons, Stokols, *Adding Social Science Knowledge to Environmental Decision Making*, 5 NAT. RESOURCES LAW. 41 (1975).
60. QUARTERLY REPORT, *supra* note 14, at 1.

With the stroke of a pen, President Nixon, in the summer of 1973, created the Energy Policy Office.[61] The first energy czar, Governor John Love, assembled a staff of some twenty-one people in the old executive office building for the purpose of formulating policy and giving guidance to the President. This effort was soon swallowed up in an avalanche of public concern over lines at gasoline stations and the prospect of gasoline rationing.

In December, 1973 the office was abolished and transformed into the Federal Energy Office by executive order of the President.[62] It has been suggested that the FEO was more interested in publicity than the energy crisis—reference an immediate hiring of over 100 public relations specialists. The most notable achievement of FEO was an organized effort to get people to turn out unnecessary lights, to wear sweaters, and turn down thermostats. The FEO never really got a chance to concentrate on keeping air conditioning thermostats turned down because on May 7, 1974, the Federal Energy Administration Act of 1974[63] became effective, which created the Federal Energy Administration. Also, the Arab oil embargo ended, reducing the pressures on these organizations.

Indicative of the growing realization that more energy research was needed and that energy constraints were going to require more than superficial efforts to conserve, President Nixon, in June 1973, proposed a ten billion dollar five-year program. It was significant for liquefaction because "[t]he largest commitment was $50 million for coal-related research and development, including liquefaction, gasification, and improved combustion."[64] From these rather insubstantial beginnings, the most substantive commitments have been made by Congress in the last three years. "On June 30, 1974, the President approved the Special Research and Development Appropriations Act which provided $2,236,000,000 during fiscal year 1975 to various agencies conducting expanded energy research and development. This act put emphasis on nuclear energy and coal liquefication."[65]

Liquefaction again was a specifically targeted technology in the Federal Nonnuclear Energy Research and Development Act of 1974

61. *See* Exec. Order No. 11726, 38 Fed. Reg. 17711 (1973), *noted at* 16 U.S.C. § 791a (1973).

62. *See* Exec. Order No. 11175, 39 Fed. Reg. 11415 (1974), *noted at* 16 U.S.C. § 791a (1974).

63. 15 U.S.C. § 761 (1974).

64. ENVIRONMENTAL LAW INSTATUTE, FEDERAL ENVIRONMENTAL LAW 1018 (1974).

65. TETRA TECH, 1976 ENERGY FACT BOOK III-1 (1976).

which became effective on December 31, 1974.[66] The Federal Nonnuclear Act directs the Administrator of ERDA to develop and design programs "to accelerate the commercial demonstration of technologies for producing syncrude and liquid petroleum from coal."[67] Also of note in the Federal Nonnuclear Act is the specific requirement that a water resources evaluation be made whenever there is a "commercial development . . . which could have significant impacts on water resources."[68]

Mindful of environmental impacts which would attend the far-reaching activities contemplated by the Act, Congress provided that the Council on Environmental Quality should "carry out a continuing analysis of the effect of application of nonnuclear energy technologies to evaluate the adequacy of attention to environmental protection and the environmental consequences of the application of energy technologies."[69] The Act also nods in the direction of the environment in Section 5(a)(3) by stating that one of the "governing principles" shall be an analysis of "environmental and social consequences." Central to the Act is its provision for a wide array of federal incentives to be used for encouraging the development of nonnuclear energy technology, including, of course, liquefaction. These include guaranteed prices for products and cost sharing.[70] It must be pointed out that these incentives are available for development only through the demonstration plant phase and do not include large scale commercial operations.

On October 11, 1974, slightly more than two months prior to the enactment of the Federal Nonnuclear Act, the President signed into law the Energy Reorganization Act of 1974.[71] This Act created the Energy Research and Development Administration (ERDA). As part of the comprehensive restructuring effected by the Act, it was provided that in the new agency there would be an Assistant Administrator for Fossil Energy.[72] That structure of Fossil Energy showed five divisions. Liquefaction had a role in three of them: Fossil Energy Research (basic research), Coal Conversion and Utilization (PDU's and pilot plants), and Demonstration Plants. Adding further perspective to our view of liquefaction as a category within this bureaucracy

66. 42 U.S.C. §§ 5901-17 (Supp. 1974-76).
67. *Id.* at § 5905 (b)(3)(E).
68. *Id.* at § 5912(a).
69. *Id.* at § 5910(a)(2).
70. *Id.* at 5906 (a)(4).
71. 42 U.S.C. §§ 5801-91 (Supp. 1974-76).
72. *Id.* at § 5812(d).

is the fact that, among its peer technologies, liquefaction receives by far the largest single appropriation. The fiscal year 1977 appropriation is estimated at 73.9 million for liquefaction, as contrasted with 52.4 million for direct combuston, which is the next largest appropriation.

Another law which has a direct applicability to liquefiaction is the Technology Assessment Act of 1972.[73] This Act created the Office of Technology Assessment (OTA), whose mission is to advise Congress as to the impacts technology has on society. In May, 1977, OTA produced a *Comparative Analysis of the 1976 ERDA Plan and Program,*[74] which is a continuation of an earlier report[75] on ERDA's plans and programs. The 1976 report did not treat any program in detail, but discussed each in terms of its contribution to the total of energy needs. For liquefaction the study concluded that "ERDA's projection that coal liquefaction will significantly affect fuel supplies by 1985 is unrealistic."[76]

In general, the OTA contribution is a reactive type of presentation. It is overly general and of very little practical value; the high purpose of making known the "consequences of technological applications"[77] seems to have become lost amid budget tables and capsule paragraphs.

Mention should also be made of yet one more recent law which became effective May 11, 1976. This is the National Science and Technology Policy Organization and Priorities Act of 1976.[78] By this Act, Congress created in the executive branch an Office of Science and Technology Policy.[79] a President's Committee on Science and Technology,[80] and a Federal Coordinating Council for Science, Engineering, and Technology.[81] This Act is another chapter in the struggle by Congress to effectively respond to the continuing press of technology on society. It yet remains to be seen whether the councils, offices, and committees created by the Act will be more effective than past efforts.

73. 2 U.S.C. §§ 471-83 (Cum. Supp. 1977).
74. OFFICE OF TECHNOLOGY ASSESSMENT, COMPARATIVE ANALYSIS OF THE 1976 ERDA PLAN AND PROGRAM (1976).
75. *See generally* OFFICE OF TECHNOLOGY ASSESSMENT, AN ANALYSIS OF THE ERDA PLAN AND PROGRAM (1975).
76. OFFICE OF TECHNOLOGY ASSESSMENT, COMPARATIVE ANALYSIS OF THE 1976 ERDA PLAN AND PROGRAM 53 (1976).
77. 2 U.S.C. § 471(b) (Cum. Supp. 1977).
78. 42 U.S.C. §§ 6601-71 (Supp. 1974-76).
79. *Id.* at § 6611.
80. *Id.* at § 6631.
81. *Id.* at § 6651.

OBSERVATIONS

Having looked briefly at the technology of liquefaction, some representative public policy issues which it poses, and at the most directly relevant reactions of the Congress, the following observations have been derived from the confluence of these elements. Given the complexity of the subject, the result has been the formulation of more questions than answers.

Probably the most fundamental question raised by the energy crisis is whether or not the legislative system is capable of resolving a complex issue. A sharper edge is put on that question when one component of the issue is a highly complex technology such as liquefaction. The legislative response to the issues presented has been general and has addressed not one technology alone, but rather groups of technologies. The only exception has been in the authorizations for continuing research efforts. Distinctions are drawn there between gasification, direct combustion, and liquefaction, but one suspects that these distinctions derive from political considerations rather than technological facts; this may be the best explanation of the application of the legislative veto to recent ERDA authorization legislation.[82]

It could be argued that, in addition to the generalization of its approach to technology, the legislature has abdicated many of its functions to the bureaucracy. One commentator contends that this is the culmination of a trend toward the development of "the 'administrative state,' a form of government where the locus of the power is to be found within the Executive Branch."[83] The pressure generated by the 1973 energy crisis apparently hastened this trend. For example, the National Science and Technology Policy, Organization, and Priorities Act of 1976[84] created no less than three new entities, all in the executive branch and all designed to cope with the developments of technology.

The Federal Nonnuclear Energy Research and Development Act of 1974[85] is further evidence that the national legislature has both generalized its approach to technology and relinquished far-reaching power to the executive branch. Indeed, the responsibility for developing a

82. Authorization of Appropriation for Fiscal Year 1976, Pub. L. No. 94-187, §§ 101-601, 89 Stat. 1063-78 (1975).

83. Miller, *Science Technology and the Law*, SATURDAY REVIEW, Aug. 3, 1968, at —.

84. 2 U.S.C. §§ 471-81 (Cum. Supp. 1977).

85. 42 U.S.C. § 5901-17 (Supp. 1974-76).

plan for meeting the nation's energy needs has been turned over to ERDA.[86] Moreover, that Act directs an administrative agency, the Council on Environmental Quality, to monitor environmental impacts and, in a most general way, directs that environmental and social consequences to be analyzed.

The economic problems of government showing the high cost of liquefaction with private enterprise has been discussed previously, with special emphasis placed on the economic distortions that arise from such arrangements. It should now be observed that this government-private enterprise partnership also creates distortions in the governmental decision-making process. It has been contended that because of this partnership, "much of the actual day-to-day governing power of the nation now rests in the hands of the leaders of private bureaucracies and even in the hands of individuals."[87]

More confusion arises from a reversal in the traditional relationship between law and technology. Previously, technology has developed independent of the law, with the law exercising a regulatory function after the technology begins to impact upon society. In the case of liquefaction, government is attempting to encourage, even compel, the development of technology by law. Legislative offers of such incentives as price guarantees, loans and cost-shared research are the instruments of this attempt.[88] Government has become a promoter of liquefaction technology, thereby guaranteeing insensitivity to the liquefaction technology's potential for creating serious social and environmental problems.

Rather than continue the government-private enterprise partnership which threatens to create a myriad of economic and governmental distortions, a better approach might be to create a liquefaction development corporation owned and operated entirely by the government. A government liquefaction corporation could be created and commissioned to develop a process for converting coal to liquid fuel at the lowest possible cost. At such time in the future when the demands of the marketplace made it commercially viable, the facilities could be sold to private interests at the fair market value, or the processes could be made available to any enterprise willing to enter the field.

86. *Id.* at § 5905(a).
87. Miller, *Science Technology and the Law*, SATURDAY REVIEW, Aug. 3, 1968, at 41.
88. 42 U.S.C. § 5906(a) (Supp. 1974-76).

Foremost among the arguments which can be marshalled in support of a development corporation is that it would tend to retard the growing association between private enterprise and the federal government. The argument of government giveaway would be fully answered and the questions of proprietary rights in processes, the right to market products, and the competition for government funds on the most favorable terms would be effectively resolved. Exclusive governmental development of liquefaction with a subsequent industry buy-out would eliminate the element of economic artificiality now present in the development of the liquefaction technology. Such a program would also allow for the concentration of technological expertise in one place. The present scatter of experts between government and industry is unproductive, inefficient and often results in duplicative efforts. For example, liquefaction experts in the government now spend the bulk of their time supervising the contracts being executed by private groups.

The guiding thought in suggesting a governmental development of this technology is that government as a promoter tends to misapprehend the public interest and see problems from a positional bias. Thus, another positive result of this plan would be the creation of a more serious concern for social and environmental impacts of liquefaction technology. The government in its role of promoter has generally ignored the potential for far-reaching cultural effects which would be inevitable by-products of a large scale liquefaction program. While it is true that ERDA has done a study,[89] Congress has barely recognized the problems. In the Federal Nonnuclear Energy Research and Development Act, a study of the general subject was ordered,[90] but there has been no serious consideration since then of specific legislation to deal with problems which would be presented by the large scale migration of people to undeveloped regions of the West and the attendant needs for social services which would result. Developments to date suggest that it will not be possible to discuss what some commentators see as the primary role of government control of technology[91] until a separation of functions is restored.

In the equation of law and technology, the constant factor seems to be the growth of technology which forces the law to be responsive.

89. FORT UNION LIGNITE, *supra* note 52.
90. 42 U.S.C. § 5904(a) (Supp. 1974-76).
91. Green, *The Role of Law and Lawyers in Technology Assessment*, 3 *Atomic Energy Law Journal* 256 (1971); Hanslowe and Oberer, *Science, Technology, Law: The Good Life*, 26 J. LEGAL EDUC. 32 (1973-74).

One writer, in something of an optimistic tone, observed that "[l]aw usually adjusts with dignity to the shocks administered to her by Science. Eventually, she works out reasonable modifications or regulations for the technological marvels that triggered the shocks."[92] It is now the law which is administering shocks of its own to technology by becoming its benefactor. The final question must be whether or not an accord can be achieved between law and technology which will allow each to continue to serve the public interest.

92. D. LOTH & M. ERNST, THE TAMING OF TECHNOLOGY 163 (1972).