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CAN NUCLEAR ENERGY SURVIVE PUBLIC SCRUTINY?

In the past, new technologies generally avoided the kind of detailed public scrutiny that occurs today. As a result of an increasingly sophisticated population, and a growing army of public interest organizations, the demand for proof of the safety, environmental propriety, and economic desirability of new technologies is growing. Such proof is not easy. Technology assessment of strictly scientific issues is hard enough, often impossible, among scientists; technology assessment in a public debate is even harder. But where there are important questions of values, where there are subjective preferences for one kind of risk-taking over another, and where there are important scientific unknowns and relevant political uncertainties, public debate is the only solution.

Thomas Edison faced some technology assessment problems with the electric light. The New York Times **editorialized on December 30, 1878 that light produced by gas lamps provided a degree of illumination intensity many degrees below that produced by electricity. It wondered if electric light would be irritating to the eye; would it be a "safe and wholesome substitute for the light produced by combustion?" Five years later, the Times noted in another editorial that winter rainstorms would produce thousands of broken electric wires carrying current much stronger than that of telegraph wires. It concluded that "the streets will soon be rendered impassable by stunned or killed horses."**

The problems faced by nuclear fission power make these apprehensions seem poor jokes. The plutonium produced by the plants is very toxic—no one is quite sure how toxic. The dangers it may present in various forms, methods of distribution, and inter-relation with other elements of the environment, is not well understood and needs study urgently. It is impossible to know, in advance of trying it, how well the material will be guarded, protected, and transported as it moves from fuel fabrication plants to reactors to repossessing plants and to waste disposal sites. This is a question of how hard we work at it.

It is impossible—quite impossible—to "prove" that the plants are safe. One can, as has been done, provide an expensive study showing that the likelihood of accident is extremely small. And one can

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CONTINUING THE ANALYSIS

In the January newsletter, many of the issues surrounding nuclear fission power reactors were discussed. This March issue carries the discussion somewhat further by relaying comments on the January issue and by describing four policy positions: speeding up reactor construction, muddling through, a moratorium on new reactor construction, and the phasing out of existing reactors.

The energy crisis is not yet really a problem of supply but a problem of consumption. The energy exists. But, for various reasons, we do not want to consume it. Arab oil is now for sale but its use may endanger our independence from embargos. Uranium exists for supplying light water reactors for yet several decades, but nuclear plants may not be safe. Coal exists for hundreds of years of consumption but coal-fired plants may be dangerous to public health by polluting the air. Off-shore oil exists but its production may pollute the coasts.

The mistaken notion that the energy crisis is a problem of supply infects the arguments of both nuclear proponents and opponents. For example, some proponents want to speed up nuclear plant construction to solve the energy crisis. Why? Any energy production *bottleneck* could more easily be solved by building the shorter lead time coal-burning plants.

For their part, the opponents embed this fallacy in subtler argument. They talk of whether nuclear plant construction—at some given rate of growth of numbers of plants—will absorb more energy of all kinds than already built plants are putting out. At *some* rate of growth of the nuclear industry this would be true. But if the purpose of the rapid growth were to move away—in the medium and long run—from both oil dependence and coal burning, it might nevertheless be the thing to do. After all, during its construction, even an individual plant absorbs more energy than it is putting out. We simply

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do extensive tests—as has generally not been done. But only time, experience, and statistics can do more. Nor can one guarantee to solve the problem of ultimate waste disposal over a period of 1,000,000 years; one can only note that this problem is qualitatively already with us as a result of the weapons program quite apart from our decision to build power reactors.

Nuclear power is linked to fears of radiation and cancer. It involves—at least under present planning that does not include nuclear "parks"—the construction of several hundred different nuclear installations around the country. (One recalls that it was the "bombs in the backyard" debate that signaled the beginning of the end of the ABM.) Furthermore, the time required to complete the construction of the plants is measured in decades running right up to the 1990s. There is therefore plenty of time to develop a movement directed to halting plant construction. The ever-present possibility of an accident hangs over the entire process—even a small accident would seem to vindicate the critics. Indeed, the longer the debate rages in public, the more rigid must the proponents become in dismissing the possibility of accident and the more they would be discredited if one occurred. The very observation that public attitudes might change abruptly against nuclear energy has become a potent argument against national dependence upon them.

Nuclear Power a Natural Issue

Underlying these encouragements to popular concern is the general loss of confidence in authority in general and in regulatory agencies in particular. There is a rising concern with safety. And for the consumer and environmental movements, civilian nuclear power has everything one might want of an issue.

For all these reasons, the possibility that nuclear plant construction might be halted by its critics has to be faced by nuclear proponents.

In short, startling as it may seem even to veterans of the ABM struggle and the fight over the SST, the possibility looms larger that nuclear power construction might be halted in a pitched battle between opponents and proponents—or in the overnight flash of a core meltdown.

What are the emerging political options? One possibility is to phase out the 50 power plants operating and 29 plants with pending licenses; and cancel the 110 plants with existing or impending construction permits and call off the program. A second possibility is to call a halt to construction after the 200 plants built or abuilding are finished, and to resume construction only under specified conditions. A third possibility is business as usual. A fourth is a speed-up of power plant siting and relaxation of some safety restraints.

We think the time is rapidly approaching to consider the costs of these alternatives and their implications.

Neither the Government nor nuclear proponents have conceded sufficient plausibility to a moratorium to study it. The opponents are neither agreed as between moratorium and phase-out nor in a position to analyse either in depth. Granted technology assessment cannot resolve the issues. Still, any kind of debate requires analysis. We have room in this issue only to sketch the kind of alternatives that should be considered. Congress should insist that ERDA, EPA, OTA or some other Governmental organization try to define the issues.

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call this capital investment and it can be justified by an industry as well.*

Of course, there could still be an energy shortage in the midst of enormous energy supplies if the Nation could not make up its collective mind on priorities. If nuclear plant construction continued to be bedeviled by longer and longer delays, while environmental controls on coal burning grew tighter, and hurdles to importing of Arab oil or off-shore construction continued, there could be a crisis of controls. Hovering over all these considerations is the single and most important determinant of the delays (controls and import hurdles) we can afford while maintaining adequate production—the rate of growth of demand.

SPEED-UP VERSUS MUDDLING THROUGH

Proponents of a speed-up in nuclear plant construction see the nuclear plant construction as part of Project Independence. They see it as leading, in due course, to lessened reliance on foreign oil, while avoiding retreat on air pollution controls, and moving in the direction in which—until recently—it was assumed that American energy programs were sure to go. Industry proponents see a speed-up in siting as a way of redressing the unfair edge that coal plants have over nuclear when interest on nuclear plant construction has to be paid on plants that are delayed by siting (and safety) debates. They consider the plants sufficiently safe to be deployed. To the extent that other problems remain—safeguarding transport or ultimate waste disposal—they see little additional difficulty over that associated with the unspeeded up program. Guarding 200 plants by 1985 does not strike them as any more difficult to arrange than the 100 or so we might otherwise have if we muddled through and construction fell off. This option would tend to help foreclose "phase-out" of nuclear plants by rapidly increasing the number deployed before the movement to stop them gained momentum.

Opponents of speed-up may see the present rate as too rapid. Two hundred reactors by 1985 would be a doubling time of about five years (56 in 1975, 100 by 1980 and 200 by 1985) or a percentage growth rate of about 15%. At this rate of growth the average age of the plant would be only seven years by 1985 out of a lifetime of about 30. If it turns out, as has been alleged, (see page 6) that the plants will not run efficiently for long, this rapid buildup would be already a risky investment and should not be further speeded up. (The investment in 100 plants is about $70 billion.)

A further problem is the ability of the venders and architect engineers, etc., to provide 200 plants on this schedule; it averages 15 plants a year, involves anywhere from 6 to 24 per year. Could industry build so many as 24 in 1980 and 1981 and still do it well?

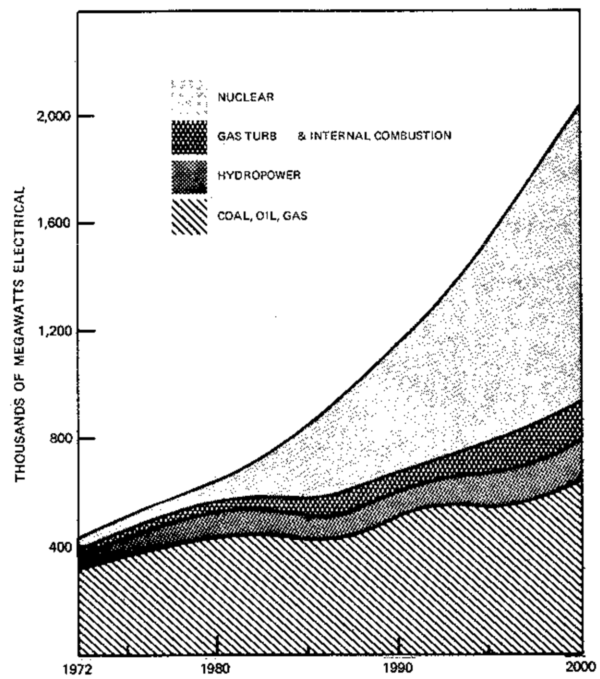

Figure 1–3. Projected Installed Generating Capacity in the United States

Rickover Won't Tell

More important than either of these observations is the problem of safety and reactor years of experience. Although the Navy has more than 1,000 reactor years of experience in its submarines with quite similar reactors, Admiral Hyman Rickover refuses to let the scientific community or public know what that experience is! No more vital fact needs to be known. But even with this experience, the buildup would complete the 200th reactor after only another 1300 reactor years of experience. This experience is still insufficient to verify the plausibility of the Rasmussen study conclusion that a core meltdown occurs about every 10,000-17,000 reactor years.

President Ford has called upon the Nation to build 200 nuclear plants by the year 1985. This is not in itself a speed-up since this is the number already planned. However, he has submitted to Congress an energy facility siting bill that would give the Federal Government greater powers in overseeing State planning. This bill would actually permit construction *prior to approval of the facility or its site* "in order to expedite the construction of needed nuclear facilities." How this would work is somewhat unclear.

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*A simple calculation suggests, however, that the expected rate of plant construction is not so high as to see the nuclear energy industry becoming a net absorber of energy. The energy content of most materials is thought to be about 10% of their value, which suggests $70 million for a $700 million plant of 1,000 megawatts. In a single year, the value of the energy produced by this plant is almost as much: $65 million (1.5¢ per kilowatt hr. × 8760 hours × 1,000,000 kilowatt hrs. × 50% capacity factor= $65.7 million). Thus if the price of the energy reflects its costs, i.e., if it is not subsidized, then the plant provides the value of the energy embodied in itself in about **one** year. Under these circumstances, the industry could grow at 100% per year without becoming a net absorber of energy costs. Obviously there are some subsidies—such as the capital costs of gaseous diffusion plants owned by the Government—not reflected in the price of the fuel provided the plant. But how far off can this calculation be? The expected rate of plant construction (200 plants by 1985, for example) reflects doubling about every 5 years or a 15% rate of growth.

MUDDLING THROUGH VERSUS THE MORATORIUM

Backers of muddling through say that a moratorium is inappropriate on speculation alone, i.e., without an accident, in view of the studies done and excellent operation experience. In view of the slowly growing rate of reactor construction—now perhaps a 5 year doubling time—the potential amount of transported material is rising only slowly (15% a year) and the Nuclear Regulatory Commission will have time to learn to cope with these problems. (In fact, since no reprocessing plants are on line, transportation of spent fuel has not started.) Since the percent of electrical energy produced by nuclear power by 1985 would only be about 25% under this program, the country as a whole would not be more addicted to nuclear energy than some single state size areas are already (e.g., Illinois).

Proponents of muddling through would prefer to let the financial community and industry attitudes take their normal course while the body politic considers the various dangers of energy production and observes future trends. For example, more might become known about the dangers—or the ways of protecting against the dangers—of fossil fuel burning. Popular support for air pollution controls on the one hand, or popular antagonism to nuclear plants on the other, could simply contest each other over time. The ratio of new fossil fuel plants to nuclear plants built each year would become the resolvent of many pressures of all kinds—presumably reflecting the real balance of political and economic attitudes. Why, supporters of muddling through would say, should we arbitrarily foreclose new nuclear plants in a moratorium? Furthermore, they fear that a complete halt amounts to the disbanding of an industrial task force. Could you, would you, ever get construction started again, they wonder, or would the halt in nuclear plant construction necessarily be permanent.

Moratorium Till When

Much turns on the interplay between the real efforts and on the declared purposes of the moratorium. Most of the political energy for the moratorium would come from all-out nuclear opponents. But, to capture the less committed, the moratorium would necessarily have to be drafted in terms of seemingly satisfiable criteria for ending the moratorium and subsequently moving ahead.

For example, the California Nuclear Initiative Petition would prohibit nuclear plant construction one year after its passage (and force operating plants to run at 60% of capacity) unless the Price Anderson Act limiting nuclear liability were removed. In any case, after five years, plants would be derated 10% annually unless the legislature by 2/3rds vote has confirmed the effectiveness of safety systems and waste disposal methods.

In the Nebraska Legislature, a bill calls for a moratorium on any further construction until such time as the evidence demonstrates with "overwhelming certainty" that nuclear energy is safe and efficient.

Another kind of moratorium could be based on the desire to shift to a new kind of reactor—perhaps a CANDU reactor—that would have inherently different (and improved) safety characteristics. In this case, the moratorium could be associated with a pause for reflection, examination of other options, etc. Although this examination could be undertaken while the program moved forward slowly, the moratorium would force the re-examination. Moratorium backers would argue that such vested interests as General Electric and Westinghouse are not about to examine other options unless they see that the existing options have been stopped cold.

MORATORIUM VERSUS PHASE OUT

Some moratorium backers among scientists consider the chance of a serious accident from the presently planned 200 reactors by 1985 as one that is acceptable: they had, after all, feared that 1,000 might be installed by the year 2000. They see no reason therefore to phase out existing plants to disrupt construction schedules, to lose the capital involved in some 50 plants built and 50 a-building (perhaps $50 billion). While a moratorium is not too difficult to conjoin with a phasing in of fossil fuel plants, a phase out of nuclear plants would require more care. For phase out, time is short. As Figure 1 shows, nuclear energy becomes significant in the 1980-1985 period.

On the other hand, most of the goals that motivate the anti-nuclear forces would not be satisfied with anything short of a phase out. Thus, for example, if one does not put credence in the ability to guard plants, the problem of sabotage remains relatively undiminished by a moratorium only. (100 sites is as bad as 1,000 since the rare saboteurs can still always find a target.) The transportation of wastes could be avoided entirely if the plants are phased out but not otherwise. Reprocessing of wastes, fuel fabrication plants, and industrial gaseous diffusion plants could all be dispensed with under phase out but not otherwise.

A phase out would leave America in a stronger position to refuse to sell reactors abroad. While other countries can still sell them, and will, America's leaving the market would certainly slow down the spread of reactors and perhaps encourage other sellers to follow suit, e.g. Canada or Great Britain.

Phase out and moratorium have the advantage of removing the uncertainty that currently shrouds the investment prospects of coal production; presumably, new coal mines would be opened rapidly and pollution control uncertainties associated with burning coal would be resolved immediately. One would go all out to produce coal, encourage conservation and move forward with other eclectic methods of producing energy.

UNCERTAINTIES TO BE CONSIDERED

In considering the political and economic feasibility of the four options, five uncertainties should be weighed, among others:

Oil Dependence: The critical issue for electric power is whether to build coal or nuclear fired plants. But the question of oil dependence undoubtedly plays an important political role because most of the public exaggerate the relevance of oil to the possibility of shortage of electric power. Oil dependence could seem quite different over the coming years in either direction! Thus, a total Arab oil embargo would make it very hard for nuclear opponents to stop nuclear plants. On the other hand, some more discoveries of oil in the North Sea, and in other locations, plus a drop in oil consumption, could lead to a break in the OPEC cartel or its growing impotence. Energy shortages have become energy surpluses before.

Nuclear Accident: If one believes the Rasmussen statistics, and if the nuclear plant construction moved steadily toward 600 by 1990, then a core meltdown has a ½ probability of occurring by the time the buildup is complete. Included in this chance would be a ¼ probability of meltdown's occurring before the buildup was two thirds complete and a ¼ probability of its occurring during the construction of the last two hundred plants. If the meltdown occurred during the earlier stages of the buildup, construction would probably be stopped even if the meltdown killed no one. If it occurred late in the program, and all else had gone well, it might be tolerated by the body politic depending upon a host of other relevant circumstances. The nuclear program is living dangerously.

Coal Dangers: While the control of coal-induced-pollutants is improving, one probably must expect ongoing scientific studies pinpointing the dangers of these pollutants that cannot yet be controlled: small particulates that cannot be removed; trace metals that go out of stacks as vaporized form; nitric acid in rain; combinations of pollutants, etc. Climatic changes are especially relevant in this regard.

Improvements in Nuclear Relative Efficiency: If lead times on nuclear plants were shortened, if plants shook down efficiently and began to work well, and if coal prices and mining costs continued to rise, nuclear plants might achieve a cost advantage of sufficient significance to face the public with the clear prospect of rate increases without it. (In the alternative case in which nuclear plants get priced out of the market, the utilities will simply decline to buy them.)

Dramatic Slowdown in Energy Consumption: It is entirely possible that the rate of energy growth will be dramatically cut. In the first place, there is reason to expect a diminution in the rate of economic growth if not a prolonged stagnation or periodic recession. The postwar boom may be over for the time. Furthermore, rapid energy growth has been associated historically with falling real prices of energy, and the arrival of higher real prices could produce a dramatic change. Above all, there is energy fat in our economy which could be absorbed without effecting growth of the Gross National Product through conservation and improved efficiency of energy use. Thus Detroit is seeking to put out a car that will be 40% more efficient in the use of gasoline by 1980.

CALL FOR PHILANTHROPISTS

Between now and September, the FAS Fund is making a major effort to locate a number of philanthropists capable of putting together the $1,000,000 endowment sought since last June. Members with relevant ideas are asked to advise us.

BETHE STATEMENT STIRS INTEREST

On January 16, as our January issue on reactors was being distributed, 32 senior scientists released a statement on energy policy. The statement was billed as calling for a "crash program" of nuclear energy. In fact, its text was milder.

The signers saw "no reasonable alternative to an increased use of nuclear power" to satisfy energy needs. In the next three to five years, it saw conservation as "essentially the only energy option". It deplored the fact that the public was being given "unrealistic assurance" that there are easy solutions and said none of the alternative energy sources in question was "likely to contribute significantly to our energy supply in this century".

The statement accused nuclear critics of lacking "perspective as to the feasibility of non-nuclear power sources and the gravity of the fuel crisis". Nuclear technology was said to be in a learning period and the signers had confidence that "technical ingenuity and care in operation" could continue to improve safety procedures. The benefits of clean, inexpensive, and inexhaustible domestic fuel far outweighed the possible risks.

The signers, besides Hans Bethe, were: Luis Alvarez, Peter Auer, William O. Baker, John Bardeen, Robert F. Bacher, Felix Bloch, Norris E. Bradbury, Harold Brown, Richard H. Chamberlain, Cyril L. Comar, Arthur Kantrowitz, Ralph E. Lapp, Joshua Lederberg, Willard F. Libby, Franklin A. Long, Edwin M. McMillan, Kenneth S. Pitzer, Edward M. Purcell, I. I. Rabi, Norman Rasmussen, Roger Revelle, Glenn T. Seaborg, Frederick Seitz, Edward Teller, James A. Van Allen, Warren Weaver, Alvin Weinberg, Victor F. Weisskopf, Edward Wenk, Jr., Eugene Wigner, Richard Wilson. (Of the above, five are FAS members.)

Response Issued

At the press conference, a response was issued by Ralph Nader and the Union of Concerned Scientists. It dismissed the signers as including long time supporters of nuclear power whose "enthusiasm for the technology" made it difficult for them to appreciate side effects. It said: "a general endorsement of nuclear power is not responsive to the urgent need for specific and well-founded answers to a set of key questions about nuclear power." The critics argued that proponents had "failed to foresee how a system created by first-rate scientists, if operated by the normal run of utility companies, could pose grave problems for society".

In particular, they argued that if construction proceeded and the answers could not be found, the country would be hooked on nuclear power and substantial economic disruptions might occur. The UCS statement argued also that not all signers of the Bethe petition had fully assimilated the Rasmussen report.

Signers of this anti-nuclear petition were: Hannes Alfven, Barry Commoner, John T. Edsall, Henry W. Kendall, Linus Pauling, Harold C. Urey, George Wald and James D. Watson. (Of these, five are FAS members.)

PRICE-ANDERSON ACT

In 1957, Congress enacted the Price-Anderson Act limiting the liability of the nuclear industry to $560 million for castastrophic accidents: of this amount $500 million was to be indemnified by the Government. Later the industry share was raised to $110 million. And in 1966, the insurance was made "no-fault" in which industry had to foreswear such possible defenses as acts of God (e.g., earthquakes), interference of third parties (e.g., sabotage), or absence of proof of fault. Some state statutes of limitations were extended to ten years which permits some liability for late revealed cancers.

Nuclear opponents attack the act as unreasonable protection of the industry; if the industry cannot get insurance from the insurance industry for the full amount of the possible liability, then how can it be considered sufficiently safe for the public? The effort to repeal Price-Anderson is a major part of their struggle against reactors.

Nuclear proponents see no reason why the judgment of the insurance industry is worth substituting for that of Government agencies or Congress. The insurance industry may simply be insufficiently large to take on any chance (no matter how small) of catastrophes even though the actuarial risk might be both moderate and worth undertaking on other public policy grounds (e.g., such as the problems associated with producing electricity by coal). Industry representatives do not argue that repeal will stop the industry but that it will create uncertainty until a substitute proposal is found.

Nuclear moderates have long argued that Price-Anderson should be repealed or amended to avoid an undeserved subsidy for nuclear power, i.e., the avoidance of premiums for the insurance required. Sometimes it is argued that this additional cost would help insure that utilities took proper care to avoid catastrophe.

Price-Anderson Has No-fault Provision

In fact, Price-Anderson also provides nuclear with a cost disadvantage over coal in its "no-fault" provision. Moreover, its repeal, while also presumably losing this advantage to the public would not necessarily lead the industry to large premiums. The costs of a really major catastrophe are so large, and so improbable, that the utility might not insure against the full consequences. Bankruptcy or long legal fights might be the alternative. Would Wall Street cease to invest in these companies who lacked full and complete insurance? It seems doubtful. Wall Street must have long ago discounted the obvious fact that core meltdowns—even if not a single fatality existed—would shake the industry politically. An accident involving hundreds of fatalities, much less thousands, could, during these initial decades, bring the industry to a halt. Isn't this clear with or without Price-Anderson?

Underlying the debate is the public policy question of who should pay for the insurance liability—stockholders, consumers, or taxpayers. If the utilities provide themselves with an insurance pool, it will come out of all consumer pockets in higher rates and the difference between this and taxpayer indemnity is philosophically small. Indeed, under Price-Anderson, a Government increase in taxes would come after the event as well. If stockholders are assessed, they will, of course, pass on the costs to consumers.

One thought comes to mind. While $560 million seems quite a low limit on liability for an accident that might cost many tens of billions of damage, some limits on liability would be clearly desirable if a limit were the only way to ensure no-fault distribution of the funds. After all, without no-fault, no one may collect.

DO PLANTS DETERIORATE AFTER AGE 4?

In November, 1974 the Bulletin of the Atomic Scientists carried a charge by nuclear critic David Dintmore Comey that nuclear plants were deteriorating with age after reaching peak capacity at about age 3-4 years. We referred to it in our January issue. A problem with the analysis arises, however, from the small number of relevant plants. The analysis only had available 8 plants of age greater than four years. Of these three are more than twelve years old and relatively small: between 175 and 265 megawatts (Dresden 1, Indian Point 1, and Yankee Rowe). Two have seven years of service—in the 400-600 megawatt range (Connecticut Yankee and San Onofre). And the remaining three have five years experience in the 500-600 megawatt range (Oyster Creek, Nine Mile Point and R. E. Ginna).

Of the oldest and smallest three, during the first 11 months of 1974, one did considerably better, one considerably worse, and one about the same as its cumulative capacity to date; this shows no clear trend. (Capacity is the percentage of full power provided, on average, over the time involved.) The average cumulative capacity factor of these three older reactors is about 50%—lower than the average for all plants (55%) but not by much; and these are a quite different generation of plant. Presumably the newer plants are, or will become, better.

The next five plants in age are considerably younger and twice the size. They have annual capacity factors that go up and down as follows:

STATION	Gross Capacity Factor 68	69	70	71	72	73	74*	Cumulative
Conn. Yankee	73	75	72	84	86	48	91	78
San Onofre	35	70	81	88	75	61	82	70
Oyster Creek			76	78	77	66	65	74
Nine Mile Pt.			42	60	60	69	63	54
R. E. Ginna			59	66	58	84	47	65

*11 months.

By this data the hypothesis of deterioration after four years seems unproved. Of the three plants with five years experience, one is much worse in its fifth year than the proposed "peak" 3-4 year period, and a second plant is slightly below. But the third is about the same and the two plants with seven years of experience both dramatically improved last year and are doing considerably better than their average or the average plant. One was about as effective as its 3-4 year period and the other much better.

FAS MEMBERS COMMENT ON THE JANUARY REPORT

The January Report received an unusual amount of praise from both proponents and opponents of nuclear reactors. Some commented that they had not yet seen a report on this subject that had even tried to be balanced between the two schools. However, as can be expected, there were a number of comments, criticisms and suggestions from interested FAS members in response to our request.

The most important philosophical disagreement with the January Report suggests a school of thought among nuclear opponents that does not consider coal to be the interim alternative. It seeks and considers feasible much more serious and rapid conservation measures. It is more optimistic about solar and wind as sources of energy and, also, eclectic methods such as energy from wastes. In a sense, this school is arguing: "Come off it, fellows, what would we be doing if we had neither coal nor nuclear?"

One of the most important technical comments concerns the number of deaths attributable to coal. The estimates given of 40-100 lives per 1,000 megawatt plant per year are virtually entirely due to atmospheric pollution associated with SO_2 and they are estimates for 1980 without controls (less than one death per plant are due to mining deaths which total only 130 or so a year). These nationwide emissions can be reduced with stack gas scrubbers by 90%.

As a result, premature deaths might be lowered to four to ten per 1,000 megawatt plant per year. Thus if SO_2 scrubbers were all maximally introduced, the gap between the cost in lives per megawatt plant for coal and nuclear would be vastly diminished. Nevertheless, the replacement of 200 nuclear plants by 200 coal burning plants would lead to the premature death of 800 to 1,600 persons. According to Rasmussen, 800 deaths or more would occur with 200 nuclear plants, only every 500,000 years—rather than every year. The more pessimistic Kendell curve with unfavorable uncertainties would still produce this result only every 500 years—rather than every year. (It should be pointed out, however, that the deaths due to fossil fuel pollution are usually premature deaths of elderly people rather than deaths of persons of average age.)

What about other health effects after sulfur removal? An August 18, 1974 draft report from the National Environmental Research Center of EPA on "Health Effects of Increasing Sulfur Oxides Emissions" has tabulated the effects for nine scenarios by 1980. Even in the most favorable scenario—which combines sulfur removal, conservation and special priorities for importing low sulfur fuel—the burning of coal to produce electricity would produce 2.8 million man-days of excess aggravation of asthma and 9.2 million man-days of heart and lung aggravation. This is about 5,000 and 15.000 days respectively per 1,000 megawatt plant.

One respondent notes that light water reactors by themselves do not fulfill the early promise of limitless energy since uranium supplies for them would run out in the first half of the next century. Only through a breeder reactor of some kind could this promise be fulfilled and the breeder reactors have their own problems. (The breeder is scheduled to be discussed in the May Report—members are encouraged to send comments on this subject promptly.)

Clarence Zenner notes that—while it is true that most scientists believe solar power awaits a breakthrough—there are ideas around which are promising. Among them, he notes his own proposals for securing energy from the temperature differential between surface water and subsurface water in the Carribean.

The report on the CANDU reactors provoked wide interest. However, explanations for their high capacity figures included these: the plants are 500 megawatts rather than 1,000 and do not stretch the non-nuclear technology involved quite so far as the new American plants; Ontario Hydro was said to be one of the best utilities in North America; and the Canadian regulatory staff was said not to be as tough in its readiness to shut down the plants as the American regulatory authorities (now NRC).

One respondent suggests holding nuclear power to 25% of our overall needs (electric needs?) through the year 2000 until we have had more experience with these plants and have proven them safe.

One member wants to know what it would cost the public to give up nuclear energy in terms of his own consumption—this is really a request for the study we are ourselves requesting.

William A. Shurcliff notes that there are now a few demonstrably successful ways to solar-heat a very well insulated house in warm, moderate or cold parts of the United States assuming the house site is such that the winter sunshine is not obstructed by other houses, trees or hills. He provided a survey of designs.

M. Weissbluth compared the irreversible drift of DDT into the environment with the possibility of plutonium pollution and emphasized that no long run solution to preventing such pollution has been achieved.

In assessing the risks of core meltdowns in reactors, interesting material was submitted emphasizing the startlingly high risks associated with liquid natural gas. One paper by Stirling Colgate suggests that a 100,000 ton LNG tanker is a potential megaton TNT-equivalent explosive if one of its compartments is breached. These results, falling under the title of "fluid-fluid explosive self-mixing", also apply to nuclear reactors in the case in which the core has heated up by the time that emergency coolant arrives to such a point that the temperature differential between core and coolant creates an explosion. This is evidently a new danger associated with the emergency core cooling system.

Dangers of oil burning plants for producing electricity were also emphasized in a paper co-authored by Ian Forbes; some believe these are as dangerous as nuclear plants in the event that the oil stored in tank farms is ignited. Dr. Forbes, a former member of UCS and early critic of Emergency Core Cooling Systems concludes that nuclear power is preferable, all things considered, to fossil fuels for production of electricity.

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Elaborate risk-benefit analyses by Richard Wilson support this view comparing different standards of expenditures normally incurred to save lives (seatbelts, safety devices, pollution controls, etc.) and concluding that nuclear is safer by great measure even when great extra weight is put on large disasters. In all these calculations, however, much depends on whether one believes the Rasmussen results. In turn, Dr. Wilson writes that they might be off by two orders of magnitude but, he believes, not by five.

One respondent complained that we had not given sufficient consideration to radioactive emulsions that resulted from safe operation of nuclear plants. However, nuclear proponents are maintaining that more radioactivity goes up the stack from burning coal (which contains traces of radioactive materials) than escapes from reactors in safe operation.

It was suggested that growth curves for energy are not autonomous and should be decided upon by national policy. Alternatively, it was felt they would be determined by utilities which might, for example, overbuild and then, by advertising and preferential pricing, oversell.

Another comment suggested that nuclear moderates might seem to have the middle ground but would be wiped out in a swing of public opinion to one extreme or the other. Nuclear proponents and nuclear opponents would, in fact, decide the issue.

A respondent suggests that more emphasis has to be given to human irrationality and war which has shown itself through the course of history. If dikes can be attacked, so can reactors. Accidents will happen. And if their results are going to be major human disasters, then every effort must be made to avoid their preconditions.

Some other technical observations: Although the wastes that have to be stored ultimately are small in volume (a sphere of radius 30 yards by the year 2,000), they do have to be substantially dispersed because they emit heat; hence a substantially greater volume of storage is involved—still small however in the sense that the storage site might be only a few square miles in area.

It was argued in the January Report that the ultimate disposal problem was already with us in kind (wastes from nuclear weapons construction, for example) and that the above increase in quantity made little difference in view of the small volume problem. It is counter-argued that one cannot be sure that the increase in quantity is irrelevant until one knows how secure the as-yet-undetermined method of storage is to failure; for example, a 10% leak from disposal in a salt deposit might not be serious if the quantity were small, but might be more serious if the overall quantity were ten times as large.

There is considerable scepticism that the Rasmussen study deserves full faith and credit. It was not only financed by the old AEC but ten members of that agency were detailed to work on it. The full study has not yet been seriously reviewed by the critics. In particular, the difficult and critical calculations that are involved in determining whether a core melt down will release radioactivity into the ground—or more dangerously into the air—need much closer examination.

Hazards associated with reprocessing plants where enormous quantities of fission products would be stored temporarily (perhaps 5-10 years) in liquid form should have been mentioned. And the theft of ten kilograms of plutonium, it was argued, does not require the stealing of heavy canisters during much of the fuel cycle.

It is also noted that usually quoted costs of nuclear plants do not reflect two important subsidies: capital construction of gaseous diffusion plants that provide the enriched uranium and are, as yet, still Government plants built for weapons purposes; and reprocessing facilities not yet in commercial operation.

NOTE TO CALIFORNIA MEMBERS

The Federation has not authorized the use of its name in support of the "Nuclear Safeguards Initiative". The now divested L.A. Chapter's Executive Committee had done so and its endorsement had been taken to be ours. But the initiative backers are now removing our name from new petitions. We undoubtedly contain sizable numbers of members on both sides of this issue.

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