THE VOICE OF SCIENCE ON CAPITOL HILL

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SPECIAL ISSUE ON NUCLEAR POWER REACTORS

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NUCLEAR POWER: THREE SCHOOLS OF THOUGHT CONTEND

There is a school of thought that believes, all things, considered, that America ought not produce electric power with nuclear reactors. In arguing that nuclear (fission) reactors are unnecessary, it points to the existence of huge reserves of coal, and the future potential of both fusion power and solar power. In arguing that nuclear reactors are unreliable and unsafe, it calls attention to availability statistics of current reactors and to continuing controversy over the small but important possibility of catastrophic failure of a reactor. It wonders if society and technology are up to the job involved. In arguing that nuclear reactors can be undesirable ecologically, it points to the problem of disposing of radioactive wastes for thousands of years. In arguing that reactors can be dangers to society, the nuclear opponents point to such problems as sabotage of reactors, theft of fissionable material and encouragement to worldwide proliferation.

There is another school of thought that has long believed that nuclear power was the power of the future. Arguing that nuclear power is necessary, the nuclear proponents note that not all Nations have coal and that we cannot and should not rely upon the assumption that ways will be found to produce electricity by fusion or from solar power, much less to do so in ways that have no environmental or social drawbacks. Thus, they argue, the world will not be dissuaded from developing nuclear reactors as indeed many countries are doing. Nuclear proponents document the fact that deaths due to producing electricity by coal are likely to be 100 times the deaths due to production by nuclear power (even assuming catastrophic failure was more likely than even the critics think). They point to the unique safety record of atomic energy in urging, in any case, that they be given a chance to show that catastrophic accidents will not happen.

With regard to long-term storage of wastes, they say that mankind irrevocably accepted that problem when it produced the nuclear wastes associated with the weapons problem. The present decisions on reactors only involve an increase in the quantity of wastes, not a new commitment.

In answering concerns about theft of material and of sabotage, they explain methods of making these crimes much more difficult than other already available terroristic schemes. Proliferation, they would argue, cannot be stopped by having our Nation fail

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This statement was reviewed and endorsed by the FAS National Council.

THE BEGINNINGS OF ANALYSIS

Whether one wants to make much or little use of fission power depends upon a number of values and perceptions of the energy situation. It also depends upon estimates of the capacity of modern technology and current American society to provide alternative sources of energy, and upon the complexities of nuclear safety. No analysis of the "facts" of the controversy can be fully understood, therefore, without reference to the underlying visions of the contending schools of thought. We have therefore undertaken below the doubly controversial task of describing not only some "facts" of the situation but also some involved points of view.

The Need for Nuclear Power: Proponents of nuclear power have long had a vision of cheap, clean and limitless power which would respond to mankind's growing appetite for energy as fossil fuels became exhausted. Recognizing that it has usually taken a half century for one source of energy to be largely replaced by another, nuclear scientists began after World War II to try to develop commercially usable power from the same nuclear reactions that had produced the atomic bomb.

Not long ago, AEC had projected energy demand for the year 2,000 to be on the order of 200 x 10^{15} BTU; reactors were expected to fill about 20% of that demand with about 1,000 (light water) reactors, each of which would produce about 1,000 megawatts of electrical energy. Recognizing that these reactors would eventually use up the richest and most desirable uranium fuel, the AEC also proceeded to develop another fission reactor called the "breeder". The breeder would produce not only electricity but enough fissionable material so that the fuel supply problem would effectively cease to exist.

A decade after these researches had begun, a commercial (if subsidized) nuclear reactor was producing electric power; two decades later, fifty plants were in operation with 150 more under construction or purchased. But by this time, society no longer considered every

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REPORT ON CANADIAN REACTOR PROGRAM — Pages 7, 8

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to build nuclear reactors in its own (already nuclear) country. With regard to other countries, we either have no decisive influence, or what influence we have comes from selling our own reactors or failing to do so, and either policy could be followed quite apart from whether we build reactors for our own needs at home.

There is also a third intermediate school of nuclear moderates. It argues that the problem is not one of deciding which is "better" for producing electricity, fission or coal—certainly not whether nuclear or solar is better (since solar cannot now be used for generating practical electricity at all). It sees potential advantages and disadvantages in all present and proposed methods of generating electricity and it wants to keep its options open. This school sees prudence in avoiding the dominance of our energy sources by any method—whether coal or nuclear. It is as afraid of the possible greenhouse effect on the world's climate due to burning fossil fuel as it is the small probability that a reactor may melt down.

This school sees dangers everywhere, certainty nowhere; for it, prudence includes maintenance of a vigorous sector of fission power until such time as at least one major nuclear accident certifies that the opponents were right. After all, it argues, even that terrible accident will represent a net saving of lives over those otherwise lost to coal. In any case, the moderates would conclude, it is too much to ask of mankind that it give up one of its only major sources of energy on speculation.

This view sometimes believes that the opponents of nuclear power are now as sensational as the proponents were dogmatic. It wants the debate to rise above the qualitative arguments. It seeks a quantitative discussion of those issues that lend themselves to it and in view of the scope of the issues and the uncertainty, it asks for a sequential strategy perserving flexibility against the chance that a wrong decision is made. Thus it asks such questions as how many plants should be permitted on the basis of how many reactor years of experience. It wants to know which problems can be avoided by spending how much money, varying reactor design, proceeding cautiously, watching the successes of others, and so on.

Because the issue is one which deeply involves both science and the Nation's future, it behooves each of FAS's scientists with their quarter century old tradition of concern to give it more than passing consideration. We are asking, therefore, that our members respond to this January issue of our Report with their comments, opinions, suggestions (and also criticisms of our presentation). In the body of the Report we have provided statistics and analysis with which to stimulate your thinking. After devoting the February issue to another topic to give you time to respond, we will devote the March issue to carrying this discussion further.

US PLANT EFFICIENCY PEAKING AT AGE FOUR?

1974 Nuclear Plant Capacity Factors vs. Age of Plant

Years of Service	No. of Plants	Average Plant Capacity (Percent)
0-1	3	48
1-2	9	58
2-3	4	48
3-4	3	67
4-7	5	54
7+	3	38

(see page 4, first column, top)

The Federation of American Scientists is a unique, nonprofit, civic organization, licensed to lobby in the public interest, and composed of natural and social scientists and engineers who are concerned with problems of science and society. Democratically organized with an elected National Council of 26 members, FAS was first organized in 1946 as the Federation of Atomic Scientists and has functioned as a conscience of the scientific community for more than a quarter century.

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possible technological advance to be "progress"—both the ABM and the SST had followed such proposals as the nuclear powered airplane to oblivion. And a new school of environmental thought questioned and opposed the underlying premise that energy use would and should increase rapidly.

This new school considered energy an addiction, especially when it arose from non-renewable sources. Nuclear power, though limitless, was simply another temporary fix on the road to environmental disharmony leading somehow and sometime to an inevitable crash as unnecessarily energy-intensive standards of living became insupportable. Even if the energy were available, it reasoned, the earth's atmosphere would eventually heat up noticeably from the total use and climactic changes would result from these thermal limits.

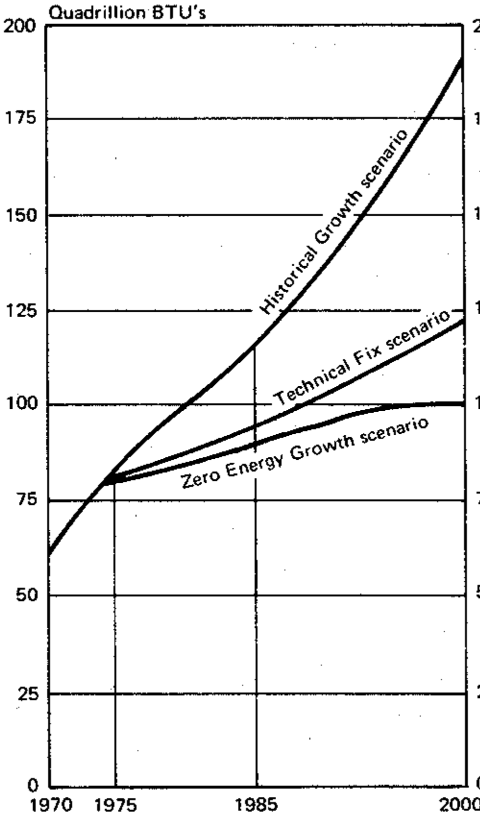
Nuclear power also had dangers and public scrutiny of power plant plans was in order. A generation before, angry and concerned scientists had set up the Atomic Energy Commission so as to ensure maximum secrecy and tight control over atomic energy. But the environmental generation saw in those same characteristics, bureaucratic obstacles to their scrutiny, paternalistic attitudes, pig-headedness, a sacrificing of safety to promotion and so on. Their efforts to influence AEC activities became, for them, a kind of "bureaucratic Watergate" in which the coverup became as much of an issue as those of substance. In the struggle AEC was divided in two (ERDA and NEC) and forced to become far more responsive.

Conservation Becomes Fashionable

The Arab oil boycott focused the debate and made a new notion fashionable—conservation. Both the Ford Energy Project and the Sawhill Project Independence Report concluded that the rate of growth of energy use could be cut in half to about 2% if conservation methods were both encouraged and required by Government. Both reports urged better insulation, more economical cars, and explained, in these and other cases, how the conservation could pay for itself if suitable financial methods were developed, e.g., to amortize the capital investments needed through reduced fuel bills. But could the reduction actually be achieved? Nuclear proponents said "lots of luck, fella" to the notion that society could rapidly and dramatically change its ways. But nuclear opponents pointed to higher Arab oil prices, the specter of shortage, and a related recession as mechanisms; formidable pressures to do the implausible. Nuclear moderates also considered the original energy estimates to be blind extrapolations of temporary and saturatable spurts in use—such as that of electricity stimulated by such innovations as air conditioning.

Nuclear opponents tended to say nothing about coal; they numbered among their troops environmentalists that knew the dangers of fossil fuel reliance only too well. Instead, they focused on the desirability of using solar energy. Arguing that utilities had never had any interest in bypassing their supply of oil or gas, and that the Atomic Energy Commission had had no interest in non-nuclear power either, they claimed that this disinterest had held back the use of solar power. Most scientific

FORD ENERGY POLICY PROJECT



Source: Energy Policy Project

observers believe, however, that the use of sunlight to generate electricity and, in general, to provide concentrated energy is far off and awaits some unexpectedly good scientific idea. Moreover, electricity generation by sunlight, like fusion power, is the beneficiary of our ignorance of its details. Implementation may well bring unforeseen problems as they have with fission—once itself considered a panacea. Electric power from sunlight will require large amounts of capital and land and could have climatic implications depending upon how much heat was pumped from where to where. Problems of storage are also possible since storage is critical for periods in which the sun does not shine.

Wind power is slightly more feasible. The main use of sunlight is for heating and cooling of buildings. Here the problem is one of persuading many homes to adopt this method in an only slowly changing pool of housing and commercial buildings.

In general, nuclear proponents would argue that "solar power" is simply a slogan of anti-nuclear power people who cannot reach a consensus on any other kind of power.

ECONOMIC CONSIDERATIONS

The upshot of economic considerations is this. The three options for electricity generation for the forseeable future are: nuclear, coal and oil. According to the AEC, in 1973 dollars, for plants that might come on line in 1981, power generation costs for nuclear, coal and oil are 15 mills per kilowatt hour; 18 mills per kilowatt hour and 33 mills per kilowatt hour. Nuclear plants would continue to be advantageous over coal even if

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plant capital costs went up 24% from $555 to $674 or if nuclear plant utilization went down from 80 percent to 65 percent. (However, a recent survey of nuclear plant capacity suggested that 3-4 years are required before plants reach the expected 80% capacity after which they decline over the next few years to as low as 40% capacity. See a reprinted table on page 2. The reason for the decline is said to be wear-related problems and enormous amounts of time spent trying to repair components under radioactive conditions. If this is true, economic factors would decide the situation. (See David Comey, in November, 1974 Bulletin of the Atomic Scientist.) Since oil is both more expensive and fails to have reliability of supply, the basic choice arises between coal and nuclear.

There is enough coal; hundreds of years worth of present level consumption exist in America. But to rely solely upon coal-fired plants to fulfill increases in demand would require a great increase in coal production. Two-thirds of coal production is already devoted to generating electricity. Sixty percent of the Nation's coal reserves contain one percent or less sulfur by weight and most of this is in the West. (However, the Clean Air Act Amendments of 1970 require something more stringent still —1.2 pounds of SO_2 per million Btu's or about .6% sulphur—and this is fulfilled by a still smaller portion of reserves found in the Great Plains, Rocky Mountain and Pacific Coast.)

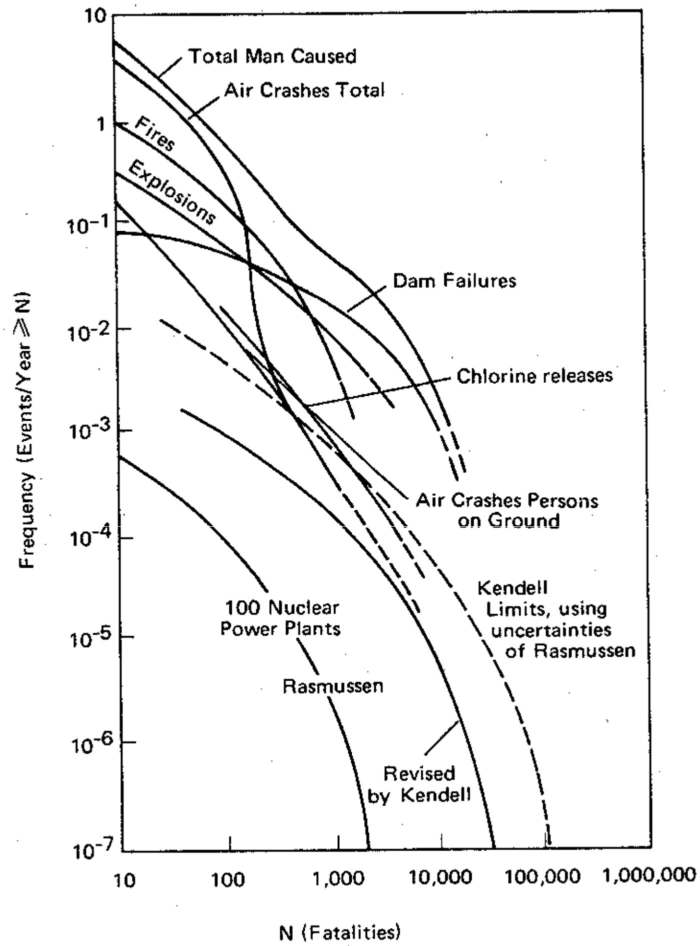
The Project Independence Report concluded that the coal industry could do the job but only if "resolution of major uncertainties" was effected for coal industries:

> "The Coal industry has the capacity to satisfy almost any foreseeable demand for coal by 1985, at prices near 1972-1973 levels and considerably below current spot market levels. To the extent that investment decisions will have to be made in the immediate future to achieve long-range production goals, a sufficient return on investment and resolution of major uncertainties will be needed."

Health Problems of Nuclear Power

Proponents calculate that the loss of life due to a 1,000 megawatt reactor nuclear power plant, when operating safely, is about one life every two years: e.g., conventional mining accidents in securing uranium ore, and radiation related deaths of about one every ten years. What about unsafe operation? The graph on this page is the Rasmussen conclusion showing the probability of fatalities of various sizes. Superimposed on it is a line provided by the Union of Concerned Scientists study based on its appraisal that the fatalities for each accident are in fact larger. In the Rasmussen case, the actuarial hazard is evidently less than a single casualty per year per 100 reactors—so low are the probabilities. In the UCS case, even with uncertainties, the losses are on the order of 10 lives a year for 100 operating reactors. UCS increases in fatalities are based on its conclusion that Rasmussen underestimated radioactivity in the core by a factor of as much as 2; understated prompt fatalities, latent cancers, genetic effects and thyroid illness by factors of from 2-6, and relied inappropriately on prompt and effective evacuation.

RASMUSSEN CONCLUSION WITH KENDELL AMENDMENT



Of course, UCS has other criticisms arising from the estimates of probability. These admittedly ignored sabotage. More generally, they relied upon a fault-free analysis which UCS believes cannot be depended upon to establish definitively that probabilities of failure are at any fixed absolute level. (For example, the question could always be asked: "What is the probability that the analysis is seriously deficient?" and this probability is always higher than the very small probability of accident derived by the analysis.)

The Rasmussen study concludes that the reactor core will melt down about 1/17,000 per reactor-year or 1/170 per 100 reactors per year. With 1,000 reactors, this would be once in every 17 years. (The year 2,000 is more likely to see only 600 reactors at current rates of construction.) It concludes however that the radioactivity would likely be released into the ground. UCS is concerned about the off-shore plants now planned which would, if they melted down, melt down into the sea. And it notes that at least one subsystem of the Emergency Core Cooling System (ECCS) called the High Pressure Coolant Systems (HPCS) have failed in practice at a rate 200-3000 times greater than that projected in the Rasmussen study.

A report to AEC quoted by UCS notes that both German and French experience with tens of thousands of pressure vessels in the sixties produced large scale or catastrophic failure rates of 2 x 10^{-5} per vessel year. The British have evidently decided, partly for the above reason, to avoid the use of a pressure vessel and to use the pressure tube type of reactor used in Canada which signals problems by gently leaking rather than by more massive failure. (See Page 7 on CANDU reactor).

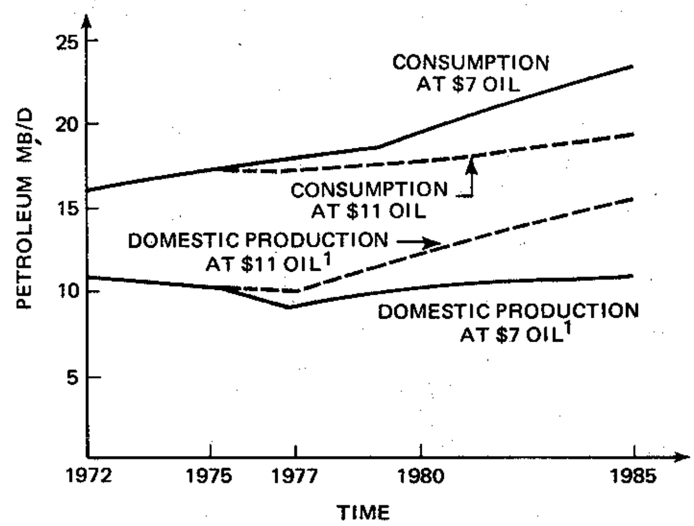
For the next few decades, these hazards have to be compared with those of coal. Per 1,000 megawatt plant, about one miner dies in an accident providing the fuel but, in the past at least, about 100 have gotten black lung (pneumokoniosis). (The latter number could decline with better dust standards in deep mines and with more reliance on strip mining.) The sulphur in the coal produces sulfur dioxide; 60% of such emissions are due to burning coal to make electricity. The sulfur turns to sulfuric acid and acid sulfates and is, increasingly, producing "acid rain" across the country and especially in the North East. In conjunction with particulants, the results of these emissions are: aggravation of health and lung disease in the elderly; aggravation of asthma; respiratory disease in children; aggravation of chronic respiratory disease such as emphysema. According to some estimates, these dangers alone amounts to 40-100 deaths per 1,000 megawatt plant. Thus replacing 200 such coal-fired plants with nuclear plants might save 10,000 lives a year—this would be a net saving unless the nuclear plants were to have the most serious accident each and every year! That would require that even the Kendell safety study curve were off by a factor of 100,000. In addition, many non-fatal health effects result from fossil fuel burning. NO_x and oxidants provide other insufficiently studied health hazards. (The 1968 air pollution study of EPA suggested $16 billion in environmental damage due to all types of pollutants—of this about $8 billion is due to burning coal for electricity generation or about 2 mills per kilowatt hour.)

The health effects of burning fossil fuels are not as well studied as one would expect; much more has been spent on health effects of radiation! But one ominous general result is the "greenhouse" effect in which the CO_2 layer produced by burning fossil fuel increases the temperature of the earth's surface by letting solar heat in, but not out. Burning of fossil fuels has already increased the CO_2 content to 323 parts per million. Possibly for this reason, the mean average temperature has increased by about .5° Centigrade. This possibility of climatic effects has to be compared with the global problems of a world going nuclear.

Theft:

The American light water reactors produce Plutonium 239 as a byproduct and they use enriched Uranium as a fuel. According to the basic work in the field (Nuclear Theft: Risks and Safeguards; Mason Willrich and Theodore B. Taylor) a few persons, possibly even one person working alone, could build a crude fission bomb with about ten kilograms of plutonium within several weeks if they were "reasonably inventive and adept" at using machine shops and knew where to find and could understand widely distributed technical materials on these subjects. It notes, however, "whoever was principally involved would also have to be willing to take moderate risks of serious injury or death" from handling the material.

PROJECT INDEPENDENCE CONCLUDES $11 A BARREL OIL REDUCES DEPENDENCE BY 2/3 RDS



[1] INCLUDES NGL

The theft is not so easy as it sounds. The hijackers would have to steal at least six tons of cargo to have enough plutonium for a crude bomb in view of the weight of the containers; the fabricated fuel required to yield enough plutonium for the bomb would itself weigh 3,300 pounds. The gang stealing the material would be separating out its ten kilograms while a fantastic search proceeded for its machine shop (which would have to include the ability to handle the heavy containers) in which the activity was taking place.

Nuclear proponents would argue that the scenario is most implausible for anything except an IRA gang or Arab terrorists and these internationally linked organizations would be more likely to obtain the material abroad than to steal it here. In any case, much depends here on the precautions against theft and it is significant that the author of this basic work sees signs of progress. After testifying that precautions were not, in his view, adequate, Dr. Theodore Taylor said:

> "I hasten to add, however, that this situation is now changing *very* rapidly in the United States, as a result of recent actions by the AEC. I am also convinced that a *very* high level of security for all such materials in the United States can be achieved . . . which would make success "highly incredible". (italics in original)" (July 15, 1974 before the Senate Committee on Banking).

Sabotage: Nuclear opponents rank sabotage by terrorists as a real threat; proponents consider it quite difficult to sabotage a plant so as to cause important population damage. For example, in one scenario, the saboteurs would first have to rush the plant successfully and overcome the guards and then be sufficently sophisticated to decide how to sabotage the plant. Moderates would argue that if a plant were sufficiently well guarded, especially if they are placed in nuclear parks (locations

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containing several plants) it should be possible to make plant takeovers less likely than plant accidents. Further safeguards would be associated with automatic methods of shutting down the plant, turning off the control board and so on, in the event of unauthorized entry.

Waste Disposal

Throughout the Post War period, all nuclear powers were producing substantial quantities of nuclear wastes that will remain dangerously radioactive for as much as 1,000,000 years. The power reactor program will provide still more. Each 1,000 megawatt reactor will produce few cubic yards of material per year when solidified in a glassy ceramic material. The total volume of wastes that will have been accumulated domestically by the year 2,000 would not exceed the value of a sphere with 20 yard radius (550,000 cubic feet).

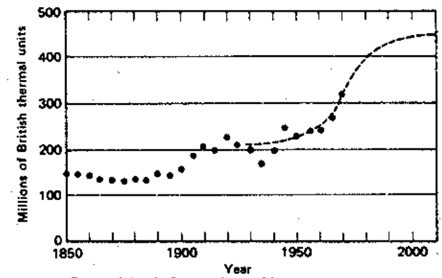
In short, the problem is not new. Nor is it one of space. And it is certainly not one of funds since no scheme for disposal of these wastes will cost even a small fraction of the cost of the nuclear program. The problem is how and where in light of the large quantities of waste expected.

The most popular solution is to place them in salt mines which can be identified as having been undisturbed by geologic processes for 250,000,000 years or 250 times the period they require to "cool off". Other possibilities are to fire them into the sun with the aid of the evolving space shuttle, to place them on an Antarctic or Greenland ice cap or in deep mines. While a decision is being made, they can be kept in mausolea: retrievable storage vaults under ground in remote areas until this generation or the next is quite sure what it wants to do.

Nuclear opponents find it disturbing that the nuclear power program would go forward without a definitive solution to this problem and a consensus upon it. Nuclear proponents tend to think it a problem which need not be solved in a hurry and often argue for the SALT mines (but local opposition in Kansas made the Kansas site unusable.) Nuclear moderates consider it a problem which we already have, notwithstanding the power program, and see the increase in volume as irrelevant. Indeed, the volume of area that would have to be walled off to contain the wastes is vastly smaller than the Nevada nuclear proving grounds which is already contaminated and will require comparable walling off for comparable periods of time. (Some have suggested storing the wastes on this already contaminated spot.) A further fear of opponents however is the sheer quantity of dangerous material, quite apart from volume, that would lead to contamination if something went wrong.

It has also been suggested that the longest lived wastes (called actinides) be burned up in reactors so that only wastes with half-lives of 30 years or less would have to be stored. (Future reactors could do it even more efficiently.) Such wastes would cease to be troublesome in about 700 years. One undiscussed possibility is that future technological progress may resolve this problem long before the wastes cool off. For all we know mankind may find these wastes useful over hundreds, thousands, and even tens of thousands of years! We are, after all, only a quarter century into the nuclear age. Obviously the problem deserves close attention. But how much does it have to do with whether we develop a nuclear power program?

PER CAPITA ENERGY CONSUMPTION TO 2010*



*Fisher, *Energy Crises in Perspective*, p. 24

Proliferation: In terms of the struggle against nuclear proliferation, reactors are a disaster. Recall that the initial estimates on nuclear proliferation prepared in the fifties were terribly over pessimistic. They failed to consider the political obstacles to bomb production and concentrated only on technical feasibility. One of the major political obstacles was the need to take a political decision fairly far in advance of building a bomb by assembling the know-how and equipment. Suddenly a device arises—nuclear reactors—which will provide most of the long lead time items under the guise of peaceful uses of power, indeed under the guise of a showcase of modernization. For those most opposed to proliferation, little could be worse.

Is Non Proliferation Lost?

Some would argue that the non-proliferation struggle is basically lost in any case. In fact, this struggle has always been only of slowing down the rate of diffusion. Viewed in this form, the existence of power reactors tends to provide a new rung on the proliferation escalation ladder in which countries can become sub-nuclear by having a nuclear reactor. Corresponding pressures will arise on their neighbors to be no less (sub) nuclear.

The most disturbing part of this situation is the knowledge of all concerned that nuclear reactors are not going to solve the power problems of most of the third world countries involved. Thus selling nuclear reactors to relatively poor countries can be compared to giving a gun to a child disguised as a lollypop. The dangers are further evident when, as in South Korea or the Middle East, the countries at issue are presently engaged in a long war.

Probably, for most FAS members, the question of reactors and proliferation turns on ways of preventing their sale to countries who have no real use for them. Presently, five countries are exporting reactors: U.S., Canada, West Germany, Great Britain and the Soviet Union. It is possible to reach agreement on limiting reactors sales? Would this agreement be any easier or more plausible if the United States did or did not itself build reactors for itself? Could the double-standard decision not to sell to some countries be based on the underlying reality that these reactors are inevitably going to be somewhat experimental for a generation and on their unsuitability for the power program of a given country? Should not each exporting country consider the sale of reactors to specific countries as a serious foreign policy problem equivalent to providing a region with a latent bomb? □

CANADIAN CANDU REACTOR PROGRAM SURPRISINGLY SUCCESSFUL

A visit to Toronto provides an eye-opening example of a nuclear program without many of the problems afflicting the United States.

In the first place, it is widely considered that the Canadian reactors are safer against catastrophic accident than the American light water reactors. We place the reactor inside a large pressure vessel which can conceivably crack and which is highly vulnerable to loss of coolant. The Canadian reactor is based on a dispersed reaction taking place in hundreds of tubes. It is far less vulnerable to complete loss of coolant; surrounded by a moderator of heavy water and held at low temperature so as to represent a heat sink, the heavy water reactors do not suffer extensive melt downs.

In the second place, the CANDU (Canada Deuterium Uranium) reactor uses natural (unenriched) uranium as its fuel avoiding the necessity both for enrichment itself and for handling enriched fuel. This helps the theft and handling safety problems.

Also, at present at least, CANDU is being used on a once-through basis in which the spent fuel rods, with their load of plutonium, are simply taken out of the reactor and stored at the bottom of a large swimming pool under water. The plan is to sell the plutonium eventually if a market arises for it in a future breeder based nuclear economy. While the long term storage problem has not been resolved, the use of a nuclear "park" (the Pickering site has four plants and is moving to eight) and the presence of the waste disposal pool at the park avoids transportation problems.

CANDU Working Well

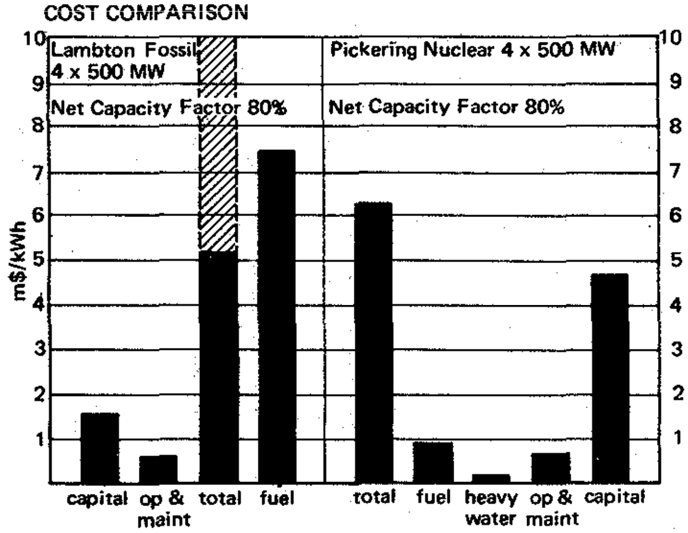
Finally, the CANDU reactors are working surprisingly well. True one of the Pickering site plants is in the midst of an eight month overhaul due to leaking pressure tubes. But it is believed that the reason for the leaks is specific to that particular plant leaking. Meanwhile, the capacity factors achieved by these plants show that, in general, they are working better than any other in the world. The average gross capacity factors of Pickering heavy water plants and of worldwide light water reactors above 400 megawatts are dramatically contrasted in the following table:

	CANDU-PHW	PWR	BWR
1971	79.8%	70.6%	51.9%
1972	81.3%	69.7%	57.6%
1973	84.7%	57.5%	60.6%

Evidently, the heavy water plants have capacity factors very significantly higher than the pressurized light water plants and much higher than the boiling water reactors. Of 32 plants worldwide of all kinds, the four Pickering plants rank 1st, 2nd, 3rd and 10th in gross capacity factors for 1973.

Will they continue to work well and be economical? Ontario Hydro, the publicly owned utility that has built the Pickering plants, evinces considerably more confidence in its nuclear plants than in its fossil fuel plants (with which it had considerable trouble the preceding winter). It expects plants to be down from time to time for one reason or another and sees no unfortunate portents in the current problems of a single Pickering generator. Instead it is moving to buy four more plants at the Pickering site. With the high costs of coal, the Pickering nuclear plants are to produce electricity at half the cost of the *fuel alone* at the fossil fuel plants. (See above.)

CANADIAN COSTS FOSSIL VS. NUCLEAR



Ontario Hydro foresees large cost advantages to nuclear energy; in the last 18 months, low sulphur coal costs have further increased the advantage by doubling the fuel costs of fossil plants to 10 mils per kilowatt hour or more than the total costs of nuclear energy.

ONTARIO HYDRO FORESEES THIS RELATIONSHIP ....

Canada is considerably more tranquil on the nuclear safety issue than America. The loss of confidence in authority that has afflicted America since the Vietnamese war has not crossed the border. Men on the Canadian street refer contemptuously to the occasional politician that may raise safety issues "for political reasons." The Atomic Energy of Canda Ltd. spokesmen, who have to answer the public concerns, note that the uneasiness travels up the U.S. East Coast into Canada and then down the St. Lawrence, but diminishing all the way and finally petering out.

Canadian officials involved in the program view the American scene as one of widespread hysteria; their fear is that the American state of mind may eventually cross the border and affect their program. The last thing in the world they want to do is to criticize the safety of U.S. plants lest this only add to the general concern about the safety of all nuclear programs. They assume, as Americans once assumed, that whatever the designs are, competent engineers can and will make and keep them safe.

There are some special safety problems facing the Canadians. For example, the use of heavy water means the inadvertent production of some tritium which is dangerously radioactive and hard to contain, forcing the wearing of gas masks inside parts of the plants. A spe-

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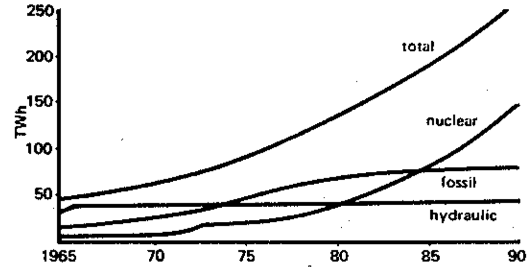
ONTARIO PLANS NUCLEAR DEPENDENCE IN 1980'S



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cial problem is the plans for an airport near the Pickering site—the flight path will be only four miles away from the site. Calculations were made, however, and it is believed that the heaviest planes anticipated (747s) would have to be flying 400 miles per hour to penetrate the four foot walls of the containment building around the reactor. Since they approach landing at speeds under 200 miles per hour, the danger is considered neutralized by the containment building. One senses, however, that an examination of the program on the same very rigorous basis that outside critics are examining the American program might well produce other stray problems (e.g., what if a plane flies into the swimming pool containing the fuel rods with their plutonium.) The Canadians have never done the kind of Rasmussen study done here.

The CANDU reactor lends itself, unfortunately, to proliferation. Using natural uranium, as it does, nations planning to build a bomb need not fear being cut off from great power suppliers of enriched uranium. (Enriched uranium is currently made from very expensive and complicated gaseous diffusion plants.) Such countries would require a chemical repossessing plant to separate out the plutonium from the spent rods but this is a simpler process and within their means. (It is a chemical process, rather than a process of separating isotopes of the same element, always more complicated).

Indian Bomb Stimulated Interest

After the Indians exploded their bomb, produced with Canadian nuclear technology, the Canadians received a spate of inquiries about buying CANDU from such states as South Korea and Argentina. Indeed, the day that FAS's Director interviewed Atomic Energy of Canada, it was planning to sign an agreement with South Korea (which already has a Westinghouse reactor). The Canadian parliament is moving to tighten rules against misuse of these reactors and to define more tightly what a "peaceful use" is since the Indians defended their bomb as peaceful.

The Canadians who want to sell reactors use the argument, that American salesmen use also, that "someone will do it if we do not". But, unlike our case, the motivation may not really be economic. In fact, little is really earned since buying countries usually insist on providing whatever plant parts they can themselves. Instead, the underlying Canadian motivation may be self-respect and the desire to persuade their countrymen that Canada has indeed developed a product as good or better than that in America. Besides this benefit, these sales may also help Canada withstand a possible future crisis in which the Americans discontinued reactor construction.

What one learns in Canada, ultimately is this: the design of nuclear reactors is not God-given. The Canadians, who emerged from war-time efforts to build a bomb with a surplus of heavy water facilities, were encouraged by this fact to move in what seems to have turned out to be the most promising direction for civil power—the heavy water reactor. The Americans, who emerged from World War II with an excess of enrichment plants and who developed reactor power through the demands of the nuclear submarine program have, instead, emphasized a program of civil power that is a spin-off from bomb-building and submarine power. Less specifically engineered for civil power, it is no surprise that it may be inferior for this purpose. Moreover, one gets the impression that Canadian engineering has been the beneficiary of the limits of the Canadian economy. It avoided large pressure vessels, for example, in part because it could not build them.

Evidently there are many ways to skin this particular nuclear cat. If reactor safety is the fundamental problem with the nuclear power program—as most observers probably would conclude—than one is forced to recognize that a U.S. decision on reactors ought not be contingent on a single design.☐

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