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VIEWPOINT

In search of the peaceful atom

Whatever became of the 'peaceful atom'? Three decades ago, in the mid-1950s, it was all the rage. US President Dwight Eisenhower, addressing the General Assembly of the United Nations, had launched Atoms for Peace - both the phrase and the programme. One of its first major manifestations was the inaugural Geneva Conference on Peaceful Uses of Atomic Energy, in 1955, The title will be echoed later this year, albeit with salient differences, when the UN Conference on International Cooperation In the Peaceful Use of Nuclear Energy convenes, once again in Geneva. For a UN megaconference it has been given an unfortunate acronym. PUNE looks and sounds entirely too much like 'puny'. Looking back to the expectations of three decades ago - to say nothing of those only a decade ago - some might consider the label apt. What, indeed, has become of the 'peaceful atom'?

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Note: This viewpoint was written before the Chernobyl incident at the end of April 1986.

Nobody refers to the 'peaceful atom' any more. Nobody, in English at least, even uses the term 'atomic energy'. It is 'nuclear power'; and it is now coming to the end of its first generation of policy and of technology. What has it to show for three decades of effort and money? There are now some 350 power reactors in operation worldwide, nearly 200 more under construction, and perhaps another 130 said to be planned. The total installed nuclear generating capacity is well over 200 GW. In some countries - France, Belgium, Switzerland, to name but three - more than half the electricity used comes from nuclear power stations. Electricity supply organizations say that nuclear power produces much the cheapest form of electricity. For an innovative, complex and demanding technology like nuclear power, are not such major achievements within three decades surely a sign of runaway success?

Not entirely, as a closer look rapidly reveals. Behind the glossy facade ot the world's nuclear power programmes bubbles a morass of uncertainty. Question marks continue to hang over the economic status and competitive prospects of nuclear electricity; over the future of the uranium supply industry; over enrichment technologies; over radioactive waste management and disposal; over stubborn issues of safety; over the social and political context of civil nuclear policy; and over the corrosive difficulty of separating civil nuclear activities from military.

Electricity use in western industrial countries has fallen dramatically short of the levels anticipated only a decade ago. The need for additional generating capacity, of whatever kind, has likewise evaporated. As a result the world's power-station construction industry has been caught up in a cutthroat battle for orders. In the home countries of the major plant suppliers the number of orders for new power stations of any kind has dwindled to near zero. The collapse of domestic programmes has been dramatic.

Even to replace old plant nuclear power is not necessarily the obvious choice. The economic status of nuclear electricity in the mid-1980s is not easy to establish with precision or confidence. It is profoundly influenced by interest rates; construction times; currency exchange rates; costs of competing fuels and power stations; long-term costs of radwaste disposal and decommissioning: and assumptions about power-station lifetimes and capacity factors. These influences vary from country to country, from utility to utility, and indeed from day to day, as the world oil market reverberates. What can be said with conviction is that nuclear electricity has yet to demonstrate that it will always be cheaper than fossil-fuel options. On the contrary, in some countries and regions - for instance the north-eastern USA - the cost of coal-fired electricity has kept pace with that of nuclear electricity, as is conceded even by the Atomic Industrial Forum.

The capital requirements of nuclear power are proving daunting, even to major utilities. Partly as a consequence, the expansion of nuclear capacity in the Third World, blithely forecast a decade ago by the International Atomic Energy Agency and others, has not happened; nor is it likely to happen in the near future. To be sure, Third World countries are starved of generating capacity. They are also, however, starved of hard currency, so much so that some are already under intensive care from the International Monetary Fund. The last thing such countries need is imported technology that uses vast amounts of capital and minimal local labour. Except for a handful of industrialized Third World countries like Argentina and South Korea, most Third World countries do not have - especially in rural areas - either the appliances to use the electricity or the grid to distribute the output of a single present-day nuclear power station, 1000 MW or more.

Reactor manufacturers faced with vanishing domestic prospects and eager for orders have until recently looked to the Third World as the promised land. In the mid-1980s, however, even this lingering hope is looking evanescent. Constraints on capital and infrastructure mean that even hitherto likely clients like Taiwan and South Korea are cutting back. Egypt continues to haggle; and Turkey insists that the plant-suppliers not only build the power stations but also operate them, selling the output to earn their fees. The brightest hope of all has been the People's Republic of China, proposing a programme of 20 000 MW of nuclear capacity by the year 2000. Western nuclear salesmen, however, have come back from China repeatedly empty-handed, as the Chinese up the ante and demand ever-more generous terms and conditions. Western firms may yet sell some nuclear technology to China; but the likelihood is that the Chinese will straightaway clone it to the best of their ability and leave the Western vendors stranded.

Some commentators feel that the Third World may nevertheless have one major lesson in store for Western nuclear interests. A key reason for the climbing capital cost of nuclear plants has been increasing concern about safety of such plants, and insistence on ever more elaborate and expensive precautions. Thus far much the most serious accident in the civil nuclear industry has been the partial meltdown at Three Mile Island 2 in the USA. Its financial cost has been crippling; but its health effects appear to have been negligible. Such may not be the case for the next major nuclear mishap. After the catastrophe at Bhopal, in India, many fatalistic observers feel that nuclear technology in the Third World - short of cash and trained staff - may be another accident waiting to happen. If it does - wherever it does - the impact on nuclear power worldwide may be terminal.

A bleak picture, then, confronts the reactor manufacturers in the mid-1980s. They are nonetheless in the main large and powerful corporations; and the most experienced among them, like General Electric of the USA, are taking a very long-term view of the nuclear power business. If they cannot make money by selling reactors, they can make it by servicing the ones already sold. Repairs, maintenance, upgrades and fuel supply are now where the nuclear profits lie. Utilities operating nuclear power stations are looking for higher capacity factors and for higher burn-up from fuel, to realize more output from a given unit. Leading US, European and Japanese nuclear engineering firms are vying for orders for improved plant components and fuel. Such firms tend to be diversified and well able to weather the rough times in which they now find themselves. Even so, they have had to close some once-thriving manufacturing facilities and lay off highly skilled staff.

The uranium mining and milling companies have had in the past decade even more turbulent ups and downs. From a peak of over US$40/lb the spot price of uranium is now hovering significantly below US$20/lb. Long-term uranium supply contracts already signed are being traded between utilities at marked down prices, as plant cancellations and higher burn up reduce their fuel-supply requirements. Unlike the reactor vendors, the uranium suppliers are often less able to diversify. Accordingly, some of the smaller concerns may not survive. Ironically, the almost total cessation of exploration is meanwhile setting the stage for yet another possible lurch into shortage rather than glut of uranium after the turn of the century.

Enrichment, too, is in confusion, technical as well as economic. Gaseous diffusion appears to have run its course, although it is still the operational choice of France and the USSR. The UK, with FR Germany and the Netherlands, has moved to gas centrifuges; but the USA abruptly cancelled its planned gas centrifuge plant, after an outlay of over US$2 billion, in favour of atomic vapour laser isotope separation. Whether this technological leapfrog in due course restores US supremacy in enrichment services will depend on whether this novel and demanding technology works reliably and economically on a commercial scale. Answering this question will entail expenditure impressive even in nuclear terms; and the answer may still be 'no'. In any event, the existing enrichment capacity worldwide seems likely to constitute a buyer's market for years to come.

So much for the 'front end' of the so-called 'nuclear fuel cycle': what of the 'back end'? In the mid-1980s it is growing progressively more difficult to accept the concept of a 'nuclear fuel cycle' at all. The original concept seems to have arisen when uranium was scarce and costly. Only seven atoms in every thousand are uranium-235, the sort that will support a chain reaction. But the same chain reaction turns the useless uranium-238 into plutonium, which will also support a chain reaction. Ergo: burn uranium fuel as long as possible: separate the spent fuel chemically, by 'reprocessing', to recover unused uranium and newly created plutonium; and use this recovered uranium and plutonium to make fresh 'mixed oxide' fuel. Better still, burn the recovered plutonium in a 'fast breeder' reactor that would produce more plutonium than it burned.

The concept is striking; but the reality has proved less so. Uranium is now known to be plentiful, indeed embarrassingly cheap. In the mid-1980s a utility concerned to ensure long-term nuclear fuel supply can readily and conveniently buy and stockpile fresh uranium if it so desires; the material is compact and easy to store, even in quantities for decades ahead. Reprocessing of modern high-burn-up fuel, on the other hand, has proved to be a technical challenge at the outer limit of feasibility, and punishingly expensive. If the cost of reprocessing is charged against the fabrication of mixed oxide fuel, such fuel becomes drastically uncompetitive with conventional enriched uranium fuel.

Until recently, the cost of reprocessing has been charged not against the fresh fuel but against the original thermal reactor operation. The justification for this assignment of cost has been the assertion that spent fuel has to be reprocessed as an essential stage in nuclear waste management. That assertion has now become profoundly debatable, especially as it applies to modern oxide fuel. A modern fuel element is a durable unit of high-integrity engineering. designed to withstand the conditions inside an operating reactor. Reprocessing involves chopping up this element, dissolving it in acid and subjecting it to chemical processes that create an assortment of gaseous, liquid and solid wastes. Some of these are discharged directly to the environment. Others require further processing to return them to solid form. The volumes thus arising are well over one hundred times those of the original spent fuel. The concentrated liquid 'high-level waste' must be resolidified, as glass or synthetic rock; neither of these techniques can be considered adequately proven as a way of guaranteeing the permanent isolation of the long-lived wastes. Nor has geological research yet established with confidence that such wastes can be placed underground in irretrievable final disposal in such a way that they cannot return to the biosphere.

That being so, utilities and planners are coming to the view that the appropriate policy is to provide for long-term storage of intact spent fuel, pending resolution of the present uncertainties. Such long-term storage, possibly in dry gas-cooled or air-cooled magazines, has been shown to be feasible, safe and indeed substantially less expensive than reprocessing with all its consequent ancillaries. Sweden, the USA, Canada, and other major nuclear countries have opted for long-term storage and rejected reprocessing, at least for the foreseeable future. On the other hand, to be sure, long-term storage leaves open the option of reprocessing, should it eventually be found necessary as a precursor to final disposal.

Reprocessing to extract plutonium is nevertheless an essential stage of the 'fuel cycle' associated with fast breeder reactors. From the inception of civil nuclear programmes plutonium-fuelled fast breeders have been envisaged as the culmination of the technology, breeding their own fuel even as they generate electricity. This vision has, however, receded steadily, until even official policies now concede that fast breeders are unlikely to be commercially credible until well into the 21st century. France's 1200 MW Super-Phenix, the world's first full-scale fast breeder power station, went critical in September 1985. But the celebrations were shadowed by the acknowledgement that electricity fromSuper-Phenix would be more than twice as expensive as that from conventional French nuclear plants.

Be that as it may, a number of other countries continue to pursue the development of plutonium-fuelled fast breeders, among them FR Germany, Japan, India and Pakistan. In each case the stated official aim is to 'close the fuel cycle'. Suspicions remain that nuclear policy makers in such countries may harbour a different and darker motive. Civil plutonium technology is in crucial respects indistinguishable from nuclear weapons technology. Indeed, the UK continues to use its Sellafield reprocessing plant to recover not only civil plutonium from its commercial nuclear stations but also bomb plutonium from its military plutonium-production reactors. France is even on record as reserving the right to use high-quality blanket plutonium from its Phenix and Super-Phenix fast breeders for French nuclear weapons.

Of all the problems facing nuclear power, this is undoubtedly the most intractable: the apparently indissoluble link between civil nuclear activities and nuclear weapons. Since the advent of 'Atoms for Peace', the most thoughtful proponents of civil nuclear power have striven mightily to separate civil and military nuclear power. To some extent they have succeeded. A modern civil nuclear power programme based on thermal reactors fuelled off load, using low-enriched uranium fuel and storing the spent fuel unreprocessed, cannot readily be redirected to weapons purposes. International 'safeguards' aim to ensure that civil programmes remain civil. In certain circumstances, however, such safeguards become less effective. A reactor refuelled on load can be covertly programmed to fuel one or more channels rapidly, and discharge fuel containing high-quality plutonium. Spent fuel is in discrete units that can be numbered and counted. Once it has been chopped up and dissolved in a reprocessing plant, the continuous process stream quantities become less easy to keep track of, and more amenable to covert 'diversion' of separated plutonium; and so on.

In any case, those countries whose nominally 'civil' nuclear programmes give rise to most concern are in the main unwilling even to accept safeguards on their most sensitive potential weapons facilities. Any country with plutonium technology is ipso facto within weeks of a nuclear bomb. Modern gas centrifuge or laser uranium enrichment technology creates a similar ambiguity. The international safeguards regime is already fragile and overstressed. A move to commercialization of plutonium fuel and the spread of small-scale uranium enrichment technology will confront it with problems it may be unable to overcome.

The nuclear industry is of course used to taking leaps in the dark. Over the years its leaders have exuded an overweening technological, economic and indeed political optimism, not to say hubris. The rose-coloured nuclear glasses have helped to generate an institutional momentum whose influence in the uppermost echelons of government is still profound. Nuclear power has promised cheap electricity, supply diversity, 'energy independence', and a way to see off OPEC and coal miners. Somewhat more circumspect promises might have been easier to defend. As it is, the performance has been anticlimatic at best.

This may be one reason why the nuclear power industry is now so preoccupied with 'public acceptance'. No other modern industry spends so much time lamenting what it sees as public ignorance, misunderstanding and ill-informed opposition. Senior government and corporate spokespeople regularly blame public opposition for the difficulties facing nuclear power. A dispassionate catalogue of the problems, however, suggests that the nuclear power industry is really seeking an external scapegoat for trouble the industry has brought upon itself, that may even be inherent in the technology. If civil nuclear power were a mature industrial enterprise, internally coherent and with valid economic and commercial relationships linking it to the rest of modern society, it could take a measure of public opposition in its stride; see, for instance, the oil, chemical and car industries. Nuclear power has yet to achieve that maturity. It may, one day, do so; but it has a long and challenging task ahead. Unless it confronts its problems with honesty and responsibility it may not survive. If in its throes it further blurs the boundaries between nuclear electricity and nuclear weapons, the demise of the 'peaceful atorn' may take human civilization with it.