# Nuclear plants—military hostages?

*Recent events suggest that nuclear reactors could make tempting military or terrorist targets, as the following two articles point out. In either case, current protective standards are inadequate.*

*by Bennett Ramberg*

ON MARCH 4, 1985, Iraqi aircraft launched an Exocet missile against one of two partially constructed Iranian nuclear power plants at Bushehr along the Persian Gulf. Although damage was limited, it marked the third attack on the facility (the others having occurred February 12, 1985, and March 24, 1984) and the sixth military assault on reactors since 1967. Other incidents include the failed Iranian strike on Iraq's Osirak research reactor in 1980, Israel's destruction of the same in 1981, and an accident in 1967 when during the Yom Kippur war Israel shot down one of its own disabled planes, fearing that it would crash onto the country's Dimona reactor. India reportedly contemplated in 1982 and 1984 taking out Pakistan's Kahuta enrichment facility, Libya called in 1981 and 1985 for Arab destruction of Israel's Dimona reactor, and former Israeli defense minister Ari'el Sharon declared in March 1985 that Jerusalem would bomb any Iraqi reactor that threatened its security. These events point to a new era in which nuclear facilities will be prime military targets.[1]

Except for the 1967 Dimona incident, none of the installations involved contained dangerous amounts of radioactive materials. Although one can hope that adversaries will continue to limit strikes to plants that have not yet operated, such hope is not reliable. Regrettably, neither scholars nor diplomats have come to grips with the implications of such attacks.

APPROXIMATELY 370 nuclear power plants are now operating in 27 countries, with a like number under construction. By the end of this century nearly 40 nations may be producing electricity with large, commercial nuclear reactors containing copious amounts of radioactive material. As long as there are no major coolant pipe breaks, reactor vessel ruptures, or mismatches of power and coolant due to excessive fission or undercooling, the most common atomic plant—the light-water reactor—operates without posing a hazard to public health. To prevent accidents, manufacturers rely on equipment of high integrity, and in the case of U.S. and European stations (but not most Soviet plants), there are emergency core cooling systems, redundant pumps, emergency external power diesel generators, and reinforced concrete containment buildings.

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Notwithstanding the care with which most reactors are built, U.S. government studies document their vulnerability to willful destruction through disruption of coolant mechanisms both inside and outside the containment building.[2] Israel's successful attack demonstrated the destructibility of a large research reactor with several feet of concrete shielding immediately surrounding the reactor, similar to a commercial plant. Reactor vulnerability is likely to increase in the decade ahead as precision-guided munitions—some fused with shaped charges capable of destroying the hardest containments—are introduced into the arsenals of many countries.

The consequences of a successful conventional weapons attack could conceivably equal those of the worst accidental meltdown in terms of radiation discharged.[3] Unlike nuclear weapons, the effects of which can be calculated reliably, the emission of radioactivity from reactors is subject to a number of variables including (but not limited to) the quantity, composition, and rate of deposition of materials. Assuming recent accident studies are well-founded, military destruction can result in moderate to major releases of radioactivity into the environment.[4]

A moderate release from a reactor the size of Three Mile Island—880 megawatts of electricity—that has been operating for more than three months could contaminate 500 square miles; a major release might affect 2,000–5,000 square miles and require occupation restrictions for perhaps decades, as the effectiveness of decontamination is very uncertain. Since nations often cluster several reactors, the problems would be compounded if the contents of more than one were discharged, as is conceivable in military scenarios. Additional problems would arise through release of the inventories of spent fuel customarily located at reactor sites. Early fatalities are possible, although late cancers and genetic effects would dominate. In densely populated countries deaths could number in the tens of thousands.[5]

In addition to reactors, such nuclear support facilities as fuel fabrication, reprocessing, and waste storage installations may be attractive military targets. Of these, highly radioactive liquid wastes resulting from the industrial process of extracting uranium and plutonium from spent fuel are of greatest concern. With the voluminous residues of many reactors, these depositories are vulnerable to military sabotage, which could result in the contamination of tens of thousands of square miles with low-level radiation.[6]

Nuclear weapons bombardment poses another problem. Although the immediate lethal effects of atomic bombs are many times greater than those that result from the conven-

tional release of radiation from a nuclear facility, the addition of the reactor inventory to one such bomb could increase its early lethal effects by one-third. Furthermore, given that nuclear energy radiation is much longer lived than that of the bomb, such radiation spread by a one-megaton weapon could contaminate 25,000 square miles with long-lived radiation—an area 20 times larger than that contaminated by the bomb alone.[7]

THE CONSEQUENCES of nuclear facility destruction beg a rationale, and certainly Israel provided one in 1981: the necessity to preempt an adversary's acquisition of atomic weapons. There are other rationales as well: crippling an antagonist's industrial capabilities for waging war, targeting energy sources, destroying the environment for military purposes, or attacking concentrations of capital investment (perhaps the rationale for Iraq's attacks on Iran).[8] Then, too, an aggressor may bomb a nuclear power station accidentally, or parties with a stake in an ongoing conflict might consider sabotaging a facility to escalate the conflict.

Still another explanation is coercion. Citizens in many countries have become acutely concerned about possible radioactive releases from nuclear power plant accidents, and a belligerent could capitalize on this fear for coercive purposes. Chester Cooper, former assistant director of the Oak Ridge National Laboratory's Institute for Energy Analysis, speculated that in certain Third World situations, this coercion could have the positive effect of containing belligerence by allowing weak states to threaten strong ones with unacceptable damage.[9] Recent events in the Middle East, however, suggest that the presence of nuclear energy among opponents may exacerbate rather than enhance stability. Certainly the costs of war would increase should plants be destroyed.

The success of such coercion lies in the target nation's psychological sensitivity to nuclear contamination. Some leaders may deemphasize the problem by arguing that population centers and valued land may not be in the vicinity of the facility, that installations may be downwind from valued locations, or that radiation will be rapidly diluted by wind or washed out by rain. Safety features of the threatened plants could be stressed as well as available shelters and relocation plans. The absence of blast, heat, and intense radiation characteristic of an atomic bomb may further reinforce this optimism.

On the other hand, some leaders and their compatriots may be hypersensitive about the prospect of contamination from nuclear facilities. Those nations most concerned would be the most easily manipulated and possibly the most disposed to take drastic measures to reduce their vulnerability. Threats of retaliation in kind are one option. Another option would be nuclear weapons. A case study of the Middle East could illuminate these points.

NUCLEAR POWER in the Middle East is currently limited to five small research reactors in Egypt, Iran, Iraq, and Israel. Given their size—the largest, Israel's Dimona installation, produces 25 megawatts of heat—none of these reactors poses a significant contamination hazard. There are plans, however, to introduce 600- to 900-megawatt electric power stations into the region. Cairo currently is being courted by nuclear firms in France, West Germany, Canada, and the United States. Libya has negotiated with the Soviet Union to purchase a facility. France has offered to rebuild Iraq's Osirak plant and also to provide Baghdad a power reactor. The future of Israel's program is uncertain. Jerusalem's failure to sign the Non-Proliferation Treaty resulted in U.S. refusal to sell reactors despite promises made in 1974, and Israel is considering other vendors (notably France), building a reactor of its own, or turning to other energy sources. Kuwait and Syria are reviewing the nuclear option. Iran, the only country to have begun construction of two atomic power stations, suspended its program with the fall of the shah but is contemplating completion of one plant.[10]

While concern has focused on the manipulation of Middle Eastern atomic plants for nuclear weapons, little attention was given to their military destruction until the Israeli bombardment. As other states in the region modernize their armed forces during the decade ahead, a number may acquire the ability to destroy atomic stations.

The consequences of military destruction could be grave. Because Israel is such a small country, a large fraction of it would be put at risk wherever future construction takes place. (A Mediterranean site 20 miles south of Tel Aviv was once under consideration; a more recent plan suggests a Negev location along the proposed Dead Sea Canal, perhaps underground.) Safety concerns compelled the Egyptian government in 1981 to abandon a site at Sidi Kreir, 36 miles west of Alexandria. Plans now call for construction of at least two plants by the year 2000 to be built about 80 miles west of Egypt's second largest city. Even at this distance, Alexandria and the densely populated Nile Delta could possibly be contaminated, although variable winds could carry fallout to largely uninhabited regions in the south.

In these and other instances, the timing of nuclear energy generation may also have strategic implications. Some Israelis advocate placing nuclear power on line by the mid-1990s. Should such a plant be the first or only large station in the region, widespread damage could be inflicted with a few well-placed bombs. Thus, Israel might be vulnerable to a new mode of Arab intimidation, to which retaliation in kind would be impossible unless the belligerent had a facility. In this case, Israel might instead turn to nuclear weapons.

Should Egypt be the first to acquire a nuclear power plant, it would expose itself to manipulation not only by Israel, but perhaps by Arab antagonists—notably Libya—as well. Likewise, development of nuclear energy by Iraq, Iran, or Libya would expose each to intimidation by its adversaries. On the other hand, if the antagonists acquired equally vulnerable installations simultaneously, stability might result *if* each were equally sensitive to the problem and there were no other significant asymmetries diminishing vulnerability and consequences.

The implications of these Middle Eastern considerations are important to countries outside the region as well. Should Israel acquire a nuclear power station, its vulnerability might force the United States to play a more active deterrent role to reassure Jerusalem. Iraq, a sometime Soviet client, might seek Soviet support against either Iranian or Israeli intimidation. Greater regional involvement by either superpower raises the risk of future confrontation between them.

SIMILAR SCENARIOS could apply to other volatile regions such as Korea, South Asia, China-Taiwan, southern Africa, and even Europe.[11] Thus, the implications of nuclear facility vulnerability in wartime should stimulate the search for alternatives that enhance stability. Assuming that nations will continue to rely upon nuclear power for their energy needs, the following discussion presents several nonexclusive avenues for controlling the dangers of nuclear facility destruction in war.

- *International law.* Legal restraint is clearly not the most reliable option for minimizing the military threat posed to nuclear energy facilities, but it does offer a means to begin addressing the problem by establishing a clear standard of behavior where one does not now exist. The only document presently addressing nuclear facility destruction in war, the 1977 Protocol Addition to the Geneva Conventions of August 12, 1949, is a mixture of ambiguity and contradiction. Article 56 addresses the permissibility of attacks against "nuclear electrical generating stations" in the broader context of "installations containing dangerous forces," including dams and dikes. Paragraph 1 declares that such installations, and military objects in their vicinity, "shall not be made the object of attack, even where these objects are military objectives, if such attack may cause the release of dangerous forces and consequent severe losses among the civilian populations." But the stipulation raises the question of what constitutes severity, a point further complicated by the fact that irradiation might not result in death until years after exposure.

Paragraph 2(b) further diminishes the strength of the prohibition: "The special protection against attack provided by paragraph 1 shall cease (b) for a nuclear electrical generating station only if it provides electrical power in regular, significant and direct support of military operations and if such attack is the only feasible way to terminate such support." In effect, this inclusion allows an adversary to decide whether such is the case.

The Geneva Protocol specifically addresses only nuclear electrical generating stations, not the large inventories of radioactivity in nuclear spent fuel storage, reprocessing plants, waste storage, and fuel fabrication facilities. Nor does the protocol address the permissibility of threats to destroy nuclear facilities.

Two views of the 1981 Israeli attack on the Osirak nuclear reactor in Baghdad, Iraq:

## Raid stopped development of Iraqi bomb

The Israeli operation against Osiraq was not just a 'time-buying measure,' as some have suggested, but rather an important reminder of the folly of Western transfer of arms and nuclear technology to unstable and irresponsible regimes in a conflict-prone region. Yet, the element of time is itself an important factor in the Arab-Israeli conflict which should not be dismissed lightly. Today it is evident that the operation dealt a severe blow to the development of an Iraqi nuclear bomb.

A former senior official in the State Department has admitted to a general agreement within the U.S. government that Iraq's probable goal was to acquire a nuclear weapons capability. Similarly, a *Wall Street Journal* editorial on December 30, 1981 argued that the world attitude to Iraq's nuclear program was reminiscent of the conspiracy of silence surrounding the initial campaign of genocide against the Jews during World War II. It was another instance, the editors said, of what psychologists term *denial*. Although the State Department could not bring itself to say that Iraq's nuclear reactor was intended for building bombs, the Osiraq facility had had no other conceivable purpose.

—Avi Beker, Israeli political scientist, "A Regional Non-Proliferation Treaty for the Middle East," in *Security or Armageddon? Israel's Nuclear Strategy*, Louis René Beres, ed. (Lexington, Mass.: Lexington Books, 1985), pp. 120–21.

## "No evidence that Iraq was planning to build a bomb"

If the raid had prevented an Iraqi bomb from coming into existence soon, Israel's security would certainly have been enhanced by it. However, there is no evidence that Iraq was planning to build a bomb in the near future. [Former Israeli Prime Minister Menachem] Begin's story of a secret underground laboratory . . . is nonsense. . . . Even the Israeli government has now backed off this story. . . .

A precedent has clearly been set, one which can lead to nation *x* bombing nation *y*'s nuclear facilities (for *x*, one can read India, for *y*, Pakistan). This is one sort of 'nonproliferation' activity which could lead to a serious war in a very sensitive part of the world. Another result might be the weakening or destruction of the whole international safeguard fabric. . . .

What about the possibility of simply ending nuclear-produced electricity as the ultimate, definitive nonproliferation technique? Would this work? Certainly not. None of the six known nuclear powers nor the two other likely ones (Israel, South Africa) produced bombs as a result of a nuclear power program. . . . For a developing nation of limited technical resources, a civilian power program would be, in one sense, a liability, in that substantial scientific effort would be diverted to it, rather than placed on a weapons project.

—Anthony Fainberg, physicist at Brookhaven National Laboratory, "Osirak and International Security," *Bulletin*, October 1981, p. 33.

Since 1981, the United Nations' Geneva-based Committee on Disarmament has attempted to remedy the situation. Unfortunately progress has been very slow, although there is a recent glimmer of hope. In the Committee's 1985 session, a "compilation" of draft treaty provisions was tendered.[12] Athough an improvement over the Geneva Protocol—it expanded the definition of nuclear facilities at risk—it also contained troubling contradictions. While declaring that state parties should "never under any circumstances attack nuclear facilities," it stipulated that the prohibition "shall not apply to nuclear facilities giving regular significant and direct support to military operations in time of war . . . providing that such attacks do not lead to the release of radioactivity."[13]

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Such language legitimizes attacks, thereby allowing for "accidental" destruction of plants, and does not address a legitimate concern that nations may use their atomic plants to fabricate and store nuclear weapons. A Japanese proposal that would prohibit attacks on facilities subject to international inspection would be a reasonable remedy to this problem.[14]

For this or any prohibition to be adopted there must be a greater sense of urgency by policy makers than has been displayed to date. As of this writing, the American position is officially, "We have not determined whether additional protections are necessary."[15]

Nevertheless, mutual recriminations between Iran and Iraq over their attacks brought the Third Review Conference of the Non-Proliferation Treaty to the brink of failure [see December 1985 *Bulletin*], and International Atomic Energy Agency Director Hans Blix declared in February 1985 that attacks on reactors are "one of the most serious problems facing the Agency."[16] The Soviets have called for "an early conclusion of an agreement . . . to prevent . . . deliberate destruction of nuclear facilities."[17] Whether these developments will provide impetus toward an agreement remains to be seen.

• *Military and civil defense.* Although international law may provide some protection, there have been too many violations of other such measures for optimism. Therefore, diminishing the vulnerability of nuclear energy installations and surrounding populations is critical. One way is to enhance military defense, including ability to intercept and destroy hostile forces before they can inflict damage. Although nuclear facilities have not been constructed with wartime bombardment in mind, their massive containment structures do provide some protection against attack. Additionally, fences, alarms, cameras, and armed guards could impede small groups of intruders bent on theft or sabotage.

Although not foolproof, alternative measures could improve point defenses. In a time of crisis, military units could be stationed around installations to prevent assaults. Antiaircraft weapons and artillery could be situated to suppress bombardment. In the future, homing missiles against cruise missiles, steel palings, and tons of steel pellets lofted by explosives similar to those intended to protect missile silos might be applicable in the defense of nuclear energy facilities.[18]

Civil defense is critical. At the very least, governments should educate populations in the vicinity of nuclear plants about the dangers of radiation. Evacuation routes should be planned, populations advised, and exercises practiced. Radiation shelters should be constructed for persons living close to nuclear installations; if shelters are not feasible, people should become acquainted with protective measures. Civil defense planning should include steps to deal with long-term radiation contamination which, if undertaken in conjunction with military defense, could reduce both immediate and long-term casualties, perhaps significantly.

• *Facility siting.* In most nations, residential populations are now banned entirely for several miles around facilities. These distances could be extended to minimize public exposure to contaminants, although the cost of transmitting electricity would increase and acceptable sites would be difficult to locate in small countries with high population densities. This option may be more attractive in countries with remote regions, such as the Soviet Union, South Africa, Egypt, and Pakistan.

Remote siting need not be limited to land; facilities can be placed on large lakes, inland seas, or oceans—on floating platforms surrounded by breakwaters, on floating vessels anchored to the marine floor, on artificial islands, or even undersea. However, there would be higher transmission costs for reactors, unique construction costs, and exposure to such dangers as ship collisions, accidental explosions, and naval bombardment.

Underground installations would be less vulnerable to attack and earthquakes and would also be immune to storms, explosions, and aircraft crashes. Rock formations able to contain releases would obviate the need for reinforced concrete containment vessels. However, one study ventured to say that burying a power plant could add as much as 40 percent to its price.[19] And since subterranean installations are likely to be very compact, inspection and maintenance would be more difficult than in a surface facility. Furthermore, ground water seepage may pose unique corrosion problems.

• *Increasing plant safety.* Some reactors are safer than others; heavy-water reactors, high-temperature gas reactors, and the proposed PIUS (Process Inherent Ultimately Safe) and molten salt breeder plants can withstand the loss of coolant and other serious disruptions better than the widely used light-water reactors.[20] Improved containment would provide additional safety.

Retaining high-level wastes in liquid form makes them particularly susceptible to release when deprived of coolant. Furthermore, there is a more acute problem in leaks resulting from containment rupture—a peril underscored by several such incidents due to corrosion—than if the wastes are solidified into a glass-like substance.

• *International management of nuclear energy.* Because destruction of nuclear installations in war affects global security, international institutions should exercise controls. The International Atomic Energy Agency should establish a working group to suggest guidelines that address the problem. A permanent standing committee might be created to advise nations about threats. Given the historical trend toward greater international institutional involvement to minimize nuclear dangers, creation of an authoritative international body may be warranted. Such a body would anticipate and regulate nuclear risks including diversion of nuclear material for weapons purposes, the vulnerability of facilities to subnational sabotage, and the safe operation of plants, as well as wartime vulnerability. Alternatively, formulating guidelines is probably the course of least resistance and is consistent with International Atomic Energy Agency practice.[21]

These remedies, while not foolproof, offer marginal means to reduce nuclear facility vulnerability in a conventional weapons conflict, and to ameliorate the radiological consequences should destruction take place. They are likely to be ineffective in nuclear war. A conundrum therefore results because the temptation to employ threats or actions against nuclear facilities adds a significant dimension to the problem of maintaining peace and minimizing the consequences of war. Given the potential to contaminate large areas, military destruction or threatened destruction may have significant implications for regional security. Recent military attacks on reactors in the Middle East suggest that the vulnerability of atomic plants to such action should be included in nuclear energy risk calculations and strategic planning. □

1. See Leonard S. Spector, *The New Nuclear Nations* (New York: Vintage, 1985), pp. 92, 144, 158, 166–67; Committee on Foreign Relations, *The Israeli Air Strike: Hearings*, 97th Cong., 1st sess., 1981, p. 71; Amos Perlmutter, et al., *Two Minutes Over Baghdad* (London: Vallentin, Mitchell, 1982). The 1967 incident involving Dimona was related to the author by a former Israeli air force officer and confirmed by staff at Livermore Laboratory.

2. Consultant Workshop, Sandia Laboratories, *Summary Report on Workshop on Sabotage Protection in Nuclear Power Plant Design*, SAND 76–0637 (Washington, D.C.: Nuclear Regulatory Commission, 1977); Dean C. Kaul and Edward S. Sachs, *Adversary Actions in the Nuclear Fuel Cycle: I. Reference Events and Their Consequences*, SAI-121–612–7803 (Schaumburg, Ill.: Science Applications, 1977); Nuclear Regulatory Commission, *Reactor Safety Study*, Appendix VI, pp. 2–1–2–4.

3. Telephone conversation with staff of Sandia laboratories who conducted a technical study on conventional weapons destruction of nuclear facilities, 1979.

4. Nuclear Regulatory Commission, *Technical Bases for Estimating Fission Product Behavior During LWR Accidents*, NUREG-0772 (Washington, D.C.: Nuclear Regulatory Commission, June 1981), pp. i–iii, F. 6.

5. Jan Beyea, *Some Long-Term Consequences of Hypothetical Major Releases of Radioactivity to the Atmosphere from Three Mile Island*. PU/CEES No. 109, Center for Energy and Environmental Studies, Princeton University, Dec. 1980, pp. 12, B-13; Steven Fetter and Kosta Tsipis, "Catastrophic Nuclear Radiation Releases," Massachusetts Institute of Technology Program in Science and Technology in International Security, Sept. 1980.

6. Jan Beyea, "The Effects of Releases to the Atmosphere of Radioactivity from Hypothetical Large-Scale Accidents at the Proposed Gorleben Waste Treatment Facility," report to the government of Lower Saxony, West Germany, Feb. 1979, p. 10.

7. Fetter and Tsipis, op. cit.

8. Spector, op. cit., pp. 167–68.

9. Chester L. Cooper, "Nuclear Hostages," *Foreign Policy*, 32 (1978), pp. 125–35.

10. For a review of nuclear energy plans in the Middle East, see Spector, op. cit., chapter IV.

11. See Bennett Ramberg, *Nuclear Power Plants as Weapons for the Enemy: An Unrecognized Military Peril* (Berkeley: University of California Press, 1984).

12. United Nations General Assembly, *Report of the Conference on Disarmament*, 40th Sess., Supplement no. 27 (New York: United Nations, 1985), pp. 128–31.

13. Ibid.

14. Committee on Disarmament, "Japan Working Paper, Prohibition of Attacks Against Nuclear Facilities," CD/323 CDRW/WP/37, Sept. 1, 1982.

15. Telephone conversation with a U.S. government official, Dec. 11, 1985.

16. Quoted in International Atomic Energy Agency, General Conference, GC (XXIX)/754, Aug. 27, 1985, p. 2.

17. U.S.S.R. Mission to the United Nations, "Statement by Ambassador Vassiliy S. Safronchuk," press release no. 146, Nov. 1, 1985, p. 3. See also "Radiological Weapons," *Arms Control Reporter* (June 1985), Sec. 703.B.11.

18. Richard L. Garwin, "Effective Military Technology for the 1980s," *International Security*, 1 (1976), pp. 53–56.

19. *Nucleonics Week*, July 28, 1977.

20. Irving Splewak and Alvin M. Weinberg, "Inherently Safe Reactors," in Jack M. Hollander et al., eds., *Annual Review of Energy*, vol. 10 (Palo Alto, Cal.: Annual Reviews, 1985), pp. 431–62.

21. See Bennett Ramberg, *Global Nuclear Energy Risks: The Search for Preventive Medicine* (Boulder, Colo: Westview, 1985).