



What the Commission Report says on:

PROLIFERATION-RESISTANT TECHNOLOGY

If peaceful nuclear energy is to play the role it should, it is critical that it be managed in a way that reduces, and does not add to, the world's problems. The first indispensable dimension of that effective management is safeguards (i.e. ensuring that there is no diversion of nuclear material from civil to military purposes...). The second is security... and the third is safety.... These are not the only factors involved in long-term effective management – others are the *development of proliferation-resistant technology*, stronger industry–government cooperation and efforts to multilateralize the fuel cycle.

Proliferation resistance involves establishing impediments or barriers to the misuse of civil nuclear energy systems to produce fissile material for nuclear weapons. There is no magic bullet to eliminate all proliferation risk. No presently known nuclear fuel cycle is completely proliferation proof: proliferation resistance is a comparative term. But a combination of institutional and technical measures can give needed robustness to non-proliferation and counter-terrorism efforts. ...[Institutional measures include] treaty-level peaceful use commitments, principally through the NPT; verification of performance of these commitments, especially by IAEA safeguards; national controls on supply of nuclear materials, equipment and technology, including those coordinated through the Nuclear Suppliers Group; and possible new ways of multilateralising the fuel cycle.

The objective of technical measures, as with institutional ones, is to increase the difficulty, time and cost of misuse and the likelihood of detection, both as a disincentive, and to provide sufficient delay for the international community to have timely warning and opportunity for intervention. These measures include avoiding production of weapons grade material, and introducing technical barriers to producing such material; ensuring fissile material is difficult to access (e.g. through high radiation levels), increasing the difficulties of diversion by states and theft or seizure by terrorists; and avoiding plutonium separation processes that result in a pure plutonium

product or a product from which plutonium can be readily purified.

The basic issue can be stated as follows: can a fuel cycle be developed which produces nuclear fuel without using enrichment, and enables plutonium recycle without plutonium separation? As to *enrichment*, the necessity for this can be avoided altogether by the use of reactors fuelled by natural uranium, but those available today are “on-load refuelling” designs that can be used to produce weapons grade plutonium. In principle, another route for avoiding the need for enrichment is the thorium fuel cycle, but this is not as straightforward as it might seem. Thorium reactors depend on recycle of uranium-233, which with current reactor types must be separated from spent fuel by reprocessing, and which (albeit with some difficulty) can be used in nuclear weapons. Further, a thorium reactor requires enriched uranium (or plutonium) for the initial operating cycles, and more efficient operation requires enriched uranium or plutonium “driver fuel” in addition to recycled uranium-233.

Enrichment is not required for fast neutron reactors, which are fuelled through plutonium recycle, and can be operated to produce more plutonium than they consume. However, for most of this century the light water reactor is likely to remain the predominant reactor type, possibly supplemented by high temperature gas-cooled reactors (such as the pebble bed reactor), so there will be a continuing – indeed, growing – need for uranium enrichment. Proliferation risk can be reduced by limiting the number of states with enrichment programs, and operating enrichment programs on a multilateral rather than wholly national basis.

As to reprocessing, this can be avoided altogether through using the “open” or “once-through” fuel cycle. However, the “closed” fuel cycle, based on plutonium recycle using fast neutron reactors, is attracting increasing interest from a number of states. Fast neutron reactors offer substantial advantages for efficiency of uranium utilization and management of spent fuel and radioactive waste. They can also,

The full text of *Eliminating Nuclear Threats: A Practical Agenda for Global Policymakers*, Report of the International Commission on Nuclear Non-proliferation and Disarmament, Co-chairs Gareth Evans and Yoriko Kawaguchi (November 2009), is available at www.icnnd.org

however, present potential proliferation and terrorism-risk challenges. The currently used “fast breeder” model involves production of plutonium, which happens to be of weapons grade, in a “breeder blanket” surrounding the core, and separation of plutonium through reprocessing. Both these characteristics give ground for concern from both non-proliferation and counter-terrorism perspectives.

Proliferation resistant approaches now under consideration for fast neutron reactors include new designs with an integrated core and no breeder blanket, and the introduction of new processing technologies that avoid separating pure plutonium. Eliminating the blanket and producing all plutonium in the reactor core ensures that it will all be “high burn-up”, well outside the weapons grade range. New reprocessing technologies include “electro-metallurgical processing” (formerly known as pyro-processing), by which spent fuel is melted in molten salts and a number of fission products and most of the uranium is removed by electrolysis. The plutonium from the spent fuel is not purified, but remains in a mix with minor radioactive elements and some fission products. This ensures that the plutonium cannot be used for nuclear weapons without further, conventional, reprocessing. The radioactivity of the associated fission products increases the difficulty of diversion, and protects the plutonium mix from theft. At this stage the costs of these new technologies are not clear, and not using a blanket will have an efficiency penalty. But they are seen as moving in the right direction, and further international research is being coordinated by the Generation IV International Forum. Also, new blanket designs which will produce plutonium well outside the weapons grade range are being studied.

As already noted, the predominant reactor type for the foreseeable future, and for most states, is expected to be the light water reactor. This design is difficult to misuse to produce weapons grade plutonium, so is considered to have good proliferation resistance. However, in the interest of non-proliferation, international measures such as spent fuel take-back arrangements by fuel suppliers, are desirable to avoid increasing spent fuel accumulations in a large number of states. Particular attention should be paid in this respect to take-back of fuel from initial core loads, where the short irradiation time results in the contained plutonium being closer to weapons grade.

A proliferation-resistant method of recycling spent fuel is the DUPIC process, being developed by South Korea, Canada and the U.S. The basis of DUPIC is that the fissile content of spent PWR (pressurised

water reactor) fuel – residual U-235 and produced plutonium) is well suited for use in heavy-water moderated CANDU reactors. It involves direct re-fabrication of spent PWR fuel into reactor fuel, thereby reducing natural uranium requirements and the overall quantity of spent fuel. Dry thermal-mechanical processes are used to reduce spent PWR fuel to a fine powder, which is subject to high temperature to drive off volatile fission products (around 40 per cent of total fission products), pressed into pellets, and fabricated into CANDU fuel bundles. Since there is no plutonium separation, DUPIC is inherently proliferation resistant. However, its potential application is limited to situations where suitable numbers of both PWRs and CANDUs are available (currently only South Korea, India and China)

Other proliferation-resistant concepts include reactor designs that reduce access to the reactor core by the operator. For example, new designs are under development that will extend the period between refuelling, or even have life-time cores, with the reactor being replaced by the supplier when refuelling is required. These developments will contribute to assurance that an expansion in the use of nuclear energy can proceed without adding to proliferation risk.

Recommendations:

Proliferation resistance should be endorsed by governments and industry as an essential objective in the design and operation of nuclear facilities, and promoted through both institutional and technical measures – neither is sufficient without the other.

The increasing use of plutonium recycle, and the prospective introduction of fast neutron reactors, must be pursued in ways which enhance non-proliferation objectives and avoid adding to proliferation and terrorism risks. In particular, a key objective of research and development on fast neutron reactors should be to design and operate them so that weapons grade plutonium is not produced.

New technologies for spent fuel treatment should be developed avoiding current forms of reprocessing altogether, and as they are established, use of MOX fuel in thermal reactors, and conventional reprocessing plants, can be phased out.

[Section 14, Paras 14.4,7-15, Recs 34,35,37]