4. PEACEFUL USES OF NUCLEAR ENERGY

§4.1 Overview

4.1 The overarching international objective in relation to peaceful uses of nuclear energy is to ensure that the benefits of nuclear energy are available to all states that choose to use it, on equitable terms and through international cooperation, while also ensuring that the use of nuclear energy does not lead to the proliferation of nuclear weapons and does not endanger human and environmental health and safety.

4.2 The use of nuclear energy for peaceful purposes is one of the three fundamental pillars of the NPT, along with nuclear disarmament and non-proliferation. The treaty sets out general peaceful use rights and obligations but does not detail approaches for determining compliance with such rights and obligations. This has resulted in a long-standing debate over compliance with NPT peaceful use rights and obligations. In recent years, a focus of this debate has been the extent to which the NPT mandates development of the most proliferation-sensitive nuclear technologies – enrichment and reprocessing.

4.3 The renewed interest in nuclear energy for power generation underscores the importance of timely resolution of differences within the international community on peaceful uses of nuclear energy issues. Politicization of peaceful uses issues, to the extent that it exists, is against the interests of the vast majority of states, be they holders of advanced nuclear technology, countries that aspire to a peaceful nuclear power program or countries unlikely ever to want to develop nuclear power.

4.4 **Nuclear Cooperation.** NPT parties at successive treaty review conferences have elaborated the basic NPT peaceful use provisions with respect to nuclear cooperation. For example, Action 51 from the 2010 NPT Review Conference called upon states parties to "Facilitate transfers of nuclear technology and international cooperation among States parties in conformity with articles I, II, III, and IV of the Treaty, and eliminate in this regard any undue constraints inconsistent with the Treaty."

No Progress	Minimal Progress	Some Progress	Significant Progress	Fully implemented

4.5 The wide uptake of nuclear power and nuclear applications, and the fact that many developing countries have been able to conclude nuclear supply agreements with supplier countries, suggest that national status and supplier non-proliferation practices are not a practical impediment to legitimate nuclear trade and cooperation. Of the 30 states, plus Taiwan, operating nuclear power programs, almost 40 per cent are developing countries. The majority of the 29 states planning or proposing nuclear power programs are developing countries, and of the seven of those states most likely to proceed with nuclear power in the near term, six are developing countries. Looking ahead, the lower capital costs and simplified operational requirements of the innovative small power reactor designs currently being developed could make nuclear power more accessible to additional developing countries.

4.6 Non-power applications of nuclear technology are also spread widely. Of the 54 states (plus Taiwan) operating research reactors, well over half are developing countries. In terms of the IAEA's Technical Cooperation Programme, which covers nuclear power-related and non-power applications, projects are being undertaken in 123 states and territories, the great majority of which are developing countries. Funding available for this program has increased over the years but debate on its adequacy continues, including the degree of reliance on extra-budgetary and in-kind contributions. This debate should continue within the discussion of the IAEA's system wide budgetary difficulties.

Overall Evaluation of Nuclear Cooperation: **Significant Progress.** NPT 2010 commitments and ICNND 2009 recommendations are generally being met. There are grounds for criticism that technical cooperation assessed funding has not increased more – though it has increased substantially over the years – but the additional funding provided by a number of states is consistent with the increase called for in the NPT 2010 Action Plan.

4.7 **Mitigating Proliferation Risks.** The nuclear non-proliferation, disarmament and peaceful use pillars of the NPT are closely related and mutually reinforcing. Effective nuclear non-proliferation measures provide confidence that peaceful nuclear trade and cooperation can proceed without contributing to nuclear weapons proliferation. Also vital is confidence that effective nuclear safety and security measures will apply.

4.8 National export controls coordinated by the Nuclear Suppliers Group (NSG) are the principal means by which nuclear suppliers give effect to the requirement that exports be consistent with their non-proliferation obligations [see Chapter 2 for detailed discussion]. With export controls now established as an international norm, including through UN Security Council Resolution 1540, the NSG and its members have an important contribution to make through assisting non-members develop and apply effective nuclear export controls.

4.9 However, little progress has been made in a number of areas with important implications for peaceful nuclear cooperation. An inclusive approach which respects state sovereignty and rights to development is critical. The international community is broadly agreed that limiting the spread of sensitive nuclear technology is in the interests of all states and making this choice will involve substantial practical benefits to countries looking to develop peaceful nuclear energy programs. But the need remains to reach a shared understanding on how to translate this general principle into practical steps and concrete actions.

4.10 There has been no progress on addressing the potential problems of national enrichment and reprocessing capabilities in non-nuclear-weapon states. These capacities inadvertently or deliberately provide such states with the technical capacity to produce nuclear weapons in a relatively short time. Likewise, the prospective spread of fast breeder reactors and plutonium fuels in the future will present serious challenges unless addressed. Highly enriched uranium (HEU) minimization is proceeding, though large quantities of HEU remain in the civil cycle; no effort has been made to minimize the use of plutonium in the civil nuclear power sector (as mixed oxide – MOX – fuel).

Overall Evaluation of Mitigating Proliferation Risks: **Some Progress.** Most states are meeting their NPT peaceful use commitments, but non-compliance cases – especially Iran and North Korea – are cause for concern. Issues of nuclear latency and hedging are not being addressed. The spread of sensitive nuclear technology and the prospective spread of fast reactors and plutonium fuels in the future will present serious challenges unless addressed. HEU minimization is proceeding, though large quantities of HEU remain in the civil cycle; but no effort has been made to minimize plutonium (as MOX). The establishment of two fuel banks and the work of the International Framework for Nuclear Energy Cooperation (IFNEC) are positive developments, but further elaboration of multilateral approaches, and the uptake of these approaches, have a long way to go.

4.11 **Safety and Security Commitments.** Nuclear safety and security have global ramifications for peaceful nuclear use but continue to be seen mainly as national concerns. A more appropriate balance is needed between national and international interests and responsibilities. This should include increased focus on the development of and adherence to international standards, as well as greater transparency and accountability.

4.12 Participation rates in existing nuclear safety and security treaties and other instruments remain inconsistent with the consequences significant nuclear safety or security incidents have for global confidence in peaceful nuclear energy. One state, Iran, operating a nuclear power reactor, is yet to join the principal treaty on nuclear safety – the Convention on Nuclear Safety (CNS). A number of states operating power reactors are yet to join the 1997 Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. Treaty participation in the area of nuclear security is similarly inadequate. The principal convention on nuclear security, the 1980 Convention on the Physical Protection of Nuclear Material (CPPNM) has 148 parties, well short of universality. Seven years after the 2005 Amendment extending application of the CPPNM was opened for signature, less than two thirds of the ratifications required for its entry into force have been obtained.

Overall Evaluation of Safety and Security Commitments: **Some Progress.** Not all states with significant nuclear activities have joined the Convention on Nuclear Safety (CNS), and there is a lack of international standards, transparency and accountability. Many states with power reactors remain outside the liability regimes. On nuclear security, many states remain outside the Convention on the Physical Protection of Nuclear Material (CPPNM), and there are insufficient ratifications/accessions for the Amended CPPNM to enter force. Again there is a lack of international standards, transparency and accountability.

§4.2 Objectives and General Strategy

4.13 The right to the peaceful use of nuclear energy is one of the three pillars of the NPT, the other two being non-proliferation and disarmament. A key objective of the NPT is to ensure that nuclear energy is indeed used only for peaceful purposes and does not contribute to the proliferation of nuclear weapons. Accordingly, Article IV of the NPT affirms the right of states to use nuclear energy for peaceful purposes, provided this is in conformity with the non-proliferation obligations of the treaty and IAEA safeguards are applied to verify fulfilment of these obligations.

4.14 The need for effective control of nuclear energy to ensure that it is used only for peaceful purposes was one of the first issues addressed by the United Nations when it was established in 1946. A number of proposals were examined, including placing all nuclear materials under the control of an international agency, but the United States and the Soviet Union were unable to reach agreement on these.

4.15 Following the Soviet Union's first nuclear test in 1949, attention turned to preventing the further proliferation of nuclear weapons. Recognizing the right of countries to exploit nuclear energy, the United States proposed a policy of cooperation under peaceful use guarantees in President Dwight Eisenhower's "Atoms for Peace" speech to the UN General Assembly in December 1953. This initiative led to the establishment of the IAEA in 1957, and subsequently to the negotiation of the NPT in 1968 and its entry into force in 1970.

4.16 The NPT does not in fact specifically define *peaceful purposes* and *peaceful uses.* What is encompassed, in effect, is anything not within two other categories of nuclear activity contemplated by the treaty, viz:

> The manufacture or other acquisition of nuclear weapons or other nuclear explosive devices, or control over such weapons or explosive devices, which activities are proscribed for all but the five countries recognized by the NPT as nuclear-weapon states (NWS); and

> Non-peaceful purposes that are not proscribed – that is, non-explosive military purposes such as naval propulsion reactors. It is clear from the wording of Article III and international practice[1] that these activities are not *peaceful purposes.* Accordingly their status is ambiguous in terms of the "inalienable right" referred to in paragraph 1 of Article IV, and they are outside the scope of the cooperation envisaged under paragraph 2 of Article IV.

4.17 The lack of a clear definition of peaceful purposes leaves a grey area with respect to nuclear latency and nuclear hedging, problems which were neither adequately foreseen nor appropriately addressed at the time the NPT was negotiated. These are discussed further in section 4.4.

4.18 For present purposes, the overarching international objective in relation to peaceful uses of nuclear energy may be described as being to ensure that the benefits of nuclear energy are available to all states that choose to use it, on equitable terms and through international cooperation; while also ensuring that the use of nuclear energy does not lead to the proliferation of nuclear weapons and does not endanger human and environmental health and safety. The strategies to advance this objective are discussed in the remainder of this chapter, under three headings as follows:

4.19 **Cooperation in developing peaceful applications.** The main NPT provision is Article IV.2, and the principal 2010 NPT Review Recommendations are Actions 48 to 51. Key questions here include: are states meeting the commitment to cooperate in developing peaceful applications of nuclear energy, and is due consideration being given to the needs of developing countries?

4.20 **Mitigation of proliferation risks associated with peaceful purposes.** The main NPT provision is Article II, and the principal 2010 NPT Review Conference recommendation is Action 61 on minimization of the use of highly enriched uranium. ICNND recommendations 34 to 38 are more specific. Key questions here include: do IAEA safeguards provide sufficient assurance against possible misuse of nuclear programs for non-peaceful purposes, are further institutional and technical measures needed to mitigate proliferation risk, and can states exercise effectively the right to use nuclear energy for peaceful purposes without needing to develop proliferation-sensitive stages of the fuel cycle? Proliferation risk issues are addressed in more detail in Chapter 2.

1. As reflected for example in paragraph 14 of the IAEA model NPT safeguards agreement, INFCIRC/153.

4.21 **Ensuring peaceful nuclear programs are conducted safely and securely.** Safety and security are not specifically referred to in the NPT, but they are covered by other treaties and in Actions 57, 59, 60, 62 and 63 of the 2010 NPT Review Conference. The key question here is: are states, in conducting their nuclear programs, applying standards of nuclear safety and security sufficient to ensure protection of other states from the consequences of nuclear accidents or terrorist acts? Nuclear security issues are discussed in more detail in Chapter 3.

§4.3 Nuclear Cooperation

4.3.1 Among States

4.22 An essential aspect of peaceful uses of nuclear energy under the NPT is the commitment to international cooperation, set out in Article IV.2. Prior to the treaty, nuclear cooperation, including supply of nuclear facilities, equipment and nuclear materials, took place under bilateral agreements between supplier and recipient states. In economic terms bilateral cooperation remains the most substantial form of nuclear cooperation, through supply of reactors, nuclear fuel and nuclear services. At the multilateral level, the main vehicle for nuclear cooperation is the IAEA and its Technical Cooperation Programme, discussed in the next section.

4.23 **Nuclear Power.** The NPT established a much broader basis for peaceful use commitments and verification, extending beyond supplied items and materials to all of the nuclear material and activities in a state. In so doing, the NPT has established the conditions under which nuclear trade has been able to grow to its current global scale. The NPT and the IAEA safeguards system have provided confidence to states that they are able to cooperate in the peaceful use of nuclear energy without contributing to the proliferation of nuclear weapons.

4.24 Nuclear energy provides just over 12 per cent of global electricity.[2] There are 30 states, plus Taiwan, operating nuclear power programs (Table 4.1). Almost 40 per cent of these (12 out of 31) are developing countries.[3] The IAEA reports that there are 29 states planning or proposing nuclear power programs. The IAEA does not identify these but indicates that most are developing countries.[4] Using a conservative figure of seven for those states most likely to proceed with nuclear power in the near term,[5] six of these are developing countries.

2. IAEA, *International Status and Prospects for Nuclear Power 2012.* GOV/INF/2012/12-GC(56)/INF/6 (Vienna: IAEA, 15 August 2012), Table B.1, p. 3.

3. States with nuclear power that are defined by the World Bank (2012) as "developing countries" (http://data.worldbank.org/about/country-classifications/country-and-lending-groups) are: Argentina, Armenia, Brazil, Bulgaria, China, India, Iran, Mexico, Pakistan, Romania, South Africa and Ukraine. The World Bank definition also includes Russia, but Russia is not counted as a developing country in this report on the basis that it is a leading nuclear power.

4. IAEA, *International Status and Prospects for Nuclear Power 2012.*

5. The seven are Bangladesh, Belarus, Lithuania, Poland, Turkey, UAE and Vietnam. All but Poland are categorized as developing countries by the World Bank.

Table 4.1: World Nuclear Energy (January 2013)

	Operating reactors		Reactors under construction	
	Number	**Total Capacity (GWe)**	**Number**	**Total Capacity (GWe)**
Argentina	2	0.9	1	0.7
Armenia	1	0.4		
Belgium	7	5.9		
Brazil	2	1.9	1	1.2
Bulgaria	2	1.9		
Canada	19	13.7		
China	17	12.8	29	28.8
Czech Republic	6	3.8		
Finland	4	2.7	1	1.6
France	58	63.1	1	1.6
Germany	9	12.1		
Hungary	4	1.9		
India	20	4.4	7	4.8
Iran	1	0.9		
Japan	3	3.1	3	4.0
Korea, Republic of	23	20.8	4	5.0
Mexico	2	1.3		
Netherlands	1	0.5		
Pakistan	3	0.7	2	0.6
Romania	2	1.3		
Russia	33	23.6	11	9.3
Slovak Republic	4	1.8	2	0.8
Slovenia	1	0.7		
South Africa	2	1.8		
Spain	8	7.6		
Sweden	10	9.4		
Switzerland	5	3.3		
Taiwan, China	6	5.0	2	2.6
Ukraine	15	13.1	2	1.9
UAE			1	1.3
United Kingdom	16	9.2		
United States	104	101.5	1	1.2
	390	**331.1**	**68**	**65.4**
Japan - shutdown reactors	48	41.3		

Source: IAEA, http://www.iaea.org/PRIS/WorldStatistics/OperationalReactorsByCountry.aspx

4.25 The long-term impact of the Fukushima accident on planned nuclear programs is not yet clear. The accident is likely to make nuclear power more expensive through higher capital costs, due to more rigorous safety requirements, and higher finance costs, reflecting lenders' reappraisal of commercial risk. The World Energy Council has reported that the Fukushima accident has not so far led to a significant retraction in nuclear power programs outside Europe, except in Japan. While progress in many national programs has been delayed, there is no indication that these countries' pursuit of nuclear power has declined in response to Fukushima.[6] The German and Japanese governments announced the phase-out of nuclear power, but it appears (January 2013) that the new Japanese government will re-examine its predecessor's decision. The Chinese government decided to cancel planned Generation II reactors and replace them by Generation III models, a move that will bring safety benefits but will increase costs and slow down China's nuclear expansion in the near term. Also in the Asian region, India has affirmed its plans to boost its nuclear capacity up to 15-fold by 2032, and Taiwan, South Korea and Vietnam are proceeding with announced plans. Indonesia and Thailand have delayed nuclear power until after 2020. However Malaysia announced *after* Fukushima that it is considering the option of nuclear power.

4.26 Of the 54 states (plus Taiwan) currently operating research reactors, well over half (31) are developing countries.[7] Apart from research reactors, statistics are not readily available on the number of states in which non-power nuclear applications are used, but this would include most if not all the world's states. In terms of the IAEA's Technical Cooperation Programme, which covers nuclear power-related and non-power applications, projects are being undertaken in 123 states and territories,[8] the great majority of which are developing countries.

4.27 The Action Plan from the 2010 NPT Review Conference elaborated on the implementation of nuclear cooperation, inter alia calling on parties to give preferential treatment to the non-NWS, particularly taking into account the needs of developing countries, and to facilitate transfers of nuclear technology and cooperation among states parties, eliminating any undue constraints inconsistent with the treaty.[9]

4.28 The figures cited above demonstrate that nuclear energy has brought benefits to a great many states, including many developing countries. The fact that the uptake of nuclear power by developing countries has not been greater reflects practical constraints, such as the high capital costs of power reactors, human and technical infrastructure requirements, and electricity grid capacity. In the near term, the main growth in nuclear power in developing countries will be where the technology is already well established – particularly China and India. Looking ahead, a number of innovative small power reactor designs[10] are under development, with features more suited to conditions in developing countries, including lower power levels, life-time or long-life fuel cores and modular construction and operation. The lower capital costs and simplified operational requirements of these reactors could make nuclear power more accessible to a number of developing countries.

6. World Energy Council, *Nuclear Energy One Year After Fukushima*, 2012, http://www.worldenergy.org/documents/world_energy_perspective__nuclear_energy_one_year_after_fukushima_world_energy_council_march_2012_1.pdf
7. IAEA, *Research Reactor Database, 2012,* http://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx?rf=1.
8. IAEA, *Annual Report 2011* (Vienna: IAEA, 2012), http://www.iaea.org/Publications/Reports/Anrep2011/index.html.
9. Actions 50 and 51 respectively – see section 4.3.1 below.
10. Small reactors are defined by the IAEA as less than 300 MWe.

4.29 Few states have developed indigenous nuclear technology and few produce nuclear materials. The uptake of nuclear power and other nuclear applications has been enabled by nuclear cooperation among states. Today no state has a wholly self-reliant nuclear energy program; there is a global market in nuclear equipment, technology, materials and services. The nuclear market operates on a commercial basis – there is no known case of a state being excluded, other than on grounds of proliferation concern.

4.30 The commitment to cooperate applies only to peaceful uses, and is subject to the other provisions of the NPT, for example Article IV.1 (which in turn refers to Articles I and II) and Article III. This is reflected in the wording of Action 51 from the 2010 NPT Review Conference. A state party considering cooperation, or asked for cooperation, may take into account the other party's performance with respect to NPT obligations, for example whether there have been safeguards violations (Article III) or whether there are grounds for concern regarding Article II (the commitment not to seek nuclear weapons). These considerations are reflected in national export controls (discussed in more detail in Chapter 2).

4.31 National export controls on nuclear equipment, nuclear-related materials and technology, and specified *dual-use* items are coordinated by the Nuclear Suppliers Group (NSG). These controls are fully consistent with the NPT, giving effect to the requirements of Articles I and II of the treaty. The NSG membership includes several major developing countries, for example Argentina, Brazil, China, Kazakhstan, Mexico, South Africa and Turkey.[11]

4.32 Apart from export controls applied by states, the technology holders (for example URENCO, TENEX, BNFL (British Nuclear Fuels Limited) and AREVA) themselves are very cautious about the states to whom they supply. In enrichment, URENCO and TENEX supply only on a black box basis, so that technology is not transferred. These issues are discussed further in section 4.4.

4.33 The fact that non-proliferation practices have not been a practical impediment to legitimate nuclear trade is demonstrated by the uptake of nuclear power and nuclear applications, discussed above, and by the many developing countries that have been able to conclude nuclear cooperation agreements with supplier countries. For example, states with nuclear supply agreements with the United States include Argentina, Bangladesh, Brazil, Colombia, Egypt, India, Indonesia, Kazakhstan, Morocco, South Africa, Thailand and the UAE. Further US agreements are being negotiated with Jordan and Vietnam.

4.34 **Other Forms of Nuclear Cooperation.** While nuclear energy is usually thought of in terms of nuclear power, non-power nuclear applications are also very important. These include the use of nuclear techniques in areas such as human health, food and agriculture, and physical and chemical sciences. Developing countries have benefitted particularly in these areas. Nuclear cooperation among states is not limited to nuclear trade, but includes non-power nuclear applications and also training, capacity-building,

11. Other NSG members categorized by the World Bank as developing countries are Bulgaria, Latvia, Lithuania, Romania and Ukraine.

sharing of experience, and so on, in areas including facility operations and the "3 Ss" – safeguards, safety and security.

4.35 Statistics are not readily available on the number of states in which non-power nuclear applications are used, but this would include most if not all the world's states. Mostly cooperation in non-power applications is provided through the IAEA. Under the IAEA's Technical Cooperation Programme, which covers nuclear power-related and as well as non-power applications, projects are being undertaken in 123 states and territories,[12] the great majority of which are developing countries, including 30 Least Developed Countries. The IAEA's program is discussed further in section 4.3.2.

4.36 In addition to cooperation provided through the IAEA, there are many bilateral and regional projects and programs. There are too many examples to list here, but mention can be made of a few: IAEA Regional Cooperative Agreements – in Africa, Asia-Pacific, Arab states, and Latin America; the International Framework for Nuclear Energy Cooperation (IFNEC – see further below); global and regional cooperation and assistance programs operated by the European Union (EU) and many governments, particularly (because of its scale) the United States; establishment of regional training centres and centres of excellence on nuclear safeguards and nuclear security, for example by China, India, Japan and South Korea; the Asian Nuclear Safety Network (ANSN); and the Asia–Pacific Safeguards Network (APSN). A recent initiative is the Gulf Nuclear Energy Infrastructure Institute (GNEII), opened in Abu Dhabi in 2011: this is a joint US/UAE venture aimed at strengthening nuclear energy security, safeguards and safety infrastructure development throughout the Gulf region. There are also the industry-based World Association of Nuclear Operators (WANO), dealing with nuclear safety, and the World Institute for Nuclear Security (WINS).

4.3.2 Role of the IAEA in Nuclear Cooperation

4.37 All of the IAEA's program areas (safeguards, nuclear safety, nuclear security, nuclear energy, and nuclear sciences and applications), include elements of cooperation, training and capacity-building for IAEA member states. The IAEA's main vehicle for nuclear cooperation, however, is the Technical Cooperation Programme. While all IAEA member states are eligible for technical support, "in practice technical cooperation activities tend to focus on the needs and priorities of less developed countries."[13]

4.38 Because the IAEA's statute does not expressly refer to a Technical Cooperation Programme, this program is not funded as part of the agency's regular budget, but primarily through voluntary contributions from member states to the Technical Cooperation Fund (TCF). Contributions are based on an assessed share of a target amount set by the member states in consultation with the IAEA secretariat. These extra-budgetary funds are supplemented by other resources and in-kind contributions provided by a number of states.

12. IAEA, *Annual Report 2011,* p. 14.
13. IAEA, *Our Work, Technical Cooperation,* http://www.iaea.org/technicalcooperation/programme/index.html.

4.39 The Technical Cooperation report for 2011 indicates that the IAEA was able "to expand its role in contributing to the global development agenda through its technical cooperation (TC) programme." The report notes the comparative advantages of nuclear technologies, applications and techniques for contributing to sustainable development within the framework of the UN Millennium Development Goals (MDGs), the Programme of Action for the Least Developed Countries for the Decade 2011–2020 and the concept of a "green economy."[14] The 2011 TCF expenditures by technical field are set out in Table 4.2.

Table 4.2: 2011 IAEA Technical Cooperation Fund Expenditure by Technical Field

Field	Expenditure €million	Per Cent of total
Nuclear fuel cycle	22.544	27.0
Human health	15.200	18.3
Nuclear safety	13.412	16.1
Human capacity development	7.994	9.6
Radioisotope production & radiation technology	6.935	8.3
Food and agriculture	6.312	7.6
Nuclear power	3.520	4.2
Environment	2.481	3.0
Water resources	1.270	1.5

Source: IAEA, *Technical Cooperation Report for 2011, Supplement*, p. 36.

4.40 The IAEA provides the foundation for international cooperation on nuclear energy infrastructure, offering a wide range of services, publications and meetings to assist member states intending to develop nuclear power. In 2009, the IAEA began providing Integrated Nuclear Infrastructure Review missions to member states. These cover the comprehensive infrastructure required for building a nuclear power program including safeguards, security and safety. The missions, shown in Table 4.3, have been carried out in seven states – Bangladesh, Belarus, Indonesia, Jordan, Thailand, UAE and Vietnam – and a mission is being planned for Turkey.

4.41 The IAEA also offers the Integrated Regulatory Review Service (IRRS), designed to enhance the effectiveness of the regulatory infrastructure of states for nuclear, radiation, radioactive waste and transport, safety and security of radioactive sources, by reviewing both regulatory technical and policy issues against IAEA safety standards and good practice in other states. The Technical Cooperation Programme also delivers substantial assistance to IAEA member states on developing the infrastructure necessary for a nuclear power program.

14. Report of the Director General, *Technical Cooperation Report for 2011,* GC(56)/INF/4 (Vienna: IAEA, July 2012), p. 5; http://www.iaea.org/technicalcooperation/Pub/Ann-Reports/index.html.

Table 4.3: IAEA Integrated Nuclear Infrastructure Review Missions

INIR Missions	Conducted in or Planned for	Review Status	Other Information
Bangladesh	2011	Phases I & II	
Indonesia	2009	Phase I	
Jordan	2009	Phase I	
Thailand	2010	Phase I	
UAE[a]	2011	Phase II	
Vietnam	2009	Phase I	
Jordan[b]	2011	Follow-up	Follow-up mission to 2009 mission
Belarus	2012	Phase I & II[c]	
Poland	2012	Phase I	
Vietnam	2012	Phase II	On-going
Jordan	2013	Phase II	Tentatively planned
South Africa[d]	2013	Self-evaluation	Tentatively planned
Turkey[e]	2013	Self-evaluation	Tentatively planned

a. http://www.iaea.org/NuclearPower/Downloads/Infrastructure/files/UAE-INIR-Mission-January-2011-Report.pdf.

b. First follow-up mission ever conducted (source: http://www.iaea.org/NuclearPower/News/2012/2012-04-10-INIG.html).

c. http://www.iaea.org/newscenter/news/2012/belarusnp.html.

d. http://www.necsa.co.za/Article/e23147b1-e19c-4a26-ae7d-38dd2528155d/6/Iaea-to-conduct-nuclear-infrastructure-mission-to-sa- october-.aspx.

e. http://www.iaea.org/NuclearPower/News/2012/2012-11-14-INIG.html.

Source: IAEA's INIR website: http://www.iaea.org/NuclearPower/Infrastructure/home.html

4.42 In non-power applications, the IAEA collaborates closely with other relevant international agencies, such as the Food and Agriculture Organization (FAO), the World Health Organization (WHO) and the United Nations Environment Programme (UNEP), to ensure that TC projects are conducted in priority areas.

4.43 In 2011 member states' contributions to the TCF were €60.5 million. Additional resources – other income, further extra-budgetary and in-kind contributions – amounted to €21.4 million, making an overall total of €81.9 million (approximately USD 114 million).[15] Resources available to the TCF in 2011 represented an increase of almost 60 per cent over the resources available a decade earlier, in 2002 (€51.5 million) – even allowing for inflation, a substantial increase. Active projects at the end of 2011 totalled 681, with an additional 80 projects in the process of being closed.[16] In addition, the IAEA Peaceful Uses Initiative, launched in 2010, "has become an important vehicle to raise extra-budgetary contributions for IAEA activities in the peaceful uses of nuclear technology."[17]

4.44 There are regular calls for the resources to the TCF to be increased. In this regard, the additional resources of €21.4 million contributed to the TCF in 2011 are consistent with the additional contributions of $100 million over five years called for in NPT 2010

15. IAEA, *Technical Cooperation Report for 2011,* Supplement, p. 3.

16. IAEA, *Annual Report 2011,* p. 97.

17. U*nderstanding the Peaceful Uses Initiative* (Vienna: IAEA 2012), http://www.iaea.org/newscenter/news/2012/pui.html.

Action 55. The suggestion that developing countries would benefit by increasing the funding of the TCF needs careful analysis. Typically each year the TCF underspends available funding, for example for 2011 the IAEA reported that the implementation rate for the TCF was 74 per cent.[18] Making better use of the available funds would bring increased benefit without increased funding levels. The TC Programme has been criticized on a number of grounds, including that recipients include a number of high- or relatively high-income states that can well afford to pay for IAEA services,[19] and that there is inadequate review and follow-up of project completion and outcomes.[20]

4.45 On the first point, it is noted that in 2011 the Europe region received some 48 per cent of TCF assistance, compared with Africa and Asia/Pacific, each around 18 per cent, and Latin America 12 per cent. As shown in Table 4.2, over 31 per cent of TCF expenditure was for projects relating to the nuclear fuel cycle and nuclear power, and 16 per cent for nuclear safety – all very important areas, but it could be asked whether those states active in these areas, certainly states operating or building nuclear facilities, should be able to afford to pay for IAEA services. These costs would be marginal compared with the costs of a nuclear power program.

4.46 Regarding the second point, the IAEA's TC review processes are undergoing improvement. For further increases to TCF funding to be warranted, it should be demonstrated that the current program is fully efficient, current funding is being fully utilized, planned outcomes are being achieved, including in subsequent years, and that funding is targeted at those in genuine need.

§4.4 Mitigating Proliferation Risks

4.4.1 Safeguards, Technology and National Supply Policies

4.47 Uranium enrichment and reprocessing, the key processes required for producing nuclear fuel at the front end and the back end of the fuel cycle, can also be used for producing fissile material[21] for nuclear weapons – indeed, they were first developed for this purpose. Accordingly, mitigating proliferation risk is largely concerned with ensuring that these technologies are used only for peaceful purposes.

4.48 The international community is broadly agreed that limiting the spread of these sensitive nuclear technologies is in the interests of all states and making this choice will involve substantial practical benefits to countries looking to develop peaceful nuclear energy programs. But an inclusive approach which respects state sovereignty and rights to development is critical. There is a need to reach a shared understanding on how to translate this general principle into practical steps and concrete actions.

18. IAEA, *Technical Cooperation Report for 2011,* p. vii.

19. Trevor Findlay, *Unleashing the Nuclear Watchdog* (Waterloo, Ontario: Centre for International Governance Innovations, 2012), p. 87.

20. Findlay, *Unleashing the Nuclear Watchdog*, p. 87, citing reviews by the IAEA's Office of Internal Oversight and the US General Accounting Office.

21. HEU (highly enriched uranium) and separated plutonium.

4.49 The need for special arrangements for these technologies was recognized at the very beginning of the nuclear era, and proposals were advanced for the internationalization of nuclear programs.[22] Agreement could not be reached, however, and nuclear programs have proceeded since on a national basis. Consequently, efforts to mitigate proliferation risk have a major place in the international agenda. There is no magic bullet to eliminate all proliferation risk – no current nuclear fuel cycle is completely proliferation proof. But a combination of institutional and technical measures can give needed robustness to non-proliferation efforts, and also to counter-terrorism efforts.

4.50 Central to these efforts is the NPT. This, however, does not specifically address the use of any particular nuclear technology and requires only that non-NWS conduct nuclear activities only for peaceful purposes under verification by IAEA safeguards. It has now become apparent that the NPT does not deal adequately with the issue of proliferation-sensitive technology.

4.51 When the NPT was negotiated it was thought that in practice enrichment and reprocessing programs would be limited to the NWS and a small number of other advanced industrialized states. Today, in addition to the five recognized NWS and the other four nuclear-armed states, there are at least eight states that have demonstrated enrichment capability, and five that have demonstrated reprocessing capability, ten states in all, with some states having both (Table 4.4).

Table 4.4: States with Demonstrated Enrichment and/or Reprocessing Capability

NWS	**Nuclear-Armed States**	**Other States**		
These states have both enrichment and reprocessing capabilities		**Enrichment capability**	**Reprocessing capability**	**Enrichment and reprocessing capabilities**
United States	India	Argentina	Belgium	Brazil
Russia	Pakistan	Australia	Italy	Germany
UK	North Korea	Iran		Japan
France	Israel*	Netherlands		
China		South Africa		

* Israel has neither confirmed nor denied nuclear--armed status.

Source: Centre for Nuclear Non--proliferation and Disarmament.

4.52 An issue neither clearly foreseen nor adequately addressed in the NPT is the distinction between nuclear latency and nuclear hedging. "Nuclear latency" refers to the situation where a state has established, under an apparently peaceful nuclear program, *dual-use* capabilities – uranium enrichment and/or reprocessing. Nuclear latency might be considered *inadvertent*: a state with enrichment or reprocessing capabilities thereby has the basic capability to produce fissile material for nuclear weapons, though it may well have – at least in foreseeable circumstances – no intention of doing so.

22. The Acheson-Lilienthal and Baruch plans considered by the UN Atomic Energy Commission in the 1940s.

4.53 It is not impossible that even a state as firmly committed to non-proliferation as Japan could change its position in the future. Some commentators refer to such a state as a *virtual* nuclear-weapon state. However, as well as weapons-useable fissile material, other capabilities would be required for weaponization, including suitable delivery systems, and Japan does have a longstanding and strongly held commitment against pursuing nuclear weapons. Nonetheless, it does illustrate the problem of enrichment and reprocessing capabilities being in national hands.[23]

4.54 If nuclear latency is supposedly inadvertent, nuclear hedging refers to a deliberate national strategy of establishing the option of relatively rapid acquisition of nuclear weapons, based on an indigenous technical capacity to produce them within a relatively short time frame – ranging from several weeks to a few years.[24] Nuclear hedging could result in *virtual* arms races, with the risk of degenerating very quickly into real arms races, break-out from the NPT, and even nuclear war. The existence of suspected nuclear hedging programs undermines the confidence and stability that the NPT is intended to promote. There is no doubt that the larger the number of states perceived as *virtual* nuclear-armed states, the greater the potential destabilizing effect on the non-proliferation regime.

4.55 **Safeguards.** When the NPT was concluded, it was assumed that IAEA comprehensive safeguards would provide timely warning of any misuse of nuclear facilities, giving the international community opportunity to intervene before a proliferator has time to turn diverted nuclear material into nuclear weapons. However, centrifuge enrichment technology presents a serious challenge to this objective – the relative ease of concealing centrifuge plants and the potential speed of break-out mean that in certain circumstances,[25] adequate warning time cannot be guaranteed. Even if removal of enriched uranium from safeguards, or use of a safeguarded facility for high enrichment,[26] is detected immediately, the time required for international deliberations could mean that practical intervention is not possible within the necessary timeframe.

4.56 Similar timeliness issues are raised where stocks of separated plutonium are held. The risks are exacerbated where high-fissile (weapon-grade) plutonium is involved, for example with fast breeder reactors or large "research" reactors.[27] There is a real concern that if plutonium is diverted, and the state has been able to make the necessary preparations in advance, the plutonium could be turned into nuclear weapons before effective intervention is possible.

4.57 Where proliferation-sensitive facilities and materials are involved, it is essential to have the most effective form of safeguards. Today this includes measures under the IAEA's Additional Protocol, together with the most advanced safeguards technologies –

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23. This concern is reinforced by the occasional comments by some Japanese political figures about the need to maintain fuel cycle capabilities in order to ensure a nuclear weapon option, or "strategic deterrence."

24. Ariel E. Levite, "Never Say Never Again: Nuclear Reversal Revisited," *International Security* 27:3 (Winter 2002/03), pp. 59–88.

25. For example a state that has an industrial-scale enrichment facility, or the capability to establish undeclared enrichment facilities for upgrading LEU diverted from safeguards.

26. One problem here is that production of HEU is not prohibited – if a state started to do this, vital time could be lost on legalistic arguments.

27. Such as Iran's Arak reactor.

remote monitoring, a "safeguards by design" approach for facilities, and so on. Although the number of states that have concluded Additional Protocols continues to grow – by 18 since the 2010 NPT Review Conference – several states with sensitive nuclear programs still remain outside this most effective form of safeguards (see Chapter 2). As important as universalization of the Additional Protocol is, however, the practical limitations to safeguards outlined here indicate the case against over-reliance on safeguards – non-proliferation is also dependent on other technical countermeasures and on institutional measures, especially establishing multilateral rather than national control of proliferation-sensitive nuclear facilities.

4.58 **Technology.** Technical approaches to mitigating proliferation risk involve avoiding or minimizing the production and use of proliferation-sensitive materials, and building proliferation resistance into facilities and technology. While the focus of proliferation resistance is on possible misuse by states, measures taken for proliferation resistance can also contribute to nuclear security through protecting nuclear materials and facilities against access and misuse by non-state actors. For example, avoidance/elimination of weapon-grade materials in civil nuclear programs reduces the risk of terrorists being able to produce a workable nuclear explosive device.

4.59 Technical measures for proliferation resistance include avoiding production of weapon-grade material and introducing technical barriers to producing such material; ensuring nuclear material is difficult to access (for example through high radiation levels) in order to increase the difficulties of diversion by states or theft/seizure by terrorists; and avoiding separation of plutonium from spent fuel, at least as a pure product.

4.60 International efforts to minimize production and use of proliferation-sensitive materials have been focused on highly enriched uranium (HEU). The principal use of HEU in civil programs has been as fuel for research reactors. HEU is also used as an irradiation target material for production of medical isotopes. These efforts have had considerable success: since 1978, 62 HEU-fueled research reactors have been converted to use LEU fuel and 17 HEU reactors have been shut down in 36 states. In the medical-isotope industry, most producers have committed to convert their reactors and targets to use LEU by 2015. However, some 70 tons of HEU remain in the civil sector[28], and remaining reactor conversions are expected to take another decade or more.

4.61 Similar attention has not been given to use of plutonium fuels. Plutonium obtained through reprocessing spent fuel has been in commercial use as reactor fuel, mainly in the form of MOX – a mix of plutonium and uranium oxides – since the 1980s. Currently MOX is used in over 30 power reactors, mostly in Europe. The plutonium currently used in MOX fuel is reactor grade, having an isotopic composition well outside the weapon-grade range. It would be difficult for a sub-state group to successfully explode a device made from this material, and the yield would be uncertain. A much higher risk would be presented if MOX was produced from weapon-grade plutonium – from the terrorism as well as the proliferation perspective, production of weapon-grade plutonium in civil programs should be avoided.

28. NTI, *Civilian HEU Reduction and Elimination Resource Collection*, http://www.nti.org/analysis/reports/civilian-heu-reduction-and-elimination/.

4.62 The main risk of weapon-grade plutonium being produced and used in the civil cycle comes from the prospective use of fast breeder reactors. In the established fast breeder reactor design, the reactor core, containing the fuel, is surrounded by a uranium "blanket" in which neutrons are captured to produce further plutonium. A major issue from the non-proliferation perspective, however, is that plutonium produced in fast breeder reactor blankets has a very high proportion of the isotope Pu-239, well within the weapon-grade range. This combination of producing weapon-grade plutonium and reprocessing presents obvious proliferation concerns. Moreover, use of separated weapon-grade plutonium on a commercial scale could present a major terrorism risk.

4.63 This problem is recognized at the technical level and reactor designs are being considered in which plutonium would be produced outside the weapon-grade range. The international programs coordinating research in this area - INPRO[29] and GIF[30] - include proliferation-resistance amongst the major development criteria. Of particular importance is the development of advanced spent fuel treatments – such as electro-metallurgical processing (otherwise known as pyro-processing) – which will enable plutonium recycle without separation. Plutonium will not be produced as a purified material, but will remain in a highly radioactive mix with fission products and other spent fuel materials. This highly radioactive mix will be made into new fuel using robotic equipment. In 2010 the US and South Korea agreed to a joint study of pyro-processing, particularly proliferation resistance aspects.

4.64 Another approach promoted by some is the thorium fuel cycle, which avoids the production of plutonium. India has a long-standing interest in developing the thorium fuel cycle, and more recently China has commenced a substantial research program in this area.

4.65 India has major thorium reserves, and the possible use of thorium reactors has been under discussion there for decades. In June 2012 R. K. Sinha, Chairman of India's Atomic Energy Commission, announced plans for a thorium power plant. About two decades would be needed to assess the performance of the thorium reactor before replicating the initial prototype in significant numbers.[31] The current Indian vision for the thorium fuel cycle, however, raises proliferation and terrorism concerns: use of plutonium "driver fuel" is an essential aspect, and this would be weapon-grade plutonium produced in fast breeder reactors.

4.66 In China, it is reported that Jiang Mianheng (son of former President Jiang Zemin) has been given a start-up budget of USD 350 million to lead a project at China's prestigious National Academy of Sciences. By January 2013, he had already recruited 140 PhD scientists to work full-time on thorium power at the Shanghai Institute of Nuclear and Applied Physics and planned to increase the number to 750 staff by 2015. The Chinese believe they have enough thorium to power their electricity needs for 20,000 years.[32]

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29. INPRO is the IAEA's International Project on Innovative Nuclear Reactors and Fuel Cycles – see http://www.iaea.org/INPRO/about.html

30. GIF is the Generation IV International Forum, a collaboration amongst 12 countries and the EU – see www.gen-4.org

31. Ashok Pradhan, "India to establish nuclear reactor that uses thorium as fuel: Atomic Energy Commission," *Times of India*, 27 June 2012.

32. Quoted in Ambrose Evans-Pritchard, "China blazes trail for 'clean' nuclear power from thorium," *The Telegraph*

4.67 The chief scientific adviser to the United Kingdom government, Sir John Beddington, conceded in September 2012 that although the benefits of thorium are "often overstated," it does have some "theoretical advantages regarding sustainability, reducing radiotoxicity and reducing proliferation risk."[33] That said, the thorium fuel cycle is not entirely proliferation resistant: uranium (or plutonium) fuels are required for initial reactor fuelling cycles, and possibly thereafter as driver fuel, and uranium-233, which is produced through irradiation of thorium, can be used in nuclear weapons. U-233 is difficult to produce as a pure material (in the reactor it is produced in association with U-232, which makes weapons use impracticable). However, there are certain reactor concepts in which U-233 can be recovered without U-232 – it is essential for proliferation risk analysis to take this into account.

4.68 Progress in the development of technical approaches can be hard to demonstrate, given the long lead times with some of the technologies involved, but adoption of proliferation resistance as an important criterion in INPRO and GIF is encouraging. The non-proliferation regime benefits from the fact that, to date, enrichment and reprocessing – which provide the capabilities to produce the materials required for nuclear weapons – are not more widespread. The regime also benefits from HEU and separated plutonium not being widespread in civil programs. It is essential for the international community to take the steps necessary not only to maintain this situation, but to reduce the availability of proliferation-sensitive technologies and materials. (See Chapter 2 for further discussion of this issue, and non-proliferation policy generally.)

4.69 **National Supply Policies.** National policies on the supply of nuclear materials, equipment and technology subject to non-proliferation conditions are one of the earliest forms of risk mitigation. Nuclear suppliers reserve the right to decide what they will supply, who to, and under what terms. Supplier conditions were the basis for the earliest form of safeguards, under which suppliers required the right to verify that supplied items remained in peaceful use. Today supply policies coordinated by the NSG remain an important part of the non-proliferation regime.

4.4.2 Multilateralizing the Nuclear Fuel Cycle

4.70 The needs of states with nuclear power programs, or planning such programs, can be outlined as follows: reliable access to reactors and fuel on secure, non-discriminatory and equitable terms; reliable access, also on such terms, to fuel cycle services, especially for used fuel management; support in establishing regulatory systems; support through training and capacity building; and sharing of expertise in reactor operations, nuclear safety and nuclear security. These needs can, and arguably should, be met through development of a new international framework for the nuclear fuel cycle – a framework based on international cooperation rather than an emphasis on national programs in proliferation-sensitive areas.

(London), 6 January 2013, http://www.telegraph.co.uk/finance/comment/ambroseevans_pritchard/9784044/China-blazes-trail-for-clean-nuclear-power-from-thorium.html. See also the critical analysis by Andrew T Nelson of the US Los Alamos National Laboratory, "Thorium: Not a near-term commercial nuclear fuel," *Bulletin of the Atomic Scientists,* September 2012, http://bos.sagepub.com/content/68/5/33.

33. Evans-Pritchard, "China blazes trail for 'clean' nuclear power from thorium."

4.71 Every state has a legitimate interest in security of energy supply, but it is neither necessary nor cost effective for every state with a nuclear power program to develop uranium enrichment and reprocessing facilities. In principle, national enrichment programs are not viable except for states with large power programs operating twenty or more reactors. Viability is even more difficult in current circumstances where global enrichment capacity is adequate and increased demand can be readily met by existing enrichers. Most analysts conclude that reprocessing is not economic in current circumstances. Because possession of enrichment and reprocessing capabilities could increase international tensions − potentially leading to “virtual” arms races − and also because of the technical complexity and high costs, most states have not sought to establish these capabilities.

4.72 While energy independence may be cited as justification for a national fuel cycle, few states are in a position to achieve real independence. Apart from technological capabilities, not many states have uranium resources sufficient to maintain a nuclear power program independent of external supply. For most states international cooperation is likely to be a necessity, and for all states such cooperation will offer major advantages. Participation in international fuel cycle arrangements will lead to better outcomes than pursuing national independence.

4.73 Consideration of these issues internationally took a negative turn when the George W Bush Administration proposed that states not currently operating commercial enrichment or reprocessing facilities should permanently renounce these technologies. Many states, particularly in the Non-Aligned Movement, saw this as an attempt to entrench existing technology holders in a monopoly position. As a consequence, even international fuel bank proposals have been opposed as in some way furthering an agenda of denial. To counter these negative sentiments it will be necessary to demonstrate that alternatives to national fuel cycle programs offer security of supply on non-discriminatory and equitable terms, with advantages through collaborative approaches (for example in used fuel management), as well as the obvious advantages of mitigating proliferation risk.

4.74 **IFNEC and International Fuel Banks.** Much work is underway on proposals for practical and attractive alternatives to national programs in proliferation-sensitive areas. A number of proposals have been made to reflect these ideas. The proposal showing most progress is the International Framework for Nuclear Energy Cooperation (IFNEC), the successor to the Global Nuclear Energy Partnership (GNEP). GNEP started as a US initiative, but IFNEC now has a substantial international character, having grown to 32 participating states – including 17 developing countries – and 31 observer states, many of which can be expected to become full members.[34]

4.75 A key feature of IFNEC is that participating states are not asked to renounce any rights. IFNEC has adopted a pragmatic approach − to set aside unproductive political arguments about national “rights” and instead focus on practical problems and solutions.

34. IFNEC members as of December 2012 were: Argentina, Armenia, Australia, Bahrain, Bulgaria, Canada, China, Estonia, France, Germany, Ghana, Hungary, Italy, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Lithuania, Morocco, Netherlands, Oman, Poland, Romania, Russia, Senegal, Slovenia, South Korea, UAE, Ukraine, United Kingdom, and United States. See www.ifnec.org.

IFNEC has two Working Groups, on Infrastructure Development and Reliable Nuclear Fuel Services, and has also convened a Finance Workshop. IFNEC has made good progress in developing the concept of comprehensive fuel service arrangements, including fuel leasing, to meet the need for reliable fuel supply and to provide used fuel disposition options. The basic idea is that nuclear suppliers would commit to provide nuclear consumers with long-term whole-of-life fuel service assurances – suppliers would provide fresh fuel and take back used fuel, or otherwise assist with used fuel management. The practical and economic benefits of this international cooperation would be such that nuclear consumers have no legitimate reason for pursuing national programs in proliferation-sensitive technologies.

4.76 The IFNEC approach of establishing strong practical and economic advantages for states not to pursue sensitive technologies has considerable merit, but in itself it is not sufficient. First, it does not address the problem cases, except indirectly in the longer term. If IFNEC succeeds in establishing an international norm of behaviour against new national enrichment and reprocessing programs, this would be helpful in isolating those who act against this norm, but this is a long way off. The need to deal with Iran, and others that may insist on establishing fuel cycle programs in dubious circumstances, is more immediate (see further the section on Iran in Chapter 2).

4.77 Second, arrangements that are mostly commercial in nature might not offer sufficient assurance to states concerned about long-term security of supply. States are likely to have greater confidence in arrangements where assurances are legally binding in international law, that is, are based on a treaty-level umbrella. It would provide additional confidence if the IAEA were given an oversight role in these arrangements, to ensure that decisions are taken on an objective non-discriminatory basis.

4.78 Third, the IFNEC concept does not address existing enrichment and reprocessing programs. Some of these programs are of potential strategic concern, and all of them provide the operating state with nuclear latency. This is not only a non-proliferation issue, it is also an issue for disarmament. As nuclear disarmament progresses, the potential for rapid break-out from disarmament commitments will be just as great a concern as the potential for break-out from non-proliferation commitments. Furthermore, non-NWS being asked to accept restrictions on national nuclear programs are likely to argue that the new approaches should be non-discriminatory and apply also to the nuclear-armed states. Accordingly, concepts are needed for the transitioning of all nationally controlled enrichment and reprocessing programs to an appropriate alternative model within a realistic timeframe.

4.79 An important complement for international approaches such as those being developed in IFNEC is the establishment of international fuel banks as a fuel provider of last resort in case supply arrangements fail. There are now two such fuel banks – one established by Russia at the International Uranium Enrichment Centre (IUEC) at Angarsk, and one being established in Kazakhstan, under IAEA auspices and with funding assistance by the Nuclear Threat Initiative (NTI) and a number of IAEA member states.

4.80 **Multinational Control.** The most practical alternative to national control of sensitive nuclear programs is some form of multinational control, of the kind referred to in the NSG Guidelines:

> If enrichment or reprocessing facilities, equipment or technology are to be transferred, suppliers should encourage recipients to accept, as an alternative to national plants, supplier involvement and/or other appropriate multinational participation in resulting facilities. Suppliers should also promote international (including IAEA) activities concerned with multinational regional fuel cycle centres.[35]

As already noted, international operation of the nuclear fuel cycle was proposed unsuccessfully in the 1940s. This was looked at again by the International Nuclear Fuel Cycle Evaluation (INFCE) in the 1970s[36], and by the IAEA's study of proposals for multilateral approaches in 2005.[37]

4.81 A key objective of the multinational approach is to establish technical and institutional barriers against a state attempting to misuse enrichment and reprocessing capabilities. The less control an individual state has over such capabilities, the harder it will be to misuse them. Of course no barrier can be totally effective – a state can always seize facilities regardless of who owns and operates them – but arrangements such as black box[38] technology can be important in making misuse more difficult, providing more time for international intervention. Multinational approaches will also help ensure best practice standards of nuclear safety and security in the most sensitive parts of the fuel cycle.

4.82 Multinational approaches are not an unrealistic aspiration – examples already exist, like the European enrichment group URENCO and the International Uranium Enrichment Centre (IUEC) at Angarsk, Siberia. The IUEC was established by Russia in 2007, with the mission *To ensure equal and assured access for all countries to the benefits of atomic energy.*[39] Russia invites other states to join the IUEC as shareholders. The benefits include a guaranteed supply of fuel and services. Kazakhstan, Ukraine and Armenia have joined, and several others have indicated interest.

4.83 The precedents of URENCO and IUEC have important characteristics that can be built upon in future models, for example: a treaty providing for mutual oversight of facility operations (URENCO); consumers having product supply guarantees and equity participation (IUEC); or supply of sensitive technology only on a *black box* basis (URENCO, also Russian practice).

4.84 Drawing all this together, a possible model for future fuel cycle arrangements could be along the following lines.

- Fuel suppliers and fuel consumers form comprehensive partnerships covering all aspects of the fuel cycle, including fuel supply guarantees and cooperation in safety

35. NSG Guidelines, INFCIRC/254/Rev.10/Part 1, paragraph 6(e).
36. IAEA, *Report of the International Nuclear Fuel Cycle Evaluation,* 1980.
37. IAEA, *Multilateral Approaches to the Nuclear Fuel Cycle,* 2005, http://www-pub.iaea.org/books/IAEABooks/7281/Multilateral-Approaches-to-the-Nuclear-Fuel-Cycle
38. The "black box" concept implies transfer of complete turnkey systems and facilities, without transfer of enabling design and manufacturing technology, under conditions that do not permit or enable replication of the facilities.
39. See http://eng.iuec.ru.

and security, fuel fabrication, and management of used fuel and high level waste:

   - partnership arrangements, including fuel guarantees, are covered by treaty, with provisions binding in international law and under IAEA oversight;
   - these include fallback arrangements in case of supplier default.

> Sensitive facilities – enrichment and reprocessing – are operated by fuel suppliers under multination arrangements

   - where possible, technology is provided to the operator on a *black box* basis, as is currently the case with URENCO supplying the United States and France, and TENEX supplying China;
   - fuel consumers have the opportunity for equity participation in the facilities, including profit-sharing;
   - fuel consumers are involved in facility operations (without accessing sensitive technology) as an additional measure to assure against misuse of the facility.

4.85 Gaining support for multilateralization of proliferation-sensitive stages of the fuel cycle will be a challenge, but already there are practical precedents, for example Russia's IUEC and the URENCO enrichment group. What is needed now is to change the focus from national fuel cycle programs to the common interests of non-proliferation, energy security and strengthened international cooperation.

§4.5 Nuclear Safety and Security Commitments

4.86 The primary focus of this section is on nuclear safety: nuclear security is discussed in greater detail in Chapter 3 of this report. But it is increasingly being acknowledged, for example at the 2012 Nuclear Security Summit, that there is a significant connection between these issues, not least in that failures in safety protection may create opportunities for sabotage. The close connection between nuclear security and nuclear safety is recognized by the 2005 Amendment to the Convention on the Physical Protection of Nuclear Material (CPPNM) which, when it enters into force, will extend the convention to include protection of nuclear facilities against sabotage.

4.87 Sometimes, existing gaps can be detected and identified by national oversight authorities. For example, on 23 August 2012, the Comptroller and Auditor General of India tabled a highly critical report in parliament on the Atomic Energy Regulatory Board (AERB) that pointed to several deficiencies in India's nuclear regulatory authority.[40] The AERB has failed to prepare a nuclear and radiation safety policy despite being mandated to do so when constituted in 1983. It has no direct role in conducting independent assessments and monitoring to ensure the safety of personnel working in nuclear power plants. It does not have a detailed inventory of all radiation sources to ensure effective compliance with regulations for the safe disposal of spent sources, so that it could not be verified whether or not radioactive waste had actually been disposed of. India lacks a legislative framework for decommissioning of nuclear power plants.

40. P. Sunderarajan, "CAG pulls up AERB for not preparing nuclear safety policy," *The Hindu,* 24 August 2012, http://www.thehindu.com/todays-paper/tp-national/article3814528.ece.

4.88 The Fukushima nuclear accident in 2011 underscores the connection between safety and security. Terrorists might well attempt to replicate an accident of this kind, for example by sabotaging a reactor's cooling system and emergency power supply or by sabotaging spent fuel ponds.

4.89 The international concerns have been reinforced by the conclusions of the Kurokawa panel's findings for the Japanese parliament, that:

> The TEPCO Fukushima Nuclear Power Plant accident was the result of collusion between the government, the regulators and TEPCO, and the lack of governance by said parties. They effectively betrayed the nation's right to be safe from nuclear accidents. Therefore, we conclude that the accident was clearly "manmade." We believe that the root causes were the organizational and regulatory systems that supported faulty rationales for decisions and actions…[41]

It was reported, for example, that workers at the crippled Fukushima No. 1 nuclear plant were ordered to cover their dosimeters – pocket-sized devices that emit an alarm when high radiation levels are detected – with lead plates in order to keep the radiation level readings low enough to keep working. Those who demurred because of safety or legal considerations were told by a senior TEPCO official that they would lose their jobs and be blacklisted from employment at other nuclear plants.[42]

4.90 For reasons of both safety and security concerns, the principal lesson of the Fukushima accident is that nuclear activities cannot be regarded as the exclusive province of individual states – nuclear activities have potential consequences well beyond the borders of any one state. While the primary responsibility for nuclear safety and security rests with each state, every state is a stakeholder in how well other states meet this responsibility. A major nuclear accident will have global consequences. Even if an accident does not result in significant trans-boundary contamination, there will be an impact on confidence in and support for nuclear energy. Likewise, a nuclear detonation or major nuclear sabotage by terrorists will have global repercussions.

4.91 Fukushima demonstrated that neither individual states nor the international community as a whole are well served by relying exclusively on national oversight of nuclear activities. If a leading state such as Japan has difficulties with nuclear regulation and emergency management, what can be expected with smaller states, and those planning new nuclear programs? Fukushima shows the need to find a more appropriate balance between national and international interests and responsibilities in the conduct of nuclear energy. There is a need for greater international cooperation and collaboration, together with international transparency and accountability.

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41. *The official report of The Fukushima Nuclear Accident Independent Investigation Commission - Executive summary* (Tokyo: National Diet of Japan, 2012), p. 16.

42. Jun Sato, Chiaki Fujimori, Miki Aoki, Tamiyuki Kihara and Takayuki Kihara, "TEPCO subcontractor used lead to fake dosimeter readings at Fukushima plant," *Asahi Shimbun*, 21 July 2012, http://ajw.asahi.com/article/0311disaster/fukushima/AJ201207210069.

Box 4.1. The Fukushima Nuclear Meltdown 2011

The meltdown of three nuclear reactors at Fukushima in March 2011 was caused as a consequence of the massive earthquake and tsunami to hit eastern Japan that month, through loss of emergency electrical supply needed to maintain systems vital to safety. But the tragedy also showed up major deficiencies in Japan's nuclear disaster preparedness arrangements and vulnerabilities in Japan's nuclear security governance.

Not only had neither the Tokyo Electric Power Co. (TEPCO) nor the government failed to construct a protection wall high enough to withstand a tsunami after a major earthquake, they had failed to adopt a multi-redundancy approach to secure power supplies at Fukushima No. 1 plant, and therefore were unable to mitigate the severity of the crisis as the critical cooling systems shut down.

The system vulnerability shown up in March 2011 was foreseeable and had been imagined. American specialists had in fact identified the very elements worst affected as the possible targets of terrorist attack: spent fuel pools, cooling systems, and backup electricity (see Associated Press, "Following U.S. antiterrorism advice might have prevented meltdowns," *Japan Times*, 4 April 2012). Since 9/11 the US has adopted a multi-redundancy approach to power supply to reactors as a precaution against a possible nuclear terrorist attack. But in Japan the risk was ignored – apparently because it was modelled against nuclear terrorists, not natural disasters.

The lesson of Fukushima is that both existing and planned nuclear reactor plants must pay full attention to the safety–security interface, including access control mechanisms, at the plant design stage. There should be common, mandatory standards for the siting, construction and operation of nuclear power plants, and for treatment of spent fuel and nuclear waste.

4.92 **Participation in treaties.** The international interest in non-proliferation is long-recognized, through a number of treaties and institutions, notably the NPT and the IAEA safeguards system. The international interest in nuclear safety and nuclear security is also of fundamental importance, but regrettably less well reflected both in uptake of the relevant treaties, and in the comparatively weak commitments under those treaties. Too much of the international governance arrangements in these areas is voluntary. There is nothing remotely equivalent to IAEA safeguards inspections. Participation in relevant treaties is uneven, a key nuclear security treaty – the 2005 Amendment to the CPPNM – still has insufficient parties to enter into force, and there is an absence of international transparency and accountability mechanisms.

4.93 Participation in the key nuclear safety and security conventions is shown in Tables 4.5 and 4.6 respectively. While universalization of these conventions is a major goal, it is especially important to have the participation of all the states with significant nuclear activities[43] – in the interest of space the tables focus on these states.

43. As defined by the IAEA – primarily applies to states with nuclear facilities.

Table 4.5: States with Significant Nuclear Activities: Participation in Nuclear Safety Conventions (indicated by shaded squares) (2011/2012)

	Nuclear Safety Convention	Joint Convention on Spent Fuel and Radwaste	Early Notification Convention	Nuclear Assistance Convention
Algeria	signed		■	■
Argentina	■	■	■	■
Armenia	■		■	■
Australia	■	■	■	■
Austria	■	■	■	■
Bangladesh	■		■	■
Belarus	■	■	■	■
Belgium	■	■	■	■
Brazil	■	■	■	■
Bulgaria	■	■	■	■
Canada	■	■	■	■
Chile	■	■	■	■
China	■	■	■	■
Colombia			■	■
Congo, DR			signed	signed
Czech Rep	■	■	■	■
Denmark	■	■	■	■
Egypt	signed		■	■
Estonia	■	■	■	■
Finland	■	■	■	■
France	■	■	■	■
Georgia		■	■	■
Germany	■	■	■	■
Ghana	■	■		
Greece	■	■	■	■
Hungary	■	■	■	■
India	■		■	■
Indonesia	■	■	■	■
Iran			■	■
Iraq			■	■
Israel	signed		■	■
Italy	■	■	■	■
Jamaica				
Japan	■	■	■	■
Kazakhstan	■	■	■	■
Latvia	■	■	■	■
Libya	■		■	■
Lithuania	■	■	■	■
Malaysia			■	■
Mexico	■		■	■

Table 4.5 continued

	Nuclear Safety Convention	Joint Convention on Spent Fuel and Radwaste	Early Notification Convention	Nuclear Assistance Convention
Morocco	signed			
Netherlands				
Nigeria				
North Korea			signed	signed
Norway				
Pakistan				
Peru		signed		
Philippines	signed	signed		
Poland				
Portugal				
Romania				
Russia				
Serbia				
Slovakia				
Slovenia				
South				
Africa				
South				
Korea				
Spain				
Sweden				
Switzerland				
Syria	signed		signed	signed
Tajikistan				
Thailand				
Turkey				
Ukraine				
UK				
United States				
Uzbekistan				
Venezuela				
Vietnam				

Source: IAEA

4.94 After the Chernobyl accident in 1986, governments and industry realized that substantial steps were needed to regain public confidence in nuclear energy. This prompted a series of new agreements – particularly the Convention on Nuclear Safety (CNS), the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident. In contrast, after the Fukushima accident the international response has been surprisingly muted. With some notable exceptions, governments and industry do not seem to understand the damage to public confidence and the need for change, to move from state primacy to greater international cooperation and accountability.

4.95 The 1994 CNS is the principal treaty on nuclear safety. The Convention applies to power reactors, but many states without power reactors have joined to show their support for safety principles. The convention has 75 parties.[44] States that have not become parties include Iran – the only state with a power reactor not a party – and Egypt (which has signed but not yet ratified), which plans to establish a nuclear power program.

4.96 Another major treaty on nuclear safety is the 1997 Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. This applies primarily to spent fuel and radioactive waste resulting from civilian nuclear reactors and applications, and to planned and controlled releases into the environment of liquid or gaseous radioactive materials from regulated nuclear facilities. The joint convention also imposes obligations in relation to the trans-boundary movement of spent fuel and radioactive waste, and the safe management of disused sealed sources. It has 64 parties.[45] It is of concern that a number of states operating power reactors are not party to this Convention, namely Armenia, India, Iran, Mexico and Pakistan.

4.97 The 1986 Convention on Early Notification of a Nuclear Accident and the 1986 Convention on Assistance in the Case of a Nuclear Accident each has 114 parties, including all of the states with power reactors and most of the states with significant nuclear activities. Exceptions include North Korea and Syria (each of which has signed) and Uzbekistan and Venezuela.

4.98 As noted in the preceding chapter on nuclear security (section 3.3.1), the principal convention on nuclear security – and currently the only legally binding multilateral instrument dealing with nuclear security – is the 1980 Convention on the Physical Protection of Nuclear Material (CPPNM). As noted in the last chapter, the CPPNM is some way from achieving universality, and by mid-December 2012 the 2005 Amendment to the CPPNM had received only 61 of the 99 ratifications required for it to enter into force. Similarly, it was noted in section 3.3.2 of the last chapter that significant states are yet to become party to the 2005 International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT).

4.99 **Standards and accountability.** Compared to non-proliferation and safeguards, international governance in nuclear safety and nuclear security is weak. The IAEA has only a recommendatory role. By its statute, the IAEA is authorized to develop and promulgate nuclear safety standards.[46] As with safeguards, the statute provides that states may conclude arrangements giving the IAEA authority to apply safety standards. To date however no such arrangements have been concluded by any state.

44. As at 5 April 2012.
45. As at 2 August 2012.
46. IAEA Statute Article III.A.6.

Table 4.6: States with Significant Nuclear Activities: Participation in Nuclear Security Conventions (indicated by shaded squares)

	CPPNM	CPPNM Amendment	ICSANT
Algeria	■	■	■
Argentina	■	■	signed
Armenia	■		■
Australia	■	■	■
Austria	■	■	■
Bangladesh	■		■
Belarus	■		■
Belgium	■		■
Brazil	■		■
Bulgaria	■	■	signed
Canada	■		signed
Chile	■	■	■
China	■	■	■
Colombia	■		signed
Congo, DR			■
Czech Rep	■	■	■
Denmark	■	■	■
Egypt			signed
Estonia	■	■	signed
Finland	■	■	■
France	■		signed
Georgia	■	■	■
Germany	■	■	■
Ghana	■	■	signed
Greece	■	■	signed
Hungary	■	■	■
India	■	■	■
Indonesia	■	■	
Iran			
Iraq			
Israel	■	■	signed
Italy	■		signed
Jamaica	■		signed
Japan	■		■
Kazakhstan	■	■	■
Latvia	■	■	■
Libya	■	■	■
Lithuania	■	■	■
Malaysia			signed
Mexico	■	■	■
Morocco	■		■
Netherlands	■	■	■

Nigeria			
North Korea			
Norway			signed
Pakistan			
Peru			
Philippines			signed
Poland			
Portugal			signed
Romania			
Russia			
Serbia			
Slovakia			
Slovenia			
South Africa			
South Korea			signed
Spain			
Sweden			signed
Switzerland			
Syria			signed
Tajikistan			signed
Thailand			signed
Turkey			
Ukraine			
UK			
United States			signed
Uzbekistan			
Venezuela			
Vietnam			
Sources:	CPPNM	IAEA, 17 Oct. 2012	
	A/CPPNM	IAEA, 12 Dec. 2012	
	ICSANT	UN Treaties Collection Database, 20 Jan. 2013	

4.100 The statute, which was concluded in 1956 before awareness of nuclear security issues had developed, makes no specific reference to nuclear security. This has led some states to question whether the IAEA should have any role in nuclear security – though the reference in the statute to "standards of safety for protection of health and minimization of danger to life and property"[47] can certainly be interpreted to encompass nuclear security. Reflecting this lack of specific reference to nuclear security, much of the IAEA's work in this area is funded by voluntary contributions rather than through its regular budget. In nuclear security the IAEA's role is limited to recommendations and advice.

4.101 The CNS is described as an "incentive instrument." Parties are committed to apply fundamental safety principles but there are no detailed or binding standards. The IAEA promulgates nuclear safety standards, but the application of these is voluntary. When the convention was negotiated some states proposed an active monitoring role for the IAEA, but this was not agreed.

47. IAEA Statute Article III.A.6.

4.102 The CPPNM sets out broad security standards and the 2005 CPPNM Amendment (not yet in force) sets out fundamental principles, but there are no detailed or binding security standards. The IAEA promulgates nuclear security guidelines, but as with nuclear safety standards, application of these guidelines is voluntary.

4.103 The CNS has a broad peer review process, which requires each party to report on its national implementation of the convention. These national reports are discussed at meetings held every three years. While many parties publish their reports, formally these reports and the discussion of them are confidential to the parties. By contrast, the CPPNM has neither any mechanism for reporting national implementation, nor even any mechanism for the parties to convene meetings.

4.104 The absence of binding standards makes it all the more important to have mechanisms for external review of nuclear safety and security implementation, and sharing of best practices in these areas. External review is not just about compliance, but helps share best practice and can be vital in identifying overlooked vulnerabilities. At present peer review is the only mechanism for external review.

4.105 As noted above, the CNS has a mandatory peer review process at the level of national implementation. More specific peer reviews, including at the facility level, are offered by the IAEA and by the non-government World Association of Nuclear Operators (WANO). IAEA reviews are entirely voluntary – there is no obligation to invite a review or to follow its recommendations. In October 2011 the members of WANO, which include nearly all the world's nuclear power reactor operators, agreed to regular mandatory peer review of nuclear safety at power reactors. This is a welcome development – but the WANO process, like the IAEA review process, lacks transparency. Outsiders have no way of knowing how well the process works in practice.

4.106 Unlike nuclear safety, in nuclear security there is no form of mandated peer review process. The need to avoid compromising security should not be used as an excuse for avoiding external review. The managed access concept is well established, and states can readily establish appropriate procedures. The members of WANO have endorsed mandatory peer review – it is to be hoped that the members of WINS (which in many cases are the same entities as in WANO) will do the same.

4.107 The Fukushima accident led to the calling of two high-level nuclear safety meetings in 2011, the first by IAEA Director General Yukiya Amano on 20–24 June and the second by the United Nations Secretary-General Ban Ki-moon on 22 September. The IAEA meeting resulted in the adoption of an action plan on nuclear safety. However, this plan is seen by a number of states as failing to meet international expectations, containing few new commitments and little in the way of increased transparency or safety peer reviews.[48] A number of states, notably France, proposed mandatory, regular and transparent external safety inspections. This was resisted by the United States, India, China and Pakistan, among others.

4.108 At the September 2011 meeting, Secretary-General Ban called for "greater

48. Reuters, "IAEA states divided on how to best to boost nuclear safety," http://www.reuters.com/article/2011/09/13/nuclear-safety-iaea-idUSL5E7KD1IY20110913.

transparency and open accountability," and for stronger international safety standards. President Nicolas Sarkozy of France said that while the IAEA plan was a step in the right direction, the world could not accept different states having different standards. "The highest requirements must be applied to everybody on all continents," he said. "This must go through a harmonization of technical safety standards."

4.109 Despite the position taken by France and several others, at this stage nuclear safety remains very much a matter of national prerogative. Fukushima shows the risks in this. For example, the IAEA and others had identified the issue of inadequate regulatory independence in Japan over a number of years, but only after Fukushima did the Japanese government accept this criticism and introduce more effective arrangements.

4.110 Most recently, the IAEA and the Japanese government convened the Fukushima Ministerial Conference on Nuclear Safety in Koriyama, Fukushima Prefecture, 15–17 December 2012. According to the Chairpersons' Summaries from this conference, participants noted the importance of peer review missions and transparency of the results of these, as well as ensuring that regulatory bodies operate in an open and transparent manner. The Summaries note that "there has been considerable focus on enhancing the international peer review mechanisms for nuclear operators and regulators worldwide, as well as on promoting openness and transparency to ensure that stakeholders – in particular the public – can hold industry and regulators properly to account, thereby enhancing trust and confidence." The Chairpersons' Summaries also note that "One of the most effective actions to strengthen nuclear safety worldwide is for member states to utilize the IAEA safety standards as broadly and effectively as possible in a consistent manner."

4.111 While the discussion at the Fukushima Conference is encouraging, serious consideration of binding safety standards and international inspections seems to be as far away as ever. Currently there is resistance from key states to the idea of binding nuclear safety standards and international safety inspections. Until governments are prepared to give the IAEA an active monitoring role in nuclear safety, for example through concluding bilateral agreements with the agency as is done with safeguards, their commitment to substantial reform of nuclear safety governance will be open to question.

4.112 Today the idea of an international nuclear security inspectorate is anathema to most national security officials. For the future, states should seriously consider how an international security inspection process could be developed so as to operate to mutual benefit.

4.113 The importance of international accountability needs to be recognized. In nuclear safety at least there is the reporting process under the CNS. There is no similar process in nuclear security for national reporting on adherence to the conventions, IAEA recommendations, and so on. The only current mechanism is reporting under Security Council Resolution 1540 – this contains some reporting requirements for nuclear security, but to date there has been no substantial follow-up on this particular aspect.

4.114 **Liability for Nuclear Damage.** Recognition of the possibility of transboundary damage from a nuclear accident led to the conclusion of several international conventions dealing with international compensation issues. The principal conventions are the 1960 Convention on Third Party Liability in the Field of Nuclear Energy (the Paris Convention) – open only to members of the Organisation for Economic Co-operation and Development (OECD); the 1963 Convention on Civil Liability for Nuclear Damage (the Vienna Convention); and the 1997 Convention on Supplementary Compensation for Nuclear Damage (CSC) – developed as an umbrella for the other conventions.[49] Participation in these conventions is shown in Table 4.7.

Table 4.7: Participation in Liability Conventions by States with Nuclear Power

State	Convention	State	Convention
Argentina	Vienna, CSC	Mexico	Vienna
Armenia	Vienna	Netherlands	Paris
Belgium	Paris	Pakistan	
Brazil	Vienna	Romania	Vienna, CSC
Bulgaria	Vienna	Russia	Vienna
Canada		Slovak Republic	Vienna
China		Slovenia	Paris
Czech Republic	Vienna	South Africa	
Finland	Paris	South Korea	
France	Paris	Spain	Paris
Germany	Paris	Sweden	Paris
Hungary	Vienna	Switzerland	Paris
India	CSC signed	Ukraine	Vienna
Iran		UK	Paris
Japan		United States	CSC

Source: Centre for Nuclear Non-Proliferation and Disarmament.

4.115 The Convention on Supplementary Compensation is not yet in force – entry into force requires ratification by five states with a minimum installed nuclear capacity of 400,000 megawatts thermal, roughly equivalent to 120,000 megawatts electrical (MWe). To date four states (Argentina, Morocco, Romania and the United States) have ratified, with a total installed capacity of 103,700 MWe. Eleven other states have signed, including three with nuclear power programs (Czech Republic, India and Ukraine). If and when these three ratified, this would be sufficient for the convention to enter into force.

49. In addition to these conventions there is the Convention Supplementary to the Paris Convention of 1963 (Brussels Supplementary Convention) and a number of protocols amending the Paris and Vienna Conventions, and the 1988 Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention.

4.116 With some variations, these conventions set out the following basic principles:

- Strict liability of the nuclear operator (that is, claimants do not have to prove fault);
- Exclusive liability of the operator – all claims are brought against the operator;
- Exclusive jurisdiction in the courts of the state in which the accident occurs;
- Mandatory insurance cover – the operator must insure to the liability limit;
- Limitation of the operator's liability in amount and in time. Beyond the limit the state and/or operators collectively take responsibility for paying compensation. The liability limit differs depending on the convention.

4.117 Over half the world's reactors are in states that are outside the Paris and Vienna Conventions. Some have ratified or signed the Convention on Supplementary Compensation (for example United States, India), which is not yet in force. A number of significant nuclear power states, including Canada, China, Japan and South Korea, have not joined any of the conventions. The situation is exacerbated by the two major nuclear power states, France and the United States, supporting different conventions – France the Paris Convention and the United States the Convention on Supplementary Compensation. Those outside these two conventions are waiting to see which prevails. The IAEA has been seeking to establish a single liability regime – the Convention on Supplementary Compensation is considered a possible basis for such a regime – but so far without success.

4.118 If a major nuclear accident occurs in a state outside the Paris or Vienna Conventions, claimants will be dependent on the domestic legislation of the state concerned. This would result in uncertainty not only for the victims of an accident, but for other parties that rightly or wrongly might become the subject of litigation, such as reactor vendors and fuel fabricators (the latter concern has been raised about India's liability legislation). Every effort should be made to establish a single international liability regime and to universalize it with all states that have nuclear reactors joining it.