CHAPTER 13

THIRD PARTY INSURANCE: THE NUCLEAR SECTOR'S "SILENT" SUBSIDY IN EUROPE

Antony Froggatt
Simon Carroll

OVERVIEW OF NUCLEAR POWER IN THE EUROPEAN UNION

Within the European Union (EU), nuclear power is a divisive issue on a public and political level. Of the 27 Member States, 15 have nuclear power, with a total of 145 nuclear reactors providing 30 percent of the EU's electricity. France has by far the largest nuclear fleet, operating with 45 percent of the EU's total capacity.

Since the Chernobyl accident in 1986, there has been a downturn in the fortunes of the nuclear industry, and the absolute number of reactors in operation is expected to decline from 172 reactors in 1987 down to 135 reactors by 2010, and in 2006 eight reactors were shut. However, there is renewed interest in nuclear power and reactors are under construction in Bulgaria (Belene), Finland (Olkiluto 3), and France (Flamanville 3), the first new reactors orders in a Member State for over a decade.

Proposals are being developed in a number of countries in the EU to order new nuclear power plants. This includes a proposal for a reactor in Lithuania that would be jointly owned by Estonia, Latvia, and Poland. The proposals in other new Member States (Romania and Slovakia) also involve considerable coop-

eration with international utilities or constructors. In the United Kingdom (UK), the Government has stated its desire to see the continual use of nuclear but says the decision rests with the utilities. A number of vendors (Areva and AECL) have submitted designs for approval.

In some countries, there are no plans to build new reactors, although the existing reactors are being subject to plant life extensions, which simultaneously expands the output from each unit and prepares to extend their operating lives.

A number of countries have politically agreed to phase out plans. The most active is in Germany where a number of reactors have been closed. In Sweden, the original timetable for closure of reactors has slipped significantly. In January 2003, in Belgium, an agreement to limit the operating life of the reactors to 40 years and to stop building nuclear power plants was reached.

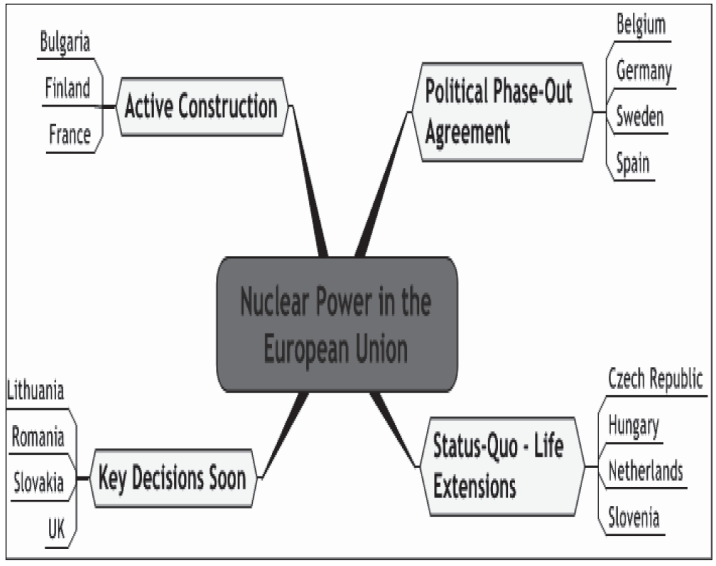

Figure 13-1. Status of Nuclear Power in Europe.

The other countries in the EU do not have nuclear power, and their view on it varies considerably. Austria has been outspoken in its criticisms of nuclear power and has been actively engaged in the nuclear debate in neighboring countries. Similarly, Ireland has actively engaged in the UK nuclear debate, particularly as it relates to the Sellafield reprocessing plant.

Under *Business As Usual* scenarios, the number of reactors being built will not even replace those due to be closed at the end of their working lives. Both the International Energy Agency (IEA)[1] and the European Commission[2] anticipate a drop of installed nuclear capacity, no later than 2030, by 44 percent and 25 percent, respectively.

STATUS OF NUCLEAR INSURANCE REGIMES IN MEMBER STATES OF THE EU

There are two basic international legal frameworks contributing to an international regime on nuclear liability: The International Atomic Energy Agency's (IAEA) 1963 Convention on Civil Liability for Nuclear Damage (Vienna Convention), the Organization for Economic Cooperation and Development's (OECD) 1960 Convention on Third Party Liability in the Field of Nuclear Energy (Paris Convention), and the associated "Brussels Supplementary Convention"[3] of 1963. The Vienna and Paris liability conventions are also linked by a Joint Protocol adopted in 1988.[4]

THE ORIGINAL LIABILITY AND COMPENSATION REGIMES

Negotiated at a time when the nuclear power industry was in its infancy, the Vienna and Paris Conventions had two primary goals: first, to create an economic environment where the nascent nuclear industry could flourish; and, second, to ensure that clear procedures and some compensation would be available in the event of an accident. The first aim would be achieved by removing legal and financial uncertainties over potentially enormous liability claims that could arise in the event of an accident. From the industry's development, it was clear that nuclear power could only be exploited as an efficient and independent source of energy if a reasonable amount of financial protection were available for private investors who were placing their financial resources in an unknown and potentially dangerous sector.[5]

While there are some differences in detail, the Vienna and Paris Conventions have some important features in common. In particular they:

- Allow limitations to be placed on the amount, duration, and types of damage for which nuclear operators are liable;[6]
- Require insurance or other surety to be obtained by the operator;
- Channel liability exclusively to the operator of the nuclear installation;
- Impose strict liability on the nuclear operator, regardless of fault, but subject to exceptions; and,
- Grant exclusive jurisdiction to the courts of one country for any given incident, normally the country in whose territory the incident occurs.

Chernobyl clearly revealed a number of deficiencies in the regimes established by both the Vienna and Paris Conventions.[7] Compared with the damage caused by the Chernobyl accident, it was obvious that the liability amounts were woefully low. Many countries were not party to either Convention.[8] Not all of the damage, or even the most serious damage, caused by Chernobyl was covered by the definition of damage applicable under either Convention. There were also problems with the limits on the time in which claims for compensation could be brought, the claims procedures, and the limitations on which courts had jurisdiction to hear claims.

POST-CHERNOBYL REVISIONS TO THE LIABILITY AND COMPENSATION REGIMES

Following the 1986 accident at Chernobyl, significant effort was made by the international nuclear community to modernize a number of conventions. This eventually led to the revision of the international regime and the adoption of a number of new conventions, including:

- The International Nuclear Safety Convention, June 1994.
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, June 2001.
- Convention on the Early Notification of a Nuclear Accident, October 1986.
- Convention on Assistance in the Case of a Nuclear Accident, September 1986.

On nuclear liability, as an interim step intended primarily to address the lack of membership in both the IAEA and OECD liability regimes, the parties to both the Vienna and Paris Conventions adopted the 1988 Joint Protocol.[9] The Joint Protocol generally extends to states adhering to it the coverage that is provided under the convention (either Paris or Vienna) to which it is not already a Contracting Party.[10] It thus creates a "bridge" between the two conventions, effectively expanding their geographical scope. In doing so, it ensures that only one of the two conventions will be exclusively applicable to a nuclear incident.[11] At the time, it was believed that the link established by the Joint Protocol would induce a greater number of Central and Eastern European countries to join the Vienna Convention, particular those that had formed part of the former Soviet Union, a hope only partially realized.[12]

The international community soon recognized, however, that the Joint Protocol was not enough to redress the liability and compensation problems brought to harsh light by the Chernobyl accident. To attract broad adherence to the international nuclear liability conventions and to make them really effective, reform had to be more far reaching. In short, it had to ensure that in the case of a nuclear accident, much greater financial compensation would be made available to a much larger number of victims, in respect of a much broader scope of nuclear damage, than ever before.

The process of negotiating amendments to the Vienna Convention began in 1990 and concluded in 1997. Work then began officially in 1997 on revisions to the Paris Convention and in 1999 for the Brussels Supplementary Convention. Amending protocols

to the Vienna, Paris, and Brussels Conventions have been adopted[13] as well as the new Convention on Supplementary Compensation (CSC), a completely new convention intended to establish a global regime of liability and compensation.[14]

The revisions to the Vienna and Paris/Brussels Conventions do increase the amount of compensation available, expand the time periods during which claims might be made, and expand the range of damage that is covered by the Conventions. It is also worth noting that in the formula to be used for State contributions to the combined fund under the revised Brussels Supplementary Convention, the proportion to be raised is more closely related to the actual generation of nuclear power by the participating states.[15]

The new liability and compensation amounts would be higher than before, with operator liability under the revised Paris Convention required to be at least €700 million and total compensation available under the revised Brussels Supplementary Convention would be €1500 million. Nonetheless, the overall amounts remain worryingly low when compared with the costs of the Chernobyl accident, currently estimated to be in the order of tens and hundreds of **billions** of euros.[16] Further, setting fixed compensation sums is not only arbitrary (in the absence of genuinely robust estimates of probable damage) but it is also unlikely to be valid over the longer term (unless they can be continually adjusted to take into account changes in the economic profile of accident consequences).[17] Table 13-1 depicts compensation and liability.

Convention	Operator Liability + Installation State	Total Combined Contributions from Other States Party	Total Compensation Available
Paris, 1960	€6 to €18	-	€6 to €18
Brussels, 1963	Up to €202	€149	€357
Paris, 2004	At least €700	-	At least €700
Brussels, 2004	Up to €1200	€300	€1500
Vienna, 1963	€50	-	€50
Vienna,1997	Up to €357	-	€357
CSC, 1997	At least €357	Depends	At least €713

All figures are rounded and for **millions** of euros (€)—See Annex 1 for details.

Table 13-1. Summary Table Showing Liability and Compensation Amounts for Different Conventions.[18]

CURRENT STATUS

Less than half the world's nuclear reactors are covered by any of the existing international agreements.[19] Moreover, although there are unifying features, the nuclear liability conventions do **not** provide one comprehensive and unified international legal regime for nuclear accidents. In fact, there is a labyrinth of intertwined international agreements on nuclear liability, the interrelations of which have become increasingly complicated.[20] Currently, there are at least eight such

agreements, including the 1960 Paris Convention, the 1963 Vienna Convention, the 1963 Brussels Supplementary Convention, the 1988 Joint Protocol, the 1997 Protocol to Amend the Vienna Convention, the 1997 Convention on Supplementary Compensation, the 2004 revised Paris Convention, and the 2004 revised Brussels Supplementary Convention. The complications arise because the earlier and revised versions of some of these instruments may coexist, and states may become party to more than one instrument.[21] Figure 13-2 is depicts reactor insurance only.

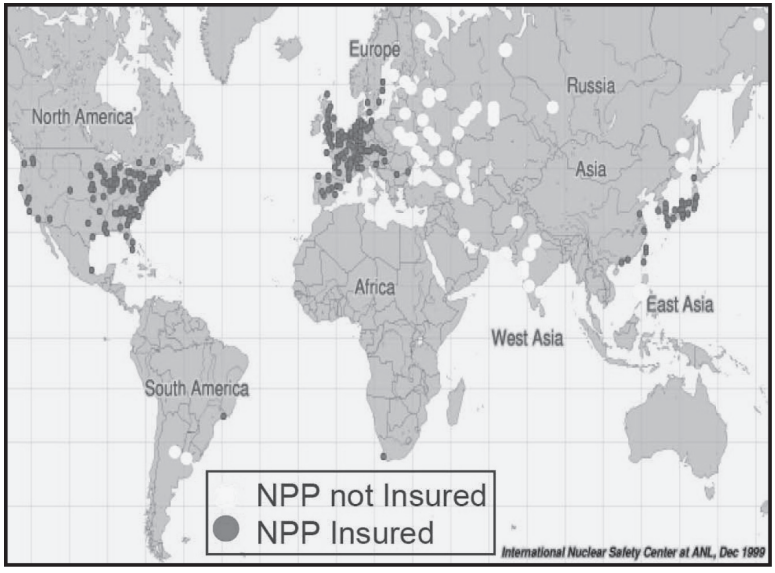

Figure 13-2. Insurance of Nuclear Reactors.[22]

The goal to ensure broad participation in the new regimes has not been achieved. At this point, only five countries have ratified the 1997 Vienna Convention. This was enough to bring the Protocol to amend the Vienna Convention into force in 2003, but the lack of

wide adherence remains problematic.[23] There has also been a delay in the ratification of the revised Paris Convention and the revised Brussels Supplementary Convention. [24] In order for the Protocol amending the Paris Convention to enter into force, it must be ratified by **two-thirds** of the Contracting Parties. For EU Member states, this was supposed to have taken place by the end of 2006, but it has not yet been done.[25] For the Protocol amending the Brussels Convention, ratification by **all** Contracting Parties is required. Only three countries have ratified the new Supplementary Compensation Convention.[26]

The revisions of the original liability and compensation Conventions may not be supportive of ensuring broad adherence by a large number of states. To ensure a favorable environment for those considering investing in nuclear programs, it is necessary for installation states, states involved in the supply of nuclear materials or services for these programs, and **all** other states that might be affected by a nuclear accident to be under the umbrella of the same liability and compensation regime. For a liability and compensation regime to be attractive to states seeking to maintain or increase their nuclear power programs, the burdens imposed by a liability and compensation regime must not be too great. However, the expanded definition of damage, extended time frames, and raised liability and compensation amounts are proving problematic for some countries.

Conversely, to be attractive for a state without nuclear power plants, the liability and compensation conventions must offer sufficient compensation, and the regime must not introduce unacceptable restrictions or burdens when seeking to obtain compensation for losses incurred. For such states, becoming party to

one of the nuclear liability conventions is not necessarily an attractive proposition, even if the revisions are taken into consideration. This is not surprising as the Paris and Vienna Conventions were essentially developed to nurture nascent nuclear industries, and the recent revisions have done little to alter this fundamental characteristic of the instruments and protecting and promoting nuclear power remains a central feature. Even as revised, the levels of compensation are relatively low when compared to the likely costs of a serious accident. By becoming a party, a non-nuclear power generating state might actually restrict its possibilities for obtaining legal remedies in the event of an accident.[27]

Until recently most EU Member States were party to the Paris/Brussels regime of nuclear liability and compensation, and this was considered a sufficiently uniform situation for the European Commission not to consider specific EU measures in this field.[28] Since the 2004 EU enlargement, this is no longer the case (see Table 13-2). EU States variously are party to the original Vienna convention; the revised Vienna convention; the Paris Convention; some have signalled their intention to adhere to the revised Paris Convention; and some are party to both the Paris and Brussels Conventions. The current range of operator liability in Member States goes from the low of €50 million in Bulgaria and Lithuania to unlimited liability in Germany. A full list of the different liability and compensation requirements in the EU Member States can be found in Appendix 2.[29]

Not Party to Any Nuclear Liability Convention	Paris Convention, 1960	Paris Convention + Brussels Supplementary Convention	Vienna Convention		Convention on Supplementary Compensation, 1997
			Original (1963)	Revised (1997)	
Austria, Cyprus, Ireland, Luxembourg, Malta	Greece, Portugal	Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Slovenia, Spain, Sweden, United Kingdom	Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Poland, Slovakia	Latvia, Romania	Romania

See Annex 2 for details.

Table 13-2. Summary of EU Country Participation in International Nuclear Liability Regimes.

Some EU Member States are not party to any of the international nuclear liability Conventions. Indeed, for EU countries like Ireland, Luxembourg, and Austria[30]—gravely concerned about the risks of nuclear power in neighboring countries, but with no nuclear power plants of their own—it would be difficult, indeed, to identify many, if any, reasons why they should accede to the current nuclear liability conventions.[31]

From the discussion above, it can be seen that there are widely divergent nuclear liability and compensation arrangements currently in place across the various EU Member States. These have profound implications for reactor safety, compensation of victims in the event of an accident, and for competition in the EU electricity market.

The problem created by this current situation has been recognized by the European Commission, which was to undertake an impact assessment in 2007 to ex-

plore the range of possible solutions and prepare a proposal to the Council.[32]

IMPACTS ON THE PRIVATE NUCLEAR INSURANCE MARKET

The capacity of the private nuclear insurance market is also a major factor in determining the amount and extent of liability imposed on nuclear operators. According to the concept of the international nuclear liability conventions, coverage and liability amount are interlinked. The problems which insurers might have with the revised conventions could therefore put the results of the revision exercises at risk. In general terms, the shortcomings in the size and extent of coverage have a direct impact on the size and extent of the operator's liability. As a consequence, liability amounts exist worldwide which largely correspond to the insurance capacity but which do not match the nuclear risk.[33] The expanded scope of operator liability and the raised liability limits introduced by the 2004 amendments to the Paris Convention need to be seen in this context.

During the negotiations to revise the Vienna and Paris Conventions, representatives of the nuclear insurance industry stated that some of the proposed amendments would be problematical.[34] In particular, the nuclear insurance industry was concerned that there was:

- Insufficient private insurance market capacity to insure nuclear operators against raised liability amounts;
- An unwillingness of the market to cover extended /extinction periods during which an operator would be liable;

- A difficulty in that private insurance could not cover all the categories included in the expanded definition of damage. [35]

Effectively, as a consequence of the revisions introduced into the Vienna and Paris Conventions, nuclear operators might no longer be able to obtain private insurance coverage to cover their full liabilities under the revised Conventions. Tetley argues that, if no insurance cover is available, then the liability for the revised scope of cover must fall either on the operator directly or on the national government. The gap which has opened up between what the liability risks the operators are required to assume under the revised convention and the coverage available from private insurers, is causing problems and is delaying ratification of the revised liability Conventions.[36] Tetley summarized the concern thus: "The financial uncertainties introduced by the new heads of cover under the revised conventions will cause a reduction in insurance cover unless a consistent approach is found to deal with the unquantifiable risks imposed upon the nuclear operators."[37]

Another problem has to do with the new perception of the possibilities of terror attacks against nuclear installations. Under the Vienna Convention (both the original Convention and as amended by the 1997 Protocol) and the original Paris Convention, terrorism is not a ground for exoneration. This is because acts of terror are not explicitly given as a basis for exoneration of operator liability and the kind of terrorism like the events of September 11, 2001 (9/11) cannot be considered as an armed conflict, hostilities, civil war, or insurrection.[38] Consequently, the operator of a nuclear installation is liable for damage due to acts

of terrorism. After the events of 9/11, the insurance pools reappraised the risks associated with acts of terror, concluding that the probability of a nuclear reactor becoming the target of such an attack was significantly higher than had been previously considered to be the case. During the negotiations on the revision of the Paris Convention, there was a call from the nuclear insurance industry for a review of the provisions of Article 9, with a view to exonerating an operator from liability for damage arising as a consequence of an act of terror.[39] This was not accepted by the parties, and consequently damage resulting from terrorism will still be covered by the revised Conventions also.[40] Nevertheless, some insurers may be able to limit their coverage to operators for damage caused by a nuclear incident resulting from a terrorist act—requiring state intervention to insure this risk.[41] This means that a new gap has opened up between the obligations on operators under the Conventions and what the private nuclear insurance market is prepared to cover.[42]

The problems with private insurance can be seen to be, at least partly, a financial question. It is not that insurance is unavailable, it is just that "few can be purchased at reasonable cost or at least at costs that are competitive with rates offered by the nuclear insurance pools."[43] The UK government laid out the current difficulties in its recent consultation paper when it said:[44]

> When the revised Conventions are implemented in the UK there will be an increase in the liability amount and the cost of insurance for UK nuclear operators (present ones and any future ones). To the extent that commercial cover cannot be secured for all aspects of the new operator liabilities, the Government will explore the alternative options available—including providing cover from public funds in return for a charge.

However, it is also, at least partly, a political decision. Simply because the private insurance industry is not able or willing to make cover available at the appropriate price to the industry does not mean that the risks are not there. As Pelzer has commented:[45]

> Tetley's conclusion clearly confirms the old school of thinking that liability means insurability. Legislators cannot agree to that view nor is it in the best interest of operators—not to mention the interest of possible victims—to be tied to the insurance industry without alternatives. For good reasons and after long difficult negotiations, States agreed on the revised conventions with a view to establishing a more risk adequate liability regime and to better protecting victims. There is no "inconsistent approach" which would warrant a change or an insurance adequate streamlining of the new liability concept only for the reason that the insurance industry is unable to cover the liability.[46]

The only conclusion which can be drawn from the insurers' reluctant position is to look for coverage other than insurance.

From the perspective of potential victims, there is a pressing need to ensure full and effective compensation for the full risks of nuclear accidents, and it is less of an issue what the specific modalities are. In accordance with the conventions, gaps in insurance coverage have to be covered by the installation state that has to step in to the extent that insurance or other financial security is not available or not sufficient to satisfy claims.[47] Pelzer argues that it would send the wrong signal if the advantages of the revised nuclear liability law could only be implemented with the help of state money. It derogates from the "polluter pays" principle, unless of course a nonsubsidized fee

or premium is paid for that security. He argues that operators, in their own best interest, would therefore be well advised if they look for solutions to cover the insurance gaps by means of their own.[48]

From the perspective of the efficient functioning of the energy markets (for example, avoiding subsidies to nuclear power by failing to internalize the full costs of nuclear generation), whatever modalities are chosen must be reflected in the price of electricity from nuclear generation. Instituting some form of operators' pooling (rather than pooling of State funds) could be one way of realizing this objective.

Europe's Changing Energy Market.

The energy sector in Europe will undergo considerable change over the coming decades. A combination of aging infrastructure, a growing awareness of climate change, and the dwindling of European fossil fuel reserves will result in considerable investment in noncarbon or low carbon emitting energy sources.

The scale of the investment anticipated in the EU over the next decade is unprecedented, the International Energy Agency (IEA) estimates that between 2005 and 2030, the EU will need 862 GW in total new capacity to replace aging conventional and nuclear power plants and meet increases in demand.[49] Of this additional installed capacity, 465 gigawatts (GWe) or 61 percent of the current total of 395 GWe will be replaced during this period.

The EU is a global driving force on climate change and has set targets to reduce its Greenhouse Gas emission by 20 percent by 2020. The European Commission has placed at the heart of its attempt to reduce emissions the European Emissions Trading Scheme

(ETS). This was finally adopted by the EU in October 2003 and was intended to introduce a "cap and trade" system for stationary CO_2 emissions. This was to cover around 40 percent of all Greenhouse Gas emissions from EU 27. The scheme became operational in January 2005, with the first trading scheme running until the end of 2007. The second period runs until the end of 2012.

The ETS covers only large industrial CO_2 producers, including: power stations over 20 MW; oil refineries; coke, iron, and steel; lime and cement production; glass production; ceramics; and paper and pulp production. The methodology of the scheme is for a set number amount of emission allowances to be allocated to each Member State, based on the existing emissions. In the first phase, a minimum of 95 percent of the allowance has to be allocated for free (or grandfathered). In the second phase, this is 90 percent. The rest are supposed to be auctioned.

The key issue, therefore, is the level of allocations. Member States made applications to the European Commission, who then offered revised allocations. The allocations for phase II are to be announced by the Commission in December 2007.

It has been retrospectively shown that in phase I, there was a major over-allocation of emission permits to such an extent that Member States handed out permits for 1829 million tons of CO_2 in 2005, while the actual emissions were 1,785 million tons.[50] With such overcapacity, it is hardly surprising that, despite a buoyant start, the price of carbon has dropped to close to zero from a high of over €30/ton. Despite the fact that virtually all of the permits were given to the utilities for free, the introduction of the ETS has had a measurable impact on the price of electricity in Eu-

rope. This has been the advantage of the large electricity generating sources, and it has been said that the main economic winners of the current scheme have been the coal and nuclear utilities.[51] This is all the more remarkable as the nuclear industry is currently excluded from the scheme.

It is anticipated that the second phase of the ETS will introduce lower permits for Member States, however, the impact that this will have on the price of CO_2 is still to be determined. In particular, the phase II allows, through a linking directive, the use of carbon credits gained through the Joint Implementation and Clean Development Mechanism of the Kyoto protocol. Depending on the volumes involved, which could be significant, this may have a considerable impact on the carbon price in the ETS.

The lack of price consistence in the carbon market has led the nuclear industry to call for a guaranteed floor price. The industry argues that its long investment cycle means that it needs some certainty over the market fluctuations and the chief executive of Electricité de France (EdF) has stated, "To make a commitment of billions of pounds to a project with a time-scale of half a century, investors above all need predictability about price. They must know the value society will place on carbon reduction not just tomorrow, but 10, 20, 30, 40 years from now."[52]

Despite the uncertain start for the ETS, it is clear that it remains a central part of the EU's policy on climate change. Over the coming years, further measures will be introduced to enlarge and refine the ETS. For it to be successful, it will require a significant and relatively certain price for carbon. Given the importance that the EU has placed on ETS in its fight against climate change, it should be assumed that a long-term

carbon price, conducive to the nuclear industry, will be introduced.

Costs of a Nuclear Accident and the Challenges of Externalities.

Limits on the liability of nuclear operators for off-site damage caused by a severe nuclear accident amount to an implicit subsidy of nuclear electricity. While there is some disagreement as to the exact degree of the subsidy, several assessments have confirmed that limits on the liability exposure of operators below the anticipated costs of a nuclear accident act as a significant subsidy to nuclear power generation.[53]

One study suggested that if EdF, the main French electric utility, was required to fully insure their power plants with private insurance but using the current internationally agreed limit on liabilities of approximately €420m, it would increase EdF's insurance premiums from €0.017/MWh, to €0.19/MWh, thus adding around 8 percent to the cost of generation. However, if there was no ceiling in place and an operator had to cover the full cost of a worst-case scenario accident, it would increase the insurance premiums to €5/MWh, thus increasing the cost of generation by around 300 percent.[54]

THE COSTS OF SEVERE REACTOR ACCIDENTS

One reason for the lack of consensus on the precise extent of the subsidy resulting from limited liability of operators is that, while it is acknowledged that the consequences of serious nuclear accidents are very large and widespread, estimates of the likelihood and off-site consequences of a severe nuclear reactor accident vary widely.[55]

It is not unusual for different risk analyses carried out at the same reactor or different reactors of the same type to produce central value estimates that differ from one another by several orders of magnitude, and upper- and lower-bound estimates of damage can vary similarly, with no secure criteria for selecting among the conflicting expert assessments.[56] In the literature various accident scenarios are sketched, whereby the damages typically range from €100 million to €10 billion,[57] although some cost estimates are dramatically higher.[58]

An early estimate put the minimum **near-term costs** of the Chernobyl accident to be in the neighborhood of $15 billion, with longer-term costs of $75-150 billion.[59] A 1990 report prepared by Yuri Koryakin, the then-chief economist of the Research and Development Institute of Power Engineering of the Soviet Union, estimated that the costs from 1986 through to 2000 for the former Soviet Republics of Belarus, Russia, and Ukraine, would be 170-215 billion rubles (at the then official exchange rate this would be equivalent to $283-358 billion).[60] The Belarus Government estimate the total economic damage caused between 1986-2015 will be $235 billion (June 1992 prices).[61] Another estimate suggests overall economic costs **in the Ukraine alone** of **$130 billion**.[62]

Following the Chernobyl accident, the U.S. General Accounting Office (GAO) conducted an analysis of the off-site financial consequences of a major nuclear accident for all 119 nuclear power plants then operating in the United States. The estimates ranged between a low of $67 million to a high of $15,536 million.[63]

Four reactor accident scenarios considered by the EU ExternE project, yielded cost estimates for damage ranging from €431 million to €83,252 million.[64] It should be noted that these cost estimates exclude de-

contamination, although it is acknowledged that these costs "can rapidly be very high," and that there are major limitations to the economic evaluation,[65] arising from:

- Uncertainties on the impact (evaluation of source term, difficulties to estimate the environmental impacts due to the long-term contamination, uncertainties on the radiation health effects, etc);
- Uncertainties on the efficiency of countermeasures; and,
- Economic evaluation of some social consequences is nearly impossible.

At the same time, the often-cited expert opinion is that the type of reactors used in Western Europe have a very low probability of the kind of failure that would produce a severe accident. The exact values associated with an event in which there is a failure of containment and hence potentially significant damage vary from one set of experts to another but, in general, experts consider that the probabilities in the order of 10^{-6} and lower. Normalized to the probability of the event and to the electricity generation over a power plant's lifetime, the expected value of formal risk (i.e., probability x consequences) from an accident appears low, even against uncertainties in the accident probability.

However, the applicability of such tools is at least questionable, as it is also widely accepted that it is not only the expected value of risk (i.e., probability x consequence) that is important for the valuation of major accidents. Moreover, it appears that the estimates of the externalized costs of nuclear electricity are much more sensitive to changes in expert assessment of the expected off-site consequences of a worst-case accident, than of its likelihood of occurrence.[66]

EXTERNALITIES

In general, comparing externalities between different energy sources and processes remains problematic. When comparing external costs of energy options, the same standard of environmental effects should be applied to all the options. However, the classification of environmental effects is inconsistent. Different valuation studies address different stages of the fuel cycles and different phases in the life cycles of the associated facilities.[67] Other difficulties arise owing to ignorance or damages that are effectively valued at zero. They are likely to be ignored in the pricing of electricity, selection of resources, and for any other policymaking purpose. Our knowledge of the environmental damages and the future is too uncertain to allow reliable estimates of damages. The consequence is that there can be little confidence that efforts to quantify and aggregate environmental externalities will yield systematic, comprehensive, or perhaps most importantly, comparable results.[68]

The ExternE Project set out to be the first systematic approach to the evaluation of external costs of a range of different fuel cycles.[69] The study's principal objectives to the end of 1995, when the first series of reports was published, were:

- To develop a unified methodology for quantifying the environmental impacts and social costs associated with production and consumption of energy;
- To use this methodology to evaluate the external costs of incremental use of different fuel cycles in different locations in the EU; and,
- To identify critical methodological issues and research requirements.

The 1995 ExternE report sought to quantify impacts and their associated externalities using an approach that accounted for the latest developments in environmental research. It reported external fuel cycle costs spanning three orders of magnitude.[70] Among the main contributing factors leading to this large range of results were the differing methodologies and assumptions used for the assessment of severe nuclear accidents.[71]

It has been subsequently noted that the boundaries and limitations of the estimation of the economic consequences, including the remaining uncertainties and nonquantifiable effects, "show the limitations of the economic modeling of the costs of accidents **which cannot integrate the complexity of a post-accidental situation**."[72] Despite further work on refining the analyses, the treatment of severe nuclear reactor accidents by ExternE remains problematic. Indeed, in a subsequent review and after considerable additional work, the ExternE team concluded: "The subject is one of the most difficult to be faced in the project: indeed despite earlier extensive research a clear solution to the problem is still to be identified."[73] The portion of the external costs that might be internalized by nuclear accident insurance was **not** addressed by ExternE.[74]

According to ExternE there remains wide divergence in opinion on what consequences should be looked at and hence what probabilities should be attached to those consequences. For the analysis of nuclear accidents from a PWR reactor, different source terms for release have been used as base data in France, Germany, and the UK. The significant differences in the release categories analyzed and in the probabilities attached to those releases, leads to considerable

variation in assessments making cross-country comparisons difficult. Even more importantly, it makes it difficult to accept that there is a unique expert view of the accident probabilities that can be defined as objective. It shows that the accident scenarios and their associated probabilities are determined partly by judgement and partly by more "objective" considerations.[75] This implies that expert opinion should not be seen as single-valued and objective, and policymakers have to choose between different sets of consequences and probabilities.[76]

Related to the discussion above is the issue of how one treats public estimates of probabilities versus expert estimates in the assessment of accidents. Clearly both matter; one cannot ignore the careful analysis carried out by the experts, but at the same time one cannot overlook the opinions of the public. In the case of accidents which occur with reasonable frequency, this problem is resolved by looking at the relative frequencies of different accidents and basing the probabilities of such accidents on the relative frequencies. For nuclear accidents, there is no such history to draw on.[77] There have been hardly any major incidents with serious consequences in the history of nuclear power; for some experts, the one at Chernobyl is not considered relevant to the reactors deployed in Western Europe. Hence the divide between public and expert opinion has not narrowed appreciably over time. The expected value of damages is not enough. The public is willing to pay something for the reduction in risk per se, which is not captured in the expected value.[78]

The potential consequences from a single incident are also recognized as an important key criteria on its own.[79] While the approach of explicitly suggesting acceptable risk levels is partly established in environ-

mental policy, up to the present ExternE failed to consistently integrate the level of potential consequences as an individual parameter into the valuation framework.[80]

The 2005 ExternE Methodology Update concluded, with respect to severe accidents in the nuclear sector, that:

> It is sometimes argued that, for so-called Damocles risks, i.e., risks with a very high damage and a low probability, the risk assessment of the public is not proportional to the risk. The occurrence of a very high damage should be avoided, even if the costs for the avoidance are much higher than the expectation value of the damage. However past attempts to quantify this effect have not been successful or accepted, so there is currently no accepted method on how to include risk aversion in such an analysis. Consequently, it is currently not taken into account within the ExternE methodology. Research on how to assess this, for example with participatory approaches, is clearly needed.[81]

Proposals for New Nuclear Legislation.

From an economic perspective, the basic rule which should underlay a nuclear liability regime is rather straightforward: the legal regime should provide for incentives to nuclear operators to internalize their risk costs in order to maximize prevention. The basic idea is that by exposing nuclear operators to the full risk costs they are generating, an efficient internalization of the nuclear risk can take place. Of course, this internalization can be reached through a variety of legal and economic tools. For the nuclear sector, safety regulation plays a crucial role (i.e., so that nuclear reactors are designed, built, and operated in such a way

as to minimize the risk of accidents). Liability rules have an important function in complementing safety regulation.

However, on the basis of straightforward economic analysis of nuclear liability law, it is clear that a nuclear operator should be exposed to the full costs his activity generates in order to provide optimal incentives for prevention.[82] From this simple rule a few equally simple rules of thumb follow as far as the structure of the regime of nuclear liability is concerned: nuclear operators should in principle be fully liable for the potential damage caused by their activity and, to the extent that compensation is provided through another source (government or insurance), mechanisms should be put in place as a result of which the nuclear operators' preventive efforts are taken into account. In insurance, these are the well-known techniques of risk differentiation as a remedy to moral hazard;[83] in case of government provided compensation the financing should in principal also be risk related whereby, a government fund is financed by risk-based premiums paid by operators.[84] The international nuclear compensation regime has been heavily criticized in the law and economics literature for not respecting these rules of thumb.[85]

It has been pointed out that the international regime of the conventions and the U.S. national nuclear compensation schemes were originally very similar, but they have since evolved along different lines to be quite markedly different today. The discussions on the international conventions and the American compensation scheme beginning in the 1950s started from the idea that nuclear energy development had to be supported. This entailed limiting the nuclear operator's liability and making public funding available to

compensate for victims of a nuclear accident. In the United States, it was accepted much faster than in Europe, that this justification cannot be upheld forever. As a result, already in 1982, the United States completely abandoned the public funding of nuclear damage, whereas the international regime today still to a large extent relies on public funding.[86]

Faure and Vanden Borre have concluded that the economic goal of cost internalization cannot be reached in the current international conventions regime for two main reasons: the individual liability of the nuclear operator[87] is only a small fraction of the potential costs of a nuclear accident (looking at the damage estimated between €10 billion and €100 billion). Moreover, the second layer of compensation in the international regime is entirely provided for through public funds (the installation state in a second layer and a collective state fund in the third layer), whereby no risk-related financing takes place whatsoever. The second and third layer of public funds are a pure subsidy to the nuclear industry and fail to make any contribution to cost internalization.[88] Faure and Vanden Borre argue that the U.S. model shows that if a compensation regime were to be organized as a collective responsibility of the nuclear industry (thus excluding public funding), much higher amounts of compensation can be provided to victims and a better internalization of the nuclear risk can be promoted. They point to the operators' pooling systems established in the United States and Germany as having demonstrated the capacity to deploy many times the amounts required under the revised nuclear liability conventions and in particular the amounts offered by the insurance industry.[89]

Pelzer has also looked at alternatives to the current system and identified international operators' pooling is an interesting option. Operators' pooling is meant to provide financial security if and to the extent insurance coverage is not available and state intervention is regarded as being an inappropriate means to cover private liabilities because it would conflict with the polluter-pays principle and would interfere with principles of market economy. Under these circumstances, the pooling could serve two purposes. First, it could be used to fill gaps in coverage due to specific exclusions from insurance coverage. Second, it could be used to increase the total amount of compensation beyond the capacity of the insurance industry. Using the pooling for both purposes is desirable. The principal advantage of an operator pooling system such as that adopted in Germany or the United States is that large sums of private money, as opposed to public funds, can be made readily available to compensate victims of a nuclear accident. Pelzer also argues that there are advantages for the liable operator, as this option could be an attractive supplement and alternative to other forms of financial security provided pooling can be organized appropriately.[90]

ADAPTING THE U.S. MODEL TO EUROPE?

Faure and Vanden Borre have suggested the creation of an international nuclear liability system modeled on that currently in place in the United States. In their approach, a key issue is to phase-out all state funding in the international (and national) nuclear compensation scheme, i.e., by replacing the current collective state funding, by a collective tier funded by the nuclear operators.[91]

The last change to the Price-Anderson Act so far was made in 2005.[92] The liability of the individual operator amounts to $300 million. However, the amount available in the second (collective) tier, is set at $95.8 million, plus an extra 5 percent for legal costs, with a maximum of $15 million per reactor per year. Given the fact that in 2005 a total of 104 reactors had a licence, the total available amount in the United States is $10.76 billion.[93] If the nuclear power industry grows, the funds available in the event of a serious accident will increase. **It should be noted that a pooling system at the U.S. national level requires that premiums or shares to be paid by an individual operator are only due after a nuclear incident has occurred causing damage in excess of a defined size**.[94]

In nine Western European countries alone, there are 135 nuclear reactors in operation—this is more than the current 104 reactors in the second tier of the U.S. compensation system. If all these operators should contribute, e.g., €10 million in the second tier (one-tenth of the current amount of the U.S. second tier), an amount of €1.35 billion of private funding would be immediately available in the second tier. Applying the same level currently in place in the United States would raise more than €10 billion.[95]

Faure and Vanden Borre identify two barriers for pursuing a U.S.-type approach: (1) in the EU, every Member State has its own regulatory structure (on nuclear safety, but also concerning the approval of the form of financial security to be presented by the nuclear operator); and, (2) differences in the way nuclear power plants are being operated throughout Europe, despite several EU Directives on nuclear safety (focussing more on issues concerning radiation protection and less on operational safety issues).[96] Furthermore,

the EU has not developed common safety standards and currently relies on the international safety guidelines of the International Atomic Energy Agency and the safety requirements instituted by the individual Member States.[97]

There are several advantages to considering action at EU level when developing a pooling approach. Pooling is easier to agree upon if it takes place among operators of like-minded states that preferably cooperate already in other fields. States that are contracting parties to an organization of regional integration or other nature provide a good basis for operators' pooling. This applies particularly to EU Member States. Limitation of the system to a certain geographical region makes pooling more reasonable because only in a geographically limited area, may a natural transboundary risk community exist. To minimize the described problems and to prevent discrimination against operators that join a pooling regime, installation states should ensure harmonized economic and legal conditions. That requires common arrangements among the concerned states and in this context, the EU could possibly play a supportive role regarding pooling among EU operators.[98]

While the U.S. system is based on a statutory obligation or duty of the individual operator to contribute, Pelzer suggests that this is not the model to follow at the international level. Instead, he considers that it should be left up to the industry to decide if, and to what extent, and under what conditions they are prepared to embark on international pooling of financial means to cover their mandatory nuclear liability. How and to what extent they do so should not, in his view, be a business of states.[99] Leaving the mandatory or voluntary nature of a pool to one side, for now at least,

it is nonetheless useful to consider how an EU-wide pool might be designed to reflect any specific characteristics of the EU nuclear electricity generating sector. Previously nuclear reactors in Western Europe tended to be operated by state agencies or national companies. This is no longer the case. Reactor ownership is also shared among private companies in an increasingly privatised electricity sector often operating at EU (and wider) rather than national levels of organization. Individual reactors may have multiple owners, in some cases there are multiple "part" owners of reactors, with large multinationals like Vattenfall, EON, etc., who have interests in nuclear reactors located in several EU Member States. Pelzer believes that the organization and structure of any international nuclear operators' pooling should be left to the discretion of operators and their respective parent companies—consideration should be given not just to operators, but owners too. It is worth noting that this is the situation today with the German national nuclear pooling system described earlier. The four parent companies owning the 19 German nuclear power plants have established a joint arrangement for nuclear pooling.[100] Based on, and corresponding to, the shares a partner holds in an individual power plant, the percentage of this plant will be attributed to the partner; the sum of all percentages for all power plants forms the total size of the guarantee of that partner.[101]

As noted above, the pooling approach is attractive because of the potentially much higher amounts of compensation and the improved internalization of the risks of nuclear power in the costs of generation of nuclear electricity. However, the extent to which these potential benefits can be realized will depend much on the details and implementation of any planned

new scheme. Pooling per se is no panacea—a flawed and inadequate pooling system will not improve the current situation. At this stage, there are two principal issues of concern: the extent to which the full costs of a Chernobyl-scale accident would be covered; and the potential for unscrupulous operators to spread their risk through the pool.

While the current pooling arrangements in Germany and United States offer considerably greater compensation amounts than the current system of liability conventions, including the revised Paris/Brussels conventions, they still do not come close to matching the actual costs of an accident on the scale of Chernobyl. Obviously, the total amount of funding that could be realized by a pooling arrangement is a function of the design of the pool (especially its financial obligations and the levels of contributions) and the number of contributors. However, it needs to be considered that a severe accident may exhaust even the large financial resources provided through a pooling mechanism. To address this concern requires maintaining options to supplement the finances made through the pool to ensure additional compensation is available for victims and to remedy damage in the event that the pool funds are insufficient. It should be recalled that the pooling itself is a funding mechanism designed to facilitate availability of funds up to a certain preferably high amount. However, the creation of such a pool should not affect the ultimate liability of the operator, which should be unlimited. This is the current situation with the German nuclear liability pool arrangement.[102] Accordingly, such a pooling system would be designed to create an EU-wide international pool to provide a large fund (in the order of tens of billions of euros, at least an order of magnitude larger than the German

national pool). This would be coupled with unlimited liability of individual nuclear operators.

Any pooling arrangement spreads the risk among its members, with the result that: (1) for any individual operator, the internalization of the nuclear risk is less than complete; and (2) the risk per reactor is averaged, so that a "risky" operator transfers a part of its risk to the pool, whereas a "safer" operator accepts a portion of the extra risk. One virtue of the pooling system is that there will be an element of self-policing by the pool members, in their own self-interest. Pool members themselves will have at least minimum requirements concerning the level of nuclear safety and security of the nuclear installations with which the risk will be shared. Operators will only be prepared to pool if the safety and security standards of other installations are up to the standards of their own installations.[103] There also has to be an adequate nuclear regulatory legal framework in all states whose operators wish to cooperate in the pool and, as noted above, there may well be a need for an EU-wide approach to safety regulation and standards.

An Opportunity for Intervention.

On a relatively ad hoc basis the European Commission publishes a background paper on the state of nuclear power in Europe (Nuclear Illustrative Program, also called the PINC paper). The most recent was published in January 2007 and stated "The Commission is aiming at harmonising the nuclear liability rules within the Community. An impact assessment will be started to this end in 2007."[104]

This was officially proposed, because, as noted above, some Member States are parties to different

versions of the Vienna Convention and Paris Convention, some are not party to the Brussels Convention, and some Member States are not party to any nuclear liability instrument. The Commission was therefore hoping to introduce measures to harmonize this current situation. In addition, there are other issues that may be included within this harmonization process.

1. In 2004, the limits and other provisions of the Paris Convention were revised. For these changes to enter into force, two-thirds of the signatory states must ratify the 2004 Protocol. This will take place when the EU Member States complete their procedure of simultaneous ratification required by the Council Decision of March 8, 2004. The deadline for this was by the end of 2006, but the EU Member States did not meet that deadline so it was (informally) reset for the end of 2007. Similarly, the 1997 Vienna Convention was only ratified by two EU Member States, and only by five countries in total worldwide. This issue is said to be causing increasing concern among legal experts.

As indicated earlier, the gap between what the nuclear insurers are willing to insure and what the operators are liable for is causing problems for the nuclear operators and governments and is delaying ratification. As Pelzer has noted, the current difficulties of the insurance industry to cover certain nuclear risks offers a chance to break new ground in providing financial security. The still-pending ratification and entry into force of the improved international nuclear liability regime creates some time pressure. All stakeholders are responsible for making those enhancements effective in a timely fashion. In his view and despite the inherent challenges, operators' pooling is a means to speed up the process and the time is ripe to explore the option more closely.[105]

2. Some Member States are not party to either the Vienna or Paris conventions and therefore do not recognize the limiting factors that these impose upon potential victims in the event of an accident. This is especially true for Austria, which is not only a nonparty to the conventions, but has domestic legislation that enables unlimited liability. Given the transboundary nature of large scale nuclear accidents, this undermines the effectiveness of the regimes to limit liability.

3. The EU is not party to either convention.

Formally, a number of bodies will now be asked to provide their opinion on the PINC paper. So far, only the European Economic and Social Committee (EESC) have done so. Concerning nuclear insurance the EESC stated:

> A harmonised liability scheme, including a mechanism to ensure the availability of funds in the event of damage caused by a nuclear accident without calling on public funds, is in the view of the EESC also essential for greater acceptability of nuclear power. The current system (liability insurance of $700 million) is inadequate for this purpose. [106]

The Commission is also trying to put its message across on this issue to a wider audience. At a recent meeting of the Nuclear Inter Jura Conference organized by the International Nuclear Law Association (INLA) the Commissioner in charge of Energy, Andris Piebalgs, stated that a "harmonized liability scheme, including a mechanism to ensure the availability of funds in the event of damage caused by a nuclear accident, is essential to the long-term acceptability of nuclear power." The Commissioner then went onto say that: "Therefore, before the end of the year, the

Commission will undertake an impact assessment to explore the range of possible solutions and prepare a proposal to the Council." [107]

Governments have signed up to the revised arrangements for nuclear liability and compensation that the nuclear insurance industry finds difficult to implement and which the nuclear industry is not comfortable with. The current nuclear insurance pooling system does not give adequate cover and the private insurance market is more expensive. Consequently, operators are putting pressure on governments not to ratify the revised conventions without having first guaranteed that their additional exposure risks will be met with Government assistance. Consequently, the public is not yet being given the fairly modest (when compared to the actual likely costs of a major nuclear accident) increase in compensation levels developed over 2 decades following the Chernobyl disaster.

Even with the proposed increase in operator liability and the new compensations arrangements—should they enter into force—only a small fraction of the potential costs of a nuclear accident will be covered. Any limitation in operator liability below the likely costs of a major nuclear accident constitutes a subsidy to the nuclear industry. Existing compensation arrangements allowing for state funds to be provided in lieu of industry responsibility for the economic consequences of an accident also are a pure subsidy to the nuclear industry and fail to make any contribution to cost internalization of the risks of nuclear power in electricity pricing.

It is nonsensical to persist with a system that:

- reduces the incentives for the nuclear industry to pursue the highest possible levels of safety by shielding the nuclear industry from the economic consequences of a nuclear accident;

- provides at best partial compensation for the damage caused by a major nuclear accident; and,
- adds an additional market distortion to the electricity market at a time when the EU is seeking to internalize environmental and other costs.

The recognition by the European Commission of the need to address the disparities and incongruities in nuclear third party liability currently existing in the EU has opened the door on this issue anew. There is now a real opportunity to develop and implement a fairer more efficient and effective nuclear liability and compensation scheme to the benefit of all.

ENDNOTES - CHAPTER 13

1. *IEA 2006: World Energy Outlook*, Paris, France: International Energy Agency, OECD/IEA, 2006.

2. *European Energy and Transport: Trends to 2030*, Luxembourg: Office for Official Publications of the European Communities, 2008.

3. Convention Supplementary to the Paris Convention of July 29, 1960, on Third Party Liability in the Field of Nuclear Energy.

4. The Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention, September 1988. The Joint Protocol entered into force on April 27, 1992.

5. The limitation of liability was considered to be necessary in order to not obstruct the development of the nuclear industry. The Exposé des Motifs for the 1960 Paris Convenion notes that "unlimited liability could easily lead to the ruin of the operator without affording any substantial contribution to compensation for the damage caused." See Exposé des Motifs, Motif 45. The reason for this limitation was therefore purely economical: the li-

ability of the operator was limited to the amount for which the insurance market was able to provide coverage. OECD Council, *Exposé des Motifs of the 1960 Paris Convention,* approved by the OECD Council on November 16, 1982, available from *www.nea.fr/html/law/nlparis_motif.html*.

6. The Vienna Convention allows liability to be extended by national legislation to cover additional types of damage.

7. See for example, Michael G. Faure and Tom Vanden Borre, "Economic Analysis of the Externalities in Nuclear Electricity Production: The U.S. versus the International Nuclear Liability Scheme," paper presented to Nuclear Inter Jura 2007, Brussels, Belgium, October 2, 2007. The major criticisms of the international compensation regime can be summarized as follows:

- the low financial cap may provide insufficient deterrence for the prevention of accidents by the nuclear operator;
- the financial cap (combined with the public compensation scheme) constitutes a subsidy to the nuclear power since full costs are not internalized;
- the monopoly of the national nuclear insurance pools creates problems for the operators (paying high premiums) and for the authorities (who are confronted with a problem of information asymmetry, not knowing what the exact capacity of the insurance market is);
- despite the public compensation scheme (and notwithstanding recent increases), victims will not be fully compensated in case of a major (or even an average) nuclear accident. Recently, the international conventions have been amended to (in some cases rather substantially) increase the amounts of liability and to increase the amounts available in the public compensation scheme, but the same criticisms still apply.

8. The Vienna Convention was intended to be a global instrument governing civil liability for nuclear damage. However by the time of the 1986 Chernobyl accident, only 10 states had ratified it and not one of these had a major nuclear program (Argentina, Bolivia, Cameroon, Cuba, Egypt, Niger, Peru, Philippines, Trinidad & Tobago, and Yugoslavia). The Paris (and Brussels) Conventions were originally negotiated to provide a regional liability and compensation regime for nuclear damage for West-

ern Europe. They had achieved wide-spread, but not universal, participation of Western European countries by the time of the Chernobyl accident.

9. The Joint Protocol entered into force in April 1992.

10. For example, where a nuclear incident occurs for which an operator in a Paris Convention/Joint Protocol state is liable and damage is suffered by victims in a Vienna Convention/Joint Protocol state, those victims will be able to claim compensation for damage suffered against the liable operator as if they were victims in a Paris Convention state.

11. The exclusive application to a nuclear incident of only one of the two conventions is accomplished by means of the conflict rule contained in Article III of the Joint Protocol.

12. Some 18 countries from those parts of Europe have ratified or acceded to that convention, more than half the total number of Contracting Parties thereto. Yet only 11 of those 18 countries have ratified or acceded to the Joint Protocol, the instrument which would link them to the regime established by the Paris Convention, a disappointing development for those who had hoped to link all of Europe with one single nuclear liability and compensation regime. See Julia A. Schwartz, "International Nuclear Third Party Liability Law: The Response to Chernobyl," in *International Nuclear Law in the Post-Chernobyl Period*, Paris, France: OECD, 2006, pp. 37-72.

13. The 1997 Protocol to Amend the 1963 Vienna Convention; the 2004 Protocol to Amend the 1960 Paris Convention; and the 2004 Protocol to amend the 1963 Brussels Supplementary Supplementary Convention.

14. The new Convention on Supplementary Compensation for Nuclear Damage was adopted in 1997. It is intended to be a free-standing instrument which may be adhered to by all states irrespective of whether or not they are party to any of the existing nuclear liability conventions. Its objective is to provide additional compensation for nuclear damage beyond that established by the existing conventions and national legislation. It would do this through additional financial contributions from states which become parties.

15. Following the example of the Supplementary Compensation Convention which imposes greater responsibility upon nuclear power generating states to provide compensation, the formula for calculating contributions to the international tier under the Brussels Supplementary Convention Protocol moves from one based equally on gross national product and installed nuclear capacity to one based on 35 percent on gross domestic product and 65 percent on installed nuclear capacity. See Schwartz, "International Nuclear Third Party Liability Law."

16. The total costs of the 1986 Chernobyl accident remain uncertain, but typical estimates place the costs in the order of € tens of billions and € hundreds of billions. See the discussion below on the estimates of costs of severe nuclear reactor accidents.

17. An illustration of this can be seen in the context of natural disasters. In the United States, until recently, the number of lives lost to natural hazards each year has declined. However, the economic cost of response to, and recovery from, major disasters continues to rise. Each decade, the cost in constant dollars, of property damage from natural hazards, doubles or triples. See "Facing Tomorrow's Challenges—U.S. Geological Survey Science in the Decade 2007-2017," Circular 1309, Washington, DC: U.S. Department of the Interior/U.S. Geological Survey, 2007, p. 30. A similar inflation would be expected for the costs of man-made disasters also.

18. This table summarizes the detailed information on the financial requirements and limits of the different Conventions, including the original and revised Conventions, set out in Appendix 1.

19. McRae has calculated that of the 10 countries with the largest installed nuclear capacity, one half are members of the international scheme. Overall, the nuclear power generating countries that operate outside the international compensation regimes account for more than half of worldwide installed capacity. See Ben McRae, "Overview of the Convention on Supplementary Compensation," in *Reform of Civil Nuclear Liability*, Paris, France: OECD, 2000, p. 175.

20. For a comprehensive discussion of the interrelationship of the various conventions, see N. L. J. T. Horbach, ed., *Contemporary Developments in Nuclear Energy Law: Harmonising Legislation in CEEC/NIS*, Cambridge, UK: Kluwer Law International (ISBN 90-411-9719-2), 1999, pp. 43-85. See also O. F. Brown and N. L. J. T. Horbach, "Liability for International Nuclear Transport: An Overview," International Symposium on Reform of Civil Nuclear Liability, Budapest, Hungary, June 1999.

21. A further complication is introduced by transitional measures introduced in the various new instruments, designed to facilitate adherence by new States (see Appendix 1).

22. Note that the figure illustrates reactor insurance only, not whether any of the liability conventions apply. For example, although they are insured, reactors in the USA, Canada, Japan, and Republic of Korea are not covered by any international liability convention. See Mark Tetley, "Underwriting the Nuclear Risk," Presentation for the West Minister Energy Forum, 2005, *Nuclear Risk Insurers Ltd*, London, UK: YJL, April 24, 2005.

23. Five countries have ratified the 1997 Vienna Convention: Argentina, Belarus, Latvia, Morocco, and Romania. Only Argentina and Romania have nuclear power generating capacity, and according to the IAEA's Power Reactor Information System, as of August 30, 2007, those capacities were 935 MWe and 1310 MWe, respectively (available from www.iaea.org/programmes/a2/). As Schwartz has noted:

> The adoption of the VC Protocol was one of the most significant developments to have taken place in nuclear liability law for several decades. It was hoped that this new instrument would attract broad adherence by both nuclear power generating states and non-nuclear power generating states, whether Party to the Vienna Convention or not. Despite the many years of difficult negotiations required to reach agreement on this instrument, the keen interest it elicited from a broad range of interested states, and the many provisions it contains to encourage and facilitate adherence to it, the VC Protocol has not drawn the wide support originally hoped for or expected. Some 80 states participated in its negotiation

> and in the Diplomatic Conference which culminated in its adoption. Yet only 15 countries have actually signed the Protocol, and 14 of those did so within one year of its adoption, when motivation and impetus were both still strong. The Protocol entered into force on 4 October 2003, some six years after it had been adopted, having been ratified by the number of states required for that purpose.
>
> Schwartz, "International Nuclear Third Party Liability Law."

24. The Protocol to the Paris Convention and the Protocol to the Brussels Supplementary Convention were opened for signature on February 12, 2004, but in October 2007, neither of these instruments had entered into force.

25. According to the Council Decision of March 8, 2004, Member States which are party to the Paris Convention shall take necessary steps to deposit simultaneously their instruments of ratification of the Protocol with the Secretary General of the OECD "within a reasonable time and, if possible, before 31 December 2006." See "Council Decision of March 8, 2004, authorizing the Member States which are Party to the Paris Convention of July 29, 1960, on Third Party Liability in the Field of Nuclear Energy to ratify, in the interest of the European Community, the Protocol amending that Convention, or to accede to it," Brussels, Belgium, *Official Journal of the European Union* (OJ), L 97/53, April 1, 2004.

26. The three states which have ratified the CSC are Argentina, Morocco, and Romania. Entry into force requires the ratification of at least five states with a combined minimum of 400,000 installed units (MWthermal) of nuclear capacity. On August 3, 2006, the U.S. Senate took the most important constitutional step of consenting to ratification of the treaty by adopting an Act to implement the CSC. The only remaining step is enactment of implementing legislation that will set forth the mechanism the United States will use to fund any contribution it might have to make in the future to the international fund established by the CSC. The U.S. Congress was considering this implementing legislation, but the biennial Congress adjourned before this Act was approved by the House of Representatives. The implementing legislation is expected to be enacted by the new Congress that was elected in November 2006. According to McRae, the United States expects

to deposit its instrument of ratification with the IAEA in the very near future. See McRae, "Overview of the Convention on Supplementary Compensation." The aim of the (draft) Act is to establish a funding mechanism under the Price-Anderson Act for the U.S. contribution to the international nuclear liability compensation system. It is also said that "CSC benefits US suppliers who face potentially unlimited liability for nuclear accidents outside the coverage of the Price-Anderson Act by replacing potentially open-ended liability with a predictable regime." If, as seems quite likely, the United States will eventually ratify the CSC, it will change U.S. policy by entering the international nuclear liability regime (only CSC). The fact that the United States ratifies the Convention will in itself not be enough for the entry into force of the convention; it is, however, a very important step and might motivate other states to join the convention as well. If another state with a large nuclear capacity such as Japan were to become a member, this would trigger the entry into force of the CSC. Second, it is important because the United States immediately shifts the financial burden it will have under the collective tier of the convention to the private sector (the nuclear suppliers).

27. See for example, Philippe Sands and Paolo Galizzi, "The 1968 Brussels Convention and Liability for Nuclear Damage," *Nuclear Law Bulletin*, No. 64, December 1999, pp. 7-27; and Paolo Galizzi, "Questions of Jurisdiction in the Event of a Nuclear Accident in a Member State of the European Union," *Journal of Environmental Law*, Vol. 8, No. 1, 1998, pp. 71-97.

28. Answer of Commissioner Matutes to Written Question E-2489/93 (S. Kostopolous), September 1, 1993 (94/C 240/45), in which it is stated, *inter alia*, that:

> All the Member States are parties to the 1960 Paris Convention save Luxembourg and Ireland, which have no nuclear installations on their territory. There is thus no need for the Commission to take the initiative suggested by the Honourable Member [to lay down provisions in insurance law relating to the civil liability of operators of nuclear installations for any damage to persons, property and the environment].

OJ, C240/24, August 29, 1994.

29. Appendix 2 contains a table setting out the different liability and compensation regimes applicable in the individual EU Member States and the varying operator liability amounts and financial security limits.

30. Although not a party to any of the conventions, Austria has enacted specific legislation covering liability for nuclear accidents. Austria's nuclear liability legislation rejects many of the fundamental principles underlying the current nuclear liability regimes. Under its legislation, for example, the operator of a nuclear installation may not be exclusively liable. Victims may even assert a claim against a nuclear operator or supplier pursuant to other liability legislation in force, for example, product liability legislation. Nor are victims precluded from pursuing claims against more than one defendant. The liability imposed is in all cases unlimited. There are no time limits during which claims may be brought. Prescription periods are determined by the general law of civil procedure of Austria. Austrian courts have jurisdiction to determine claims and Austrian law is applicable, regardless of where the incident causing damage took place, subject only to certain limited exceptions. See *Bundesgesetz über die zivilrechtliche Haftung für Schäden durch Radioaktivität* (Federal Law on Civil Liability for Damages Caused by Radioactivity) *Atomhaftungsgestz*, 1999, BGB1, Vol. I, No. 170, 1998. A description is given in M. Hinterregger, "The New Austrian Act on Third Party Liability for Nuclear Damage," *Nuclear Law Bulletin*, No. 62, 1998, pp. 27-34.

31. It should be noted, in this respect, that Commissioner Matutes' response to the Parliamentary question described above, is deficient. Although neither Ireland nor Luxembourg have nuclear installations, they may be affected by a nuclear accident at a reactor located in one of the other EU Member States. In such circumstances, the fact that they are not party to the Paris Convention would pose problems in that **none** of the provisions of the Paris Convention would apply with respect to them. This creates the possibility of claims being pursued through other mechanisms, without the limitations on type of damage, time periods and amounts of liability of the operator, or the channeling, exclusivity, and other special requirements favorable to the nuclear operator, which are established by the Paris Convention. Plaintiffs in such countries might seek compensation through the courts in their

own country, i.e., where the damage occurred (or, at the plaintiff's discretion, in the country where the incident occurred), relying on the general conflict of law rules relating to international jurisdiction, including, for example, the 1968 Brussels Convention on the Jurisdiction and Enforcement of Judgements in Civil and Commercial Matters. See Galizzi. While the outcome of such a proceeding is by no means certain, it might be considered to offer certain advantages not found in pursuing claims pursuant to the limitations of the Paris Convention. See, also: Sands and Galizzi.

32. In January 2007, the Commission stated: "The Commission is aiming at harmonising the nuclear liability rules within the Community. An impact assessment will be started to this end in 2007." See Illustrative Nuclear Programme, Presented Under Article 40 of the Euratom Treaty for the Opinion of the European Economic and Social Committee, *Communication from the Commission to the Council and the European Parliament*, COM(2006) 844 Final, European Commission, July 12, 2007. This aim was restated recently by Energy Commissioner Piebalgs at the *Nuclear Inter Jura Conference 2007* in Brussels, Belgium, on October 2, 2007.

33. See, for example, Norbert, Pelzer, "International Pooling of Operators' Funds: An Option to Increase the Amount of Financial Security to Cover Nuclear Liability?" Discussion Paper for the IAEA INLEX Group Meeting on June 21-22, 2007, pp. 37-55.

34. *Ibid*., p. 9. The nuclear insurance industry made its concerns known at an early stage in the discussion of amendments of the Paris Convention, see Letter of the Comité Européen des Assurances of December 8, 2000.

35. The nuclear insurance industry concerns with regard to the full insurability of these various risks stems from a variety of issues. In some cases, particularly for "reinstating a significantly impaired environment," insurers take the view that there is no insurable interest to be protected, or that there is no quantifiable economic interest. They maintain that it will be difficult to establish the type and extent of damage caused by the accident and at what stage of progression that damage occurred; they point out that it is not always easy to relate decreases in land values to a particular source. They have expressed concerns over uncertainty as to how courts may define or interpret a significant impairment

of the environment. Finally, they have indicated their opposition to extended prescription periods both on the basis of problems related to causality, but as well, the difficulty of quantifying exposure, the need to defend against speculative claims and the questioned value of legally authorised exposure limits. See M. Tetley, "Revised Paris and Vienna Nuclear Liability Conventions—Challenges for Nuclear Insurers," *Nuclear Law Bulletin*, No. 77, June 2006, pp. 27-39; and Faure and Vanden Borre.

36. Julia A. Schwartz, "Alternative Financial Security for the Coverage of Nuclear Third Party Liability Risks," OECD-NEA, paper presented to Nuclear Inter Jura 2007, Brussels, Belgium, October 2, 2007.

37. Tetley, "Revised Paris and Vienna Nuclear Liability Conventions," p. 39.

38. Important in answering the question whether the nuclear operator is liable in case of a nuclear incident caused by an act of terrorism is Article IV.3 of the 1963 Vienna Convention and Article 9 of the Paris Convention. These provide essentially the same exoneration from liability. Article IV.3 of the 1963 Vienna Convention states:

> a. No liability under this Convention shall attach to an operator for nuclear damage caused by a nuclear incident directly due to an act of armed conflict, hostilities, civil war or insurrection.
>
> b. Except in so far as the law of the Installation State may provide to the contrary, the operator shall not be liable for nuclear damage caused by a nuclear incident directly due to a grave natural disaster of an exceptional character.

Article 9 of the Paris Convention states that:

> The operator shall not be liable for damage caused by a nuclear incident directly due to an act of armed conflict, hostilities, civil war, insurrection or, except in so far as the legislation of the Contracting Party in whose territory his nuclear installation is situated may provide to the contrary, a grave natural disaster of an exceptional character.

Article 6.1 of the Protocol amending the provisions of the Vienna Convention repeals only the exoneration for a grave natural disaster of an exceptional character.

39. Roland Dussart Desart, "The Reform of the Paris Convention on Third Party Liability in the Field of Nuclear Energy and of the Brussels Supplementary Convention: An Overview of the Main Features of the Modernisation of the two Conventions," *Nuclear Law Bulletin*, No. 75, 2005, pp. 7-33.

40. The 2004 Protocol to the Paris Convention would amend Article 9 of the Paris Convention to read: "The operator shall not be liable for damage caused by a nuclear incident directly due to an act of armed conflict, hostilities, civil war, or insurrection." Thus, for the purposes of this analysis, the two revised Conventions may be treated as equivalent in this respect, exonerating an operator from liability **only** for nuclear incidents directly due to an act of armed conflict, hostilities, civil war, and insurrection. See Tom Vanden Borre, "Are Nuclear Operators Liable and Insured in Case of an Act or Terrorism on a Nuclear Installation or Shipment?" paper presented to the Symposium Rethinking Nuclear Energy and Democracy after 09/11, PSR/IPPNW/Switzerland, April 26-27, 2002.

41. Dussart Desart, "The Reform of the Paris Convention."

42. See, for example, Schwartz, "Alternative Financial Security." In the United States, the U.S. Congress passed (and has subsequently renewed) the Terrorism Risk Insurance Act under which the U.S. Government will contribute funds in the event of significant industry needs, and pay terrorism claims; in return, the Act prohibits insurers from discontinuing their terrorism risk insurance. These provisions are temporary, allowing the insurance industry to gain enough experience to properly price its continuing coverage for terrorism risks.

43. In Europe there are two mutual insurance arrangements which supplement commercial insurance pool cover for operators of nuclear plants. The European Mutual Assurance for the Nuclear Industry (EMANI) was founded in 1978, and the European Liability Insurance for the Nuclear Industry (ELINI) was created

in 2002. ELINI plans to make €100 million available as third party cover, and its 28 members have contributed half that as late as 2007 for a special capital fund. ELINI's members comprise most EU nuclear plant operators. EMANI's funds are also only about €500 million. See UIC 2007: "Civil Liability for Nuclear Damage," Uranium Information Centre, Issues Briefing Paper # 70, October 2007, available from *www.uic.com.au/nip70.htm* (updated October 2010, renamed "Liability for Nuclear Damage").

44. Her Majesty's Government, "The Role of Nuclear Power," Consultation Paper May 2007, available from *webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file39197.pdf*.

45. Pelzer, "International Pooling," p. 47.

46. In his article, Tetley identifies a number of problematic issues in the revised conventions, and, in particular, stresses in bold that "almost all forms of environmental liability are currently uninsurable," p. 36. That may be correct generally. But a closer look into the heads of environmental damage in the nuclear conventions show that the definitions contain qualifiers which enable judges to restrict and define an individual damage quite clearly in terms of money. (This footnote is part of the above quote, taken directly from Pelzer's article.)

47. New legislation proposed in Sweden shows one way of dealing with the shortfall. In Sweden, at least for the moment, private nuclear insurance will not be available to fully cover the €700 million of liability to be imposed upon a nuclear operator under the 2004 Protocol to Amend the Paris Convention. Not only will insurance capacity be unavailable for that amount, but it will equally be unavailable (in whole or in part) for certain types of risks which nuclear operators will be required to assume once the Protocol has come into force, such as claims made more than 10 years following the date of the incident; or the costs of reinstating a significantly impaired environment. The Swedish Government's inquiry into an appropriate nuclear liability regime for that country concluded that the Government (should) be authorized by the Swedish Parliament to provide alternative financial security to supplement the amount of (currently) available insurance, subject to charges that are calculated on the basis of standard commercial terms and that conform to EU regulations regarding restrictions

against competition, within the framework of a state guarantee. This self-financed commitment should preferably take the form of a reinsurance commitment so that financial coverage of the operator's liability may be available for up to €1200 million, the amount required to be paid by operators and by their governments under the first two tiers of the Brussels Supplementary Convention as amended by the 2004 Protocol. Summary of the Report of the Swedish Government Inquiry in the Swedish Government Official Report Series (SOU) 2006:43, p. 27 *et seq*., available from *www.sweden.gov.se/content/1/c6/06/25/90/25aa61e8.pdf*.

48. Pelzer, "International Pooling," p. 48.

49. *IEA 2006: World Energy Outlook*, see Table 6, p. 148.

50. "The High Price of Hot Air," *Open Europe*, August 2007.

51. Peter Atherton, head of European Utility Research, Citigroup, "Citigroup Analysis of the Impact of the EU Carbon Market on European Utilities," Powerpoint presentation, 2006.

52. Vincent De Rivaz, Chief Executive EDF Energy, "Can we make nuclear energy a reality in the UK?" Westminster Energy Forum Speech, London, UK, November 16, 2006.

53. For reactors in Canada, it has been estimated that the limit on the liability of operators, which currently excludes about 80 percent of expected off-site damage, amounts to an implicit subsidy of between 1 and 4 cents per kWh, depending on the risk assessments used. See Anthony Heyes, and Catherine Heyes, "An empirical analysis of the Nuclear Liability Act (1970) in Canada," *Resource and Energy Economics*, Vol. 22, 2000, pp. 91-101. In the United States, it has been estimated that the value of the Price-Anderson subsidy was $60 million per reactor year before 1982, but it then dropped to $22 million per reactor year following the 1988 amendments. See Jeffrey A. Dubin and Geoffrey S. Rothwell, "Subsidy to Nuclear Power through Price-Anderson Liability Limit," *Contemporary Economic Policy*, Vol. 8, No. 3, 1990, pp. 73-79; and A. Heyes and C. Liston-Heyes, "Subsidy to Nuclear Power Through Price-Anderson Liability Limit: Comment," *Contemporary Economic Policy*, Vol. 16, No. 1, 1998, pp. 122-124. More generally, see R. L. Ottinger *et al*., *Environmental Costs of Electricity*,

New York: Oceana Publications, 1991. While this paper focuses on externalities resulting from damage caused to third parties after a nuclear accident, it is clear that nuclear power generation may well generate other externalities as well (e.g., including those related to the costs of decommissioning and the management of nuclear waste and spent fuel) which should be taken into account in a more comprehensive economic analysis.

54. "Solutions for environment, economy and technology," Report for DG Environment, Environmentally harmful support measures in EU Member States, European Commission, January 2003, p. 132.

55. A severe nuclear accident means one where there is a breach of the containment, loss of integrity of the core, and uncontrolled emission of core substances into the environment. The 1986 Chernobyl accident was in this category. In the Chernobyl accident, it is believed that about 4 percent of the reactor core material was released.

56. There no single, internationally accepted, methodology for assessing and valuing damage incurred as a result of a nuclear accident, particularly for damage arising in different countries. In addition, different assessments include or exclude particular categories of damage to a greater or lesser extent, sometimes even entirely excluding particular types of damage from consideration. An illustration of the complexities involved can be seen by considering the Chernobyl accident. Most of the population of the Northern hemisphere was exposed, to various degrees, to radiation from the Chernobyl accident. Even now it is possible to arrive only at a reasonable, but not highly accurate, assessment of the ranges of doses received by the various groups of population affected by the accident. Within the former Soviet Union, large areas of agricultural land are still excluded from use and are expected to continue to be so for a long time. In a much larger area, although agricultural and dairy production activities are carried out, the food produced is subjected to strict controls and restrictions of distribution and use. The progressive spread of contamination at large distances from the accident site caused considerable concern in many countries outside the former Soviet Union, and the reactions of the national authorities to this situation were extremely varied, ranging from a simple intensification of the

normal environmental monitoring programs, without adoption of specific countermeasures, to compulsory restrictions concerning the marketing and consumption of foodstuffs. Some of these restrictions remain in place today. To date we are aware of no comprehensive overall assessment of the total costs of the Chernobyl accident which compiles and integrates the costs of these different damages, preventive responses, and related actions in all affected countries.

57. See, for example, Dubin and Rothwell, "Subsidy to Nuclear Power"; Heyes and Liston-Heyes, "Subsidy to Nuclear Power Through Price-Anderson Liability Limit"; Ottinger *et al*., "Environmental Costs of Electricity"; Heyes and Heyes, "An empirical analysis of the Nuclear Liability Act"; Anthony Heyes, "PRA in the nuclear sector: quantifying human error and human malice," *Energy Policy*, Vol. 23, No. 12, 1995, pp. 1-8; Greenpeace International, "Review of Estimates of the Costs of Major Nuclear Accidents," prepared for the 9th Session of the IAEA Standing Committee on Nuclear Committee, Vienna, Austria, February 7-11, 1994.

58. Woolley Report 17, citing Greenpeace International, Review of Estimates of the Costs of Major Nuclear Accidents, prepared for the 9th Session of the IAEA Standing Committee on Nuclear Committee, 1994. The so-called "Sandia siting report" (1982) concluded that a very large accident could cause damages in the order of $695,000 million. Cited in Michael Faure, "Economic Models of Compensation for Damage Caused by Nuclear Accident: Some Lessons for the Revision of the Paris and Vienna Conventions," *European Journal of Law and Economics*, Vol. 2, 1995, pp. 21-43.

59. Report to the Congress from the Presidential Commission on Catastrophic Nuclear Accidents (Volume One), August 1990, p. 73, footnote 10.

60. Richard Hudson, "Study Says Chernobyl Might Cost 20 times more than Prior Estimates," *Wall Street Journal Europe*, March 29, 1990.

61. *The Republic of Belarus: 9 Years after Chernobyl. Situation, Problems, Actions*, National Report, Ministry for Emergencies and

Population Protection from the Chernobyl NPP Catastrophe Consequences, 1995.

62. See G. J. Vargo, ed., *The Chornobyl Accident: A Comprehensive Risk Assessment*, Columbus, OH: Batelle Press, 2000, cited in M. C. Thorne, *Annals of Nuclear Energy*, Vol. 28, 2001, pp. 89-91.

63. Nuclear Regulation, "A Perspective on Liability Protection for a Nuclear Power Plant Accident," GAO/RCED-87-124, 1987, p. 20 and Appendix II.

64. Report Number 5, Nuclear Fuel Cycle, Externalities of Fuel Cycles 'ExternE' Project, European Commission, DGXII, Science, Research and Development (JOULE), Brussels, Belgium, 1995, p. 5.

65. Alain Sohier, ed., *A European Manual for "Off-site Emergency Planning and Response to Nuclear Accidents,"* prepared for the European Commission Directorate-General Environment (Contract SUBV/00/277065), SCK-CEN Report R-3594, December 2002, Chap. 13, "Economic Impact," in particular, pp. 245-248.

66. Heyes and Heyes, "An empirical analysis of the Nuclear Liability Act."

67. For example, while the generation of nuclear electricity does not emit CO_2 and other "classical" pollutants associated with the combustion of fossil fuels, there a number of environmental problems associated with nuclear technology. In addition to the risks of major accidents, in particular, it is still argued that the mechanisms to safely manage nuclear waste over the timescales necessary have not been developed or deployed. It is expected that governments will be required, at some time in the future, to pay for full cost of the safe disposal of nuclear waste, and this should somehow be factored into the present-day pricing of nuclear-generated electricity. However, there is no agreement on exactly how these costs can be factored into analyses.

68. See, for example, R. L. Ottinger, "Have recent studies rendered environmental externality valuation irrelevant?" in O. Hohmeyer, ed., *Social Costs and Sustainability: Valuation and Implementation in the Energy and Transport Sector*, Berlin, Germany: Springer, 1997, pp. 29–43; and Sang-Hoon Kim, "Evaluation of

negative environmental impacts of electricity generation: Neoclassical and institutional approaches," *Energy Policy*, Vol. 35, 2007, pp 413–423.

69. ExternE Report No. 1, "Summary, Externalities of Fuel Cycles 'ExternE' Project," European Commission, DGXII, Science, Research and Development, JOULE, 1995.

70. The results ranged from 0.1 to close to 100 mECU/kWh. ExternE Report No. 5, "Nuclear Fuel Cycle," European Commission, DGXII, Science, Research and Development, JOULE, 1995, p. 7.

71. *Ibid*. The priority impacts of the nuclear fuel cycle to the general public are radiological and nonradiological health impacts due to routine and accidental releases to the environment. The source of these impacts are the releases of materials through atmospheric, liquid, and solid waste pathways. The most important impacts to the natural environment that could be expected would be the result of major accidental releases. This type of impact has been included in the economic damage estimates as the loss of land-use and agricultural products after a potential severe reactor accident. Possible long-term ecological impacts have not yet been considered. Within the framework of the ExternE project, the cost associated with a nuclear accident was derived on the basis of the economic module available in the COSYMA code (based on the "direct" economic loss associated with health and environmental consequences), including further considerations on the probability of occurrence of the different accidental scenarios as well as specific values for health effects. At that period of time, it was clearly pointed out that this approach was limited and that there was a need for further investigation in order to deal with the risk perception.

72. Sohier, p. 248 (emphasis added).

73. 1998 Update to the ExternE Methodology Report, 1999, citing: A. Markandya and N. Dale, eds., *Improvement of the Assessment of Severe Accidents*, Unpublished report from the ExternE Core Project for European Commission, DGXII, under contract number JOS3-CT95-0002, 1998.

74. ExternE - Report No. 5, p. 5.

75. Peter Bickel and Rainer Friedrich, eds., "Methodology 2005 Update," ExternE—Externalities of Energy, European Commission, 2005.

76. In this respect, a telling slide was presented at a 2005 ExternE meeting. In response to the Stakeholders' concern: "Is the risk of a nuclear accident evaluated correctly?" the response from ExternE was "Who can agree on 'correctly'?" with the additional explanation that "Someone who does not agree can modify the assumptions of ExternE or do an alternative analysis." See *External costs of energy and their internalization in Europe - Dialogue with industry, NGO, and policy-makers*, Brussels, Belgium, December 9, 2005, available from *www.externe.info/index.html*.

77. As Tetley has pointed out, with fewer than 500 reactors worldwide—not all of which are insured—the nuclear insurance industry does not have a large database on which to base premiums and loss assessments. Much of the modeling and premium assessment is therefore done on an actuarial and theoretical basis, rather than using real data. The inherent uncertainty of this methodology makes many insurers even more reluctant to commit their capital to nuclear risks. See Tetley, "Revised Paris and Vienna Nuclear Liability Conventions."

78. 1998 Update to the ExternE Methodology Report.

79. Welt im Wandel: Strategien zur Bewältigung globaler Umweltrisiken (*World in Transition: Strategies for Managing Global Environmental Risks*), Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderung (WGBU), Jahresgutachten 1998, Berlin, Heidelberg, Germany, and New York: Springer, 1999.

80. Wolfram Krewitt, "External costs of energy - do the answers match the questions? Looking back at 10 years of ExternE," *Energy Policy*, Vol. 30, 2002, pp. 839–848.

81. Bickel and Friedrich, eds., (emphasis added).

82. This follows from the standard economic analysis of tort. See for example S. Shavell, "Strict Liability Versus Negligence,"

Journal of Legal Studies, 1980, pp. 1-25; and S. Shavell, *Economic Analysis of Accident Law*, Cambridge, MA: Harvard University Press, 1987.

83. S. Shavell, "On Moral Hazard and Insurance," *Quarterly Journal of Economics*, 1979, pp. 541-562.

84. For conditions for efficient functioning of compensation funds, see M. Faure, "Financial Compensation for Victims of Catastrophes: An Economic Perspective," *Law & Policy*, Vol. 29, No. 3, July 2007, pp. 339-366.

85. See in this respect, more particularly, M. Faure and R. Van den Bergh, "Liability for Nuclear Accidents in Belgium from an Interest Group Perspective," *International Review of Law & Economics*, 1990, pp. 241-254; M. Faure and G. Skogh, "Compensation for Damages Caused by Nuclear Accidents: A Convention as Insurance," *The Geneva Papers on Risk and Insurance*, Vol. 17, 1992, pp. 499-513; Faure, "Economic Models of Compensation"; and M. Trebilcock, and R. A. Winter, "The Economics of Nuclear Accident Law," *International Review of Law & Economics*, Vol. 17, 1997, pp. 215-243.

86. The result of the changes of the Price-Anderson Act has been that the costs of a nuclear accident were increasingly internalized, that the externalities decreased to an important degree. Although there are still issues to consider under the Price-Anderson Act, in particular that operator liability remains limited, Faure and Vanden Borre conclude that there are substantially less remaining externalities under the U.S. than under the international nuclear compensation scheme. Faure and Vanden Borre, "Economic Analysis of the Externalities," pp. 34-35.

87. As far as the existing Paris Convention regime is concerned: €150 million; once the 2004 Protocol to the Paris Convention will enter into force: €700 million.

88. Faure and Vanden Borre, "Economic Analysis of the Externalities." Faure and Vanden Borre note that this last criticism can be met (partially) if the Contracting Parties charge the operators for the costs of making public money available. These costs should then be market reflective and should take into account

risk differentiation, etc. They add that it is far from sure that any governmental institution is equipped well enough to assume this difficult task, and thus whether such an institution could do so in a more efficient manner than an insurance company or mutual insurance scheme.

89. The discussion here focuses on the U.S. pooling system. However, some features of the German system are also worth noting. While the U.S. system is based on a statutory obligation or duty of the individual operator to contribute, the German system is formed by a voluntarily concluded contract under civil law among the four leading German energy producing companies, the "Solidarvereinbarung" (a "Solidarity Agreement").

Since 2002, when German nuclear operators had to respond to their Government's decision to increase the amount of financial security to be provided by the private sector to up to €2.5 billion. The nuclear insurance industry still provides a portion of coverage which currently rests at up to €255.6 million. However the remainder of the security, up to €2.24 billion, is to be provided by an operator pooling system which enables the operators of those plants to provide the financial security required of them by the German Atomic Energy Act. Under this new arrangement, each partner accepts liability, vis-à-vis the others, to contribute a percentage of the total amount of coverage to be provided by the liable operator, and the total of all partners' commitments in this regard is agreed to be 100 percent of that amount.

The size of each partner's guarantee is determined on the basis of the number of shares it holds in each and every nuclear power plant. Where a nuclear incident occurs, the guarantee must be paid to the liable operator as long as neither it nor its parent company can provide the required financial security; proof of that inability must be proved by a public accountant's certificate. As under the American system, no money is required to be paid in advance of a nuclear accident; and where the partners do pay following an accident, they will have a right of recourse against the operator. In the meantime, they will offer claims handling support to the liable operator through deployment of their infrastructure and expertise. The German regulatory authorities accept this arrangement in satisfaction of obligations under both domestic legislation and international conventions, on condition that the partners annually submit a public accountant's certificate attesting to their financial capacity to meet their obligations under the

scheme. See, for example, Schwartz, "Alternative Financial Security," p. 18; and Pelzer, "International Pooling," pp. 43-45.

90. Pelzer, "International Pooling," in particular p. 46.

91. Faure, and Vanden Borre, *Economic Analysis of the Externalities*, p. 32.

92. See "Legislative updates," *NEA News*, Vol. 23, No. 2, 2005, p. 32.

93. On the basis of $300 million of the first tier + [(95.8 + 5%) x 104 = 10,461] of the second tier. This implies the following if a nuclear accident occurs in the United States causing $7 billion (roughly €5.2 billion) of damage. In a first layer, the liability insurer will have to pay $300 million. This leaves a remainder of $6.7 billion to be covered in the second tier of the U.S. compensation scheme. This will be financed collectively by all the 104 nuclear operators in the United States. This means that every U.S. nuclear operator will have to pay, in the second layer, a total amount of $64.4 million ($6.7 billion/104 nuclear power plants) per power plant.

94. The second tier payment, in the scenario described above, will be collected through retrospective premiums which are currently limited to $15 million per year and per reactor. The result is that the second layer ($6.7 billion) will be financed by the operators of all 104 nuclear power plants in a period of 5 years, whereby each will pay $15 million during the next 4 years and $4.4 million in the fifth year.

95. Faure and Vanden Borre, "Economic Analysis of the Externalities," p. 32.

96. *Ibid*.

97. *Ibid*., p. 33. To address these concerns, Faure and Vanden Borre note the following. The model is to be applied on a limited international, e.g., European basis—at least at the start of setting up such a model. The reason for this is quite simple: such a model can only work if the (operational) safety of the participating nuclear power plants is similar or at least comparable. Those opera-

tors wanting to participate in the model will have an incentive to enhance the safety of their power plants. Lastly, the model will only work if major regulatory issues have been resolved. In their view, by far the most important one is the creation of a European independent regulatory body (a kind of European Nuclear Regulatory Agency); this body will deliver permits to nuclear installations falling under the international nuclear liability regime and will determine the way the operators will insure their liability.

98. Pelzer, "International Pooling," pp. 50-52.

99. *Ibid*., p. 50. Note that this conclusion does not, however, exclude state measures designed to support respective efforts of operators if states deem them useful.

100 . The parties to the Agreement are: Energie Baden-Württemberg AG (EnBW), E.ON Energie AG, Hamburgische Electricitäts-Werke AG (now: Vattenfall Europe AG), and RWE AG.

101. The approximate percentages read as follows: E.ON, 42 percent; RWE, 25.9 percent; EnBW, 23.9 percent; and Vattenfall, 8.2 percent.

102. Under the current German pooling arrangement, there is a guaranteed amount of compensation available of €2.5 billion (approximately $.32 billion). But the liability of the German operator is not affected, the liability remains unlimited, and in the event that the damage caused exceeds the financing of the pool the other assets of the operator are available to add to compensation.

103. Pelzer, "International Pooling," p.51. It is conceivable that operators develop formal mechanisms in order to enable the partners to decide on the eligibility of an installation—these might include direct monitoring, inspection, and assessments by or on behalf of the pool.

104. Illustrative Nuclear Programme.

105. Pelzer, "International Pooling," p. 55.

106. EESC 2007: Opinion of the European Economic and Social Committee on the Communication from the Commission to the Council and the European Parliament— Illustrative Nuclear Program, Presented Under Article 40 of the Euratom Treaty for the Opinion of the European Economic and Social Committee, *Communication from the Commission to the Council and the European Parliament*, COM(2006) 844 Final, European Commission, July 12, 2007.

107. Andris Piebalgs, "The Euratom Treaty and development of the Nuclear Industry," Keynote speech at the International Nuclear Law Association Congress, Brussels, Belgium, October 3, 2007.

APPENDIX 1

CONVENTION LIMITATION AMOUNTS[1]

Convention	Operator Liability	Installation State[2]	Combined States Party	TOTAL
Paris Convention, 1960	*At least* Special Drawing Rights (SDR) 5 million and up to a maximum of 15 million SDRs. *(a) (b)* (*At least* € ±6 million and up to €17.83 million)	-	-	*At least* SDR 5 million and up to a maximum of 15 million SDRs (*At least* € ±6 million and up to €17.83 million)
Brussels Suppl. Convention, 1963	*At least* SDR 5 million. *(c)* (*At least* €±6 million)	The difference between the operator liability amount and SDR 175 million (€202.13 million)	125 million SDRs *(d)* (€148.62 million)	SDR 300 million (€356.7 million)
Paris Convention, 2004	*At least* €700 million *(e) (f)*	-	-	*At least* €700 million
Brussels Suppl. Convention, 2004	*At least* €700 million	The difference between the operator liability amount and €1200 million	€300 million *(g)*	€1500 million
Vienna Convention, 1963	$ 5 million gold (€±50 million)	-	-	$ 5 million gold (€±50 million)

APPENDIX 1

CONVENTION LIMITATION AMOUNTS[1] (Cont.)

Convention	Operator Liability	Installation State[2]	Combined States Party	TOTAL
Vienna Convention, 1997	*At least* SDR 150 million *(h)* (€178.25 million)	The difference between the operator liability and SDR 300 million *(i)* (€356.7 million)	-	SDRs 300 million (€356.7 million)
Convention on Supplementary Compensation for Nuclear Damage, 1997	Not specified. *(j) (k)*	At least SDRs 300 million (At least € 356.7 million)	If damage exceeds 300 million SDR, calculated separately for each individual state party. *(l)*	At least SDRs ±600 million. *(m)(n)* (At least €±713.4 million)

NOTES:

Paris Convention, 1960

(a) Switzerland introduced a system of unlimited liability which it considered incompatible with the Paris Convention system and therefore it elected not to become a party to the Paris Convention. However, in practice, some Paris Convention parties did not implement this provision too strictly as to the maximum amount of liability. Some imposed a higher amount of liability (e.g. in Belgium an amount of €300 million was set) or even by introducing a system of unlimited liability (Germany).

(b) The Steering Committee of the NEA recommended Contracting Parties to set a maximum liability of not less than 150 million SDRs (€178.35 million or $217.13 million). Recommendation of the Steering Committee of April 20, 1990, NE/M(90)1, *Paris Convention: Decisions, Recommendations, Interpretations*, Paris, OECD/NEA, 1990, p. 13.

Brussels Supplementary Convention, 1963

(c) Figures given are for the Paris Convention as amended by the 1982 Protocol which entered into force on August 1, 1991. Prior to the entry into force of the 1982 Protocol, the amounts were SDRs 70 million (€±59.5 million) for the Installation State, SDRs 50 million (€±83 million) for the combined state contribution, to a total of SDRs 120 million (€±142.7 million).

(d) Only half (50 percent) of the fund comes from contributions from those states party who have nuclear power plants. The other 50 percent comes from all states party, independent of whether or not they have nuclear power plants.

The formula for contributions is:

a. as to 50 percent, on the basis of the ratio between the gross national product at current prices of each Contracting Party and the total of the gross national products at current prices of all Contracting Parties as shown by the official statistics published by the Organization for Economic Cooperation and Development for the year preceding the year in which the nuclear incident occurs;

b. as to 50 percent, on the basis of the ratio between the thermal power of the reactors situated in the territory of each Contracting Party and the total thermal power of the reactors situated in the territories of all the Contracting Parties. This calculation shall be made on the basis of the thermal power of the reactors shown at the date of the nuclear incident in the list referred to in Article 2(a)(i): provided that a reactor shall only be taken into consideration for the purposes of this calculation as from the date when it first reaches criticality.

Paris Convention, 2004

(e) The Protocol revising the Paris Convention now explicitly provides for the possibility of unlimited operator liability.

(f) States adhering after January 1, 1999, may limit an operator's liability to €350 million for a period of 5 years starting from February 12, 2004.

Brussels Supplementary Convention, 2004	*(g)*	Most of the fund (65 percent) comes from contributions from states party with nuclear power plants. The remaining 35 percent comes from all states party, independent of whether or not they have nuclear power plants. The formula for contributions is: a. as to 35 percent, on the basis of the ratio between the gross domestic product at current prices of each Contracting Party and the total of the gross domestic products at current prices of all Contracting Parties as shown by the official statistics published by the Organization for Economic Cooperation and Development for the year preceding the year in which the nuclear incident occurs; b. as to 65 percent, on the basis of the ratio between the thermal power of the reactors situated in the territory of each Contracting Party and the total thermal power of the reactors situated in the territories of all the Contracting Parties.
Vienna Convention, 1997	*(h)*	For a transitional period of 15 years from the date of opening up for signature of the Protocol (September 12, 1997) a lesser amount of 100 million SDRs or less might be stipulated. If it is less than 100 million SDRs, the state must make available the difference up to 100 million SDRs, during the transitional period.
	(i)	For a transitional period of 15 years from the date of opening up for signature of the Protocol (September 12, 1997) a lesser amount of 100 million SDRs might be stipulated.
Convention on Supplementary Compensation, 1997	*(j)*	According to Art. III.1.a of the Convention on Supplementary Compensation (CSC), the Installation State shall ensure the availability of at least 300 million SDRs (356.7 million **€**). This provision provides for an obligation of the Installation State to ensure that 300 million SDRs are available; the Installation State is free to choose how this amount is funded (private insurance, regional agreement, . . .). A State meets its obligation under Art. III.1.a of the CSC when it imposes a nuclear liability on the operator for the entire amount.

Convention on Supplementary Compensation, 1997

(k) For a transitional period of 10 years (from September 12, 1997) a lesser amount (150 million SDRs) might be stipulated.

(l) Most, but not all, of the contributions to the international fund will come from States with nuclear power plants. Specifically, 90 percent of the contributions to the international fund will be based on the installed nuclear capacity in a member country and thus will come from only those member countries where reactors are located. The remaining 10% of the contributions will be based on the UN rate of assessment of a member country. Given that many nuclear power generating States have a large UN rate of assessments, it is likely that, as a group, non-nuclear-generating States will provide no more than 2 or 3% of the contributions to the international fund.
The contributions will be made according to the following formula:

- the amount which shall be the product of the installed nuclear capacity of that Contracting Party multiplied by 300 SDRs per unit of installed capacity;

and

- the amount determined by applying the ratio between the United Nations rate of assessment for that Contracting Party as assessed for the year preceding the year in which the nuclear incident occurs, and the total of such rates for all Contracting Parties to 10 percent of the sum of the amounts calculated for all Contracting Parties.

(m) One-half of the international fund is reserved exclusively for transboundary damages (that is, damages outside the Installation State).

(n) This requirement is set out in Art. XI of the CSC, which states that the funds of the second tier shall be distributed as follows: 50 percent of the funds shall be available to compensate claims for nuclear damage suffered in or outside the Installation State; 50 percent of the funds shall be available to compensate claims for nuclear damage suffered outside the terrirory of the Installation State to the extent that such claims are uncompensated from the former amount.

ENDNOTES - APPENDIX 1

1 . The exact value of the SDR is determined by the International Monetary Fund (IMF) and is published on its website. For this Table, we used the exchange rate of March 20, 2006: €1.189 $1.44757 USD.

2 . That is, the State party to the Convention in which the nuclear installation is operated.

APPENDIX 2

OPERATOR LIABILITY AMOUNTS AND FINANCIAL SECURITY LIMITS IN EU COUNTRIES

Operator Liability Amounts And Financial Security Limits in EU Countries (as of October 2006, OECD Unofficial)

State	Paris/Brussels Convention (PC/ BC) or Vienna Convention (VC)	Liability Amount in National Currency or Special Drawing Rights with USD Equivalent [*]	Financial Security Limit if Different from Liability Amount with USD Equivalent
Austria	-[1]	Unlimited	€407 million (USD = 498 M)
Belgium	PC/BC	SDR 300 million (USD = 438 M) (12 billion BEF)	
Bulgaria	VC	Approximately €49 million. (BGL 96 million)	
Cyprus	-	-	
Czech Republic	VC	CZK 6 billion (USD = 252,8 M)	CZK 1.5 billion (USD = 63 M)
Denmark	PC/BC	SDR 60 million (USD = 87,6 M)	
Estonia	VC[2]	No specific legislation	
Finland	PC/BC	SDR 175 million (USD = 255,5 M) [1]	€700 million under new legislation (not yet EIF)
France	PC/BC	SDR 76 million (USD = 111,5 M) [2]	€700 million under new legislation (not yet EIF)

Operator Liability Amounts And Financial Security Limits in EU Countries (*cont.*)
(as of October 2006, OECD Unofficial)

State	Paris/Brussels Convention (PC/BC) or Vienna Convention (VC)	Liability Amount in National Currency or Special Drawing Rights with USD Equivalent [*]	Financial Security Limit if Different from Liability Amount with USD Equivalent
Latvia	Revised VC[3]	Approximately €122 million. (LVL 80 million)	
Lithuania	VC[4]	€50 million[5]	
Luxembourg	-[6]	No specific legislation	
Malta	-	-	
Netherlands	PC/BC	SDR 285 million (USD = 416 M)	
Poland	VC	SDR 150 million (USD = 219 M)	
Portugal	PC (not BC)	No specific legislation	
Romania	Revised VC and CSC[7]	SDR 300 million[8] (USD 438 M)	
Slovakia	VC	Approximately €75 million (2 billion SKK)	
Slovenia	PC/BC	SDR 150 million (USD = 219 M)	
Spain	PC/BC	ESP 25 billion (approx SDRs 150 million)	

Operator Liability Amounts And Financial Security Limits in EU Countries (*cont.*)
(as of October 2006, OECD Unofficial)

State	Paris/Brussels Convention (PC/BC) or Vienna Convention (VC)	Liability Amount in National Currency or Special Drawing Rights with USD Equivalent [*]	Financial Security Limit if Different from Liability Amount with USD Equivalent
Sweden	PC/BC	SDR 300 million (USD = 438 M) New proposal is unlimited.	 New proposal is for state guaranteed reinsurance to complement private insurance, together this should cover SDR 1200 million.[9]
United Kingdom	PC/BC	SDR 150 million (USD = 219 M)	

Notes:

[1] New Nuclear Liability Act (not yet EIF) provides for unlimited liability where BSC coverage exhausted and damage remaining

[2] New liability provisions (not yet EIF) provide for 700 million EUR

[*] As of 19 September 2005, 1 SDR = 1.46 USD

ENDNOTES - APPENDIX 2

1. Austria signed the 1960 Paris Convention and the 1963 Brussels Supplementary Conventions upon their adoption, but has not ratified these instruments.

2. With reservation that reservation that Estonia would not be liable for damage resulting from nuclear installations or nuclear material located on its territory if the operator is of foreign nationality.

3. Latvia ratified the 1997 Protocol to amend the Vienna Convention (it ratified on December 5, 2001, and the revised Convention entered into force on October 4, 2003).

4. Lithuania has signed the 1997 Convention on Supplementary Compensation.

5. Minimum amount under 1963 VC.

6. Luxembourg signed the 1960 Paris Convention and the 1963 Brussels Supplementary Conventions upon their adoption, but has not ratified these instruments.

7. Romania ratified the 1997 Protocol to amend the Vienna Convention (it ratified on December 29, 1998, and the revised Convention entered into force on October 4, 2003) and the Convention on Supplementary Compensation (March 2, 1999).

8. Less than SDR 300 million but at least SDR 150 million, provided that the amount of SDRs 300 million is made available from public funds. For a 10-year transitional period of 10 years (from December 3, 2001) it may be limited to less than 150 million SDRs, but not less than SDRs 75 million, provided that the difference up to SDRs 150 million SDRs shall be made available from public funds.

9. For Swedish operators, private nuclear insurance will not be available to fully cover the €700 million of liability to be imposed upon a nuclear operator under the 2004 Protocol to Amend the Paris Convention. Under the new proposals, the Government (should) be authorised by the Swedish Parliament to provide alternative financial security to supplement the amount of (currently) available insurance, subject to charges that are calculated on the basis of standard commercial terms and that conform to European Union regulations regarding restrictions against competition, within the framework of a state guarantee. This self-financed commitment should preferably take the form of a rein-

surance commitment so that financial coverage of the operator's liability may be available for up to 1200 million euros, the amount required to be paid by operators and by their governments under the first two tiers of the Brussels Supplementary Convention as amended by the 2004 Protocol to Amend that Convention.