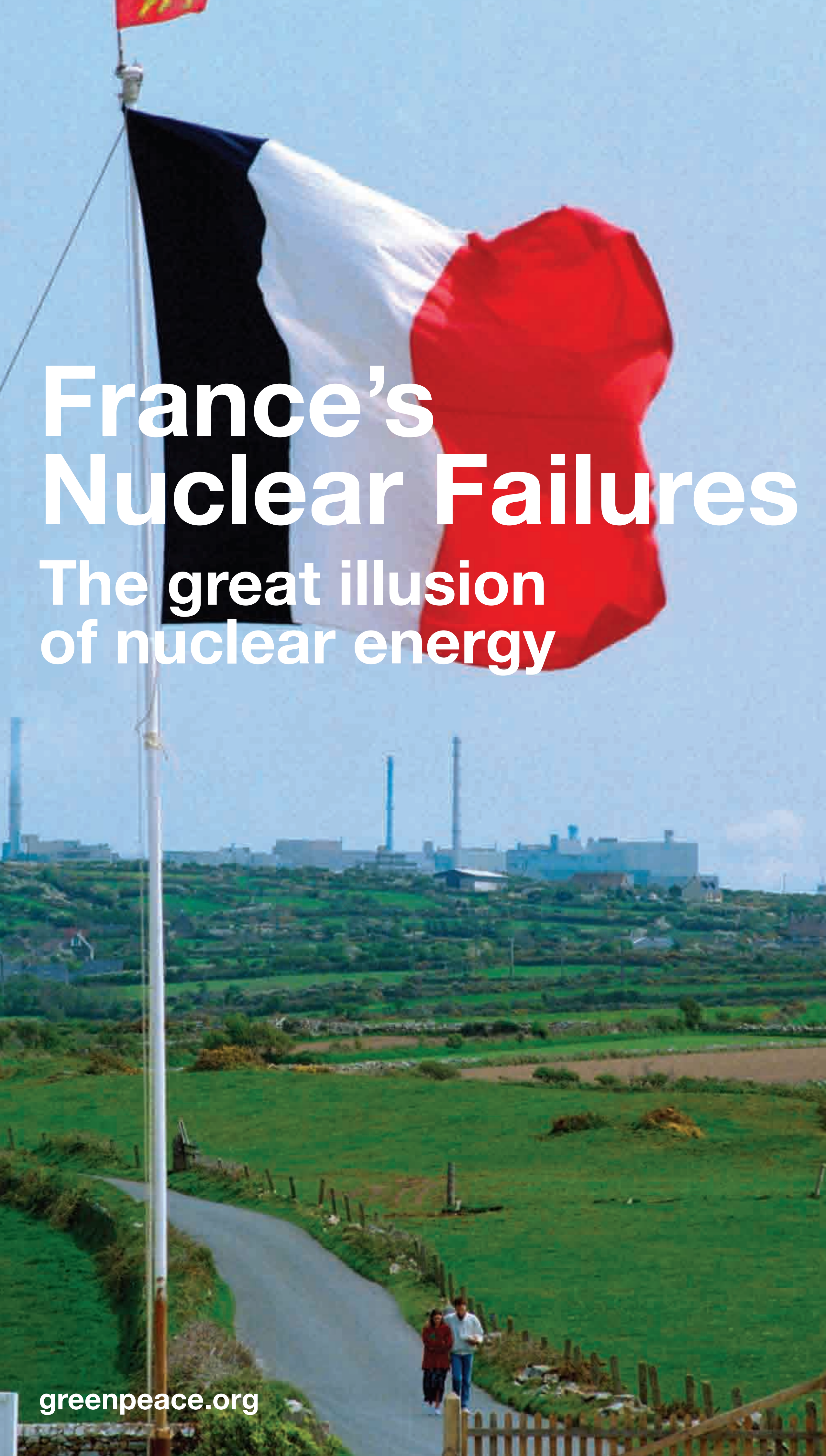
France's Nuclear Failures

The great illusion of nuclear energy



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Catalysing an energy revolution

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The French nuclear industry's key players:

The Commissariat à l'Énergie Atomique (CEA – Atomic Energy Commissariat) was established as a public corporation in 1946 and charged with overseeing research and development, up to the industrial stage, of all processes necessary for the military programme and subsequently for nuclear electricity generation, including uranium extraction, fuel manufacture and management of spent fuel and waste. Currently, CEA is a large French research organisation working mainly on energy and defence technology.

A branch of the CEA was created to manage all its industrial activities, mainly through the Compagnie Générale des Matières Nucléaires (Cogema – General Company for Nuclear Materials), a private company established in 1976. In 2001, this merged with Framatome, the nuclear reactor builder, to create the Areva group. Currently, 96% of the share capital of the Areva group is held by the French state and large French industries.

Electricité de France (EDF) was established in 1946 through nationalisation of a number of state and private companies. First and foremost responsible for overseeing development of the electricity supply across France, today EDF operates all 59 nuclear reactors in service in France. EDF was partly privatised in 2005-06, with the State controlling 84.9% of its shares.

In 1991, the Agence Nationale de Gestion des Déchets Radioactifs (Andra – National Agency for Radioactive Waste Management), and in 1998 the Institut National de Radioprotection et de Sûreté Nucléaire (IRSN – Institute for Radiological Protection and Nuclear Safety, known until 2002 as the Institut National de Protection et de Sûreté Nucléaire, IPSN) were formed from internal departments of the CEA.

The IRSN is the public expert body responsible in particular for supporting the Autorité de Sûreté Nucléaire (ASN - Nuclear Safety Authority), originally a government department but since 2006 an independent authority.

Introduction

Today, the world is confronted with dangerous climate change that threatens the lives of millions of people and the ecological integrity of the entire planet. To avoid the most dangerous effects of climate change, we must at least halve our carbon emissions by 2050. The energy investment decisions taken today will determine whether we will achieve the necessary CO_2 emission reductions in time.

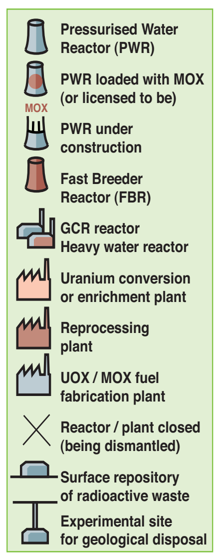
The nuclear industry, which has been in decline for several decades, has seized upon the climate crisis as a revival opportunity, aggressively promoting nuclear technology as a "low-carbon" means of generating electricity and thus an important part of our future energy mix. However, nuclear power forms an expensive and dangerous distraction from the real solutions to climate change - the necessary greenhouse gas reduction targets can only be met through using the proven alternatives of renewable energy technologies and energy efficiency.

At a time when France is setting itself up as the political and industrial champion of a supposed worldwide expansion of nuclear power, Global Chance – an association that includes among its members several of France's few independent nuclear experts – has produced a report that shows how France's nuclear promises are a dangerous illusion. France is locked into nuclear power in a way that presents an obstacle to the development of renewable energy and energy efficiency measures.

The Global Chance report – "Nuclear power, the great illusion: promises, setbacks and threats", shows:

- how France's nuclear programme fails to rise to the challenges of climate change and energy security;
- how France has not benefited economically from their 'all electric, all nuclear' approach
- how nuclear power is liable to suffer serious accidents – whether due to system failure, natural disaster or deliberate attack
- how no satisfactory solution has been found for the management of long-term waste; and
- how France contributes to proliferation, which remains a major risk for global security.

This Greenpeace briefing summarises the lessons that can be drawn from the Global Chance report. www.global-chance.org/spip.php?article89



France’s nuclear ‘success story’: a 50-year history of failures

The “success story” of its nuclear programme, as promoted by the French government and the nuclear industry, is far from the reality of the 50-year history of technological dead-ends, failed industrial challenges and planning mistakes.

image Nuclear protest in 2007 at Olkiluoto-3, the French EPR in Finland. Greenpeace called on TVO, the company that ordered the reactor, to make all the documents describing the 1,000 reported quality problems public, repay the state subsidies it has received for the project and drop any plans on new nuclear projects.

Key decisions in the evolution of the French nuclear programme have been based on dramatically incorrect predictions. The development of a large fleet of light water reactors (LWRs), decided in the early 1970s, was based on unrealistic forecasts of electricity demands. This decision had the strongest and longest-lasting impact on the national nuclear and energy policies; the pursuance of the nuclear choice was declared the major pillar of French energy policy.

Like many other western countries, France based its planning on a doubling of energy consumption every ten years. The planned nuclear capacity included an assumed massive potential for technology exports; when the reactor programme was launched, France reckoned on exporting, on average, one unit for each unit built for domestic purposes. In reality, the French industry only exported nine units to four countries (Belgium, South Africa, China and South Korea), prior to the European Pressurised Reactor (EPR) order by Finland in 2005, compared to 58 reactors built in France.

By the end of the 1970s, the increase rate of energy demand slowed down significantly compared to economic growth. At this point, many countries abandoned their nuclear programmes and cancelled reactor projects. France persisted in its course. As a consequence, France has a structural overcapacity of nuclear power to this day, which locks the energy system into an ageing reactor fleet and presents an obstacle to energy efficiency measures and the development of renewables in the energy sector.

The French nuclear industry has frequently bet on the wrong horse in technology choices. The French Atomic Energy Commission (CEA) initially supported the development of natural uranium-graphite-gas (UNGG) reactors, but EDF ultimately chose the American pressurised water reactor (PWR) technology, building the first 50 of its current 58 reactors under American licence. Similarly wrong decisions were made regarding uranium enrichment and waste management (see Box).

The EPR project continues in the footsteps of past decisions. With no critical public evaluation of previous projects, little has been learned, and the industry consistently refuses to acknowledge any earlier mistakes in order to preserve its image. Promises of the nuclear industry itself, often highly unrealistic, have remained the basis for French energy policy decisions. Consequently, France is trapped in a nuclear "quicksand" causing the country to fall seriously short on policies for energy efficiency and clean energy sources.

Better pay the bill than plead guilty
The case of reprocessing

France's reprocessing programme was developed in the 1950s in order to produce plutonium for nuclear weapons. The technology was adopted for civil purposes on the supposition that an increase in the uranium price would drive the deployment of fast breeder reactors. By the 1980s, forecasts on the price of uranium had proven totally wrong and reprocessing, therefore, had lost its ground. Instead of adapting or closing the expensive reprocessing plants, the industry developed a new justification. Separated plutonium would be used in existing light water reactors in the form of mixed-oxide fuel (MOX), blending plutonium with uranium.

An internal report in 1989, by EDF's Department of Fuel Management, concluded that, due to the investments already made in the programme, the reprocessing option should be maintained, even though the initial justification had disappeared. The operator decided that increased operational costs of € 350 million over ten years (according to EDF's low estimate of the time) were a convenient price to pay in order to preserve the industry's successful image.

Uranium enrichment: France's dead-end choice

In the early 1970s, the US held a monopoly on low enrichment of uranium, which prompted the French to design and build the Eurodif uranium enrichment plant. The Eurodif consortium used the gaseous diffusion technology, and would serve the whole European nuclear industry. Later to improve the enrichment efficiency, the French invested in the development of enrichment by laser.

An alternative technology, developed and implemented by Urenco, was based on ultra-centrifugation and proved to be more robust and effective, and much less energy-intensive. In 2004, when Areva needed to gradually replace the Eurodif plant, it turned to ultra-centrifugation technology, because by then the laser enrichment route had turned out to be a dead end. Areva had to buy the technology from Urenco, and purchased 50% of the subsidiary company that owns the designs and sells the centrifuges. But, because of its highly sensitive status regarding proliferation risks, Areva does not get to learn about the actual design itself.

In other words, 30 years of industrial development of France's own enrichment technologies had to be abandoned, and France now relies on Urenco like everybody else.

Climate change and energy security: nuclear power's marginal contribution

Even if more than tripled, nuclear power's contribution to total emission reductions in the energy sector would be only 6% in 2050 (i.e. 3.5% of total greenhouse gas savings) – far behind the contribution of energy savings (54%) and of that offered by renewable energy solutions (at least 21%).

image Greenpeace activists holding banner that reads: 'No EPR, Go Wind" in French after having displayed 10 wind turbines on the grounds of the nuclear power plant in Penly, near Rouen, France, in 2003

©Greenpeace / Gleizes

Questions on energy security and the threat of climate change loom ever larger. The French nuclear industry's capacity as an alleged climate change mitigation option must be evaluated against existing solutions, taking into account the very limited timescale available for climate protection, the magnitude of emission reductions required and the risks that nuclear expansion entails.

Presently, the nuclear industry is in no position to make major contributions to improving either energy security or tackling climate change. Nuclear power can only contribute to the production of electricity, and cannot meet heating and transport needs. Nuclear power accounted for 15% of the electricity produced worldwide in 2006, contributing 6% of primary energy production but only 2.4% of final energy consumption (that is to say, the share of consumers' energy needs that it met).[1]

The marginal nature of its potential contribution to climate protection contrasts sharply with the considerable potential offered by other solutions. The International Energy Agency suggests a proactive scenario for reducing worldwide greenhouse gas emissions that includes an ambitious development of nuclear output from today's 2,800 TWh per year to 6,000 TWh in 2030 and 9,000 TWh in 2050. This nuclear growth scenario is highly unlikely in view of industrial capacity and economical demands. Yet, even at such a level, only 6% of the total emission reductions in the energy sector (i.e. 3.5% of the reductions in all sectors) would be brought about by increased use of nuclear power. This is far behind the contribution of energy savings (54%) and of that offered by renewable energy solutions (at least 21%).[2]

Nuclear power's effective contribution to greenhouse gas emission reduction has also been falling steadily since the 1980s. Obviously, the level of emission reductions that nuclear power brings about depends on the power sources it is assumed to be replacing. Using the overall worldwide electricity generation mix as a reference, reductions associated with nuclear power are 3.6% of global emissions and 10% of EU emissions in 2006, and 20% of French emissions in 2005. But, if assumed to replace a fleet of combined cycle gas power plants, these percentages fall to 2%, 7% and 15% respectively. If an increased level of renewable energy is added to the mix, these percentages become even less.

Nuclear power in France is very large, providing 79% of electricity produced in 2007, however electricity accounts for only 20.7% of the final energy consumption in France for this same year. Excluding electricity exports, the overall contribution of nuclear power to France's final energy consumption is only in the range of 14%.

If the real aim of the nuclear programme was to reduce oil dependence, then it has clearly failed in its objectives. Over 70% of France's final energy is provided by fossil fuels (oil, gas, coal), with oil accounting for 49% of the energy consumption in 2007. Nuclear power cannot provide energy security, as it only has a marginal effect upon oil consumption, which is dominated by the transport sector. France consumes more oil per capita than the European average, and despite its long-term objective to reduce greenhouse gas emissions by three-quarters, it seems incapable of bucking an upward trend. This is due largely to the weak policies on energy efficiency and new energy sources, influenced by the lock-in of nuclear power.

Analysis of official and alternative scenarios indicates that France's present energy policy will not enable it to comply with either European climate commitments for 2020, or its own commitments for 2050. Controlling energy demand and developing renewable energy are more crucial than maintaining the nuclear programme if France is to achieve its dual objectives of energy security and long-term greenhouse gas emission reductions.

Economics:
the underestimated costs of nuclear power

Official cost estimates for nuclear power tend to neglect or downplay hidden costs from the fuel cycle, waste management, decommissioning of nuclear facilities, security, infrastructural changes and state guarantees for liabilities. All in all, nuclear power poses an economic risk that is ultimately borne by the taxpayer.

image Greenpeace activists block the entrance of the French Ministry of Economics, Finance and Industry in 2005, where the international conference of the International Atomic Energy Agency 'Nuclear in the 21st century' is being held. They are highlighting the fact that nuclear power is expensive, dangerous and encourages nuclear weapons.

Nuclear power is claimed to be a key positive feature of French economics, both for contributing to national energy security and for providing abundant and cheap energy to French industry and households. Avoiding the costs of importing energy is one of the nuclear programme's major goals. However, though largely invisibly, French taxpayers bear a large part of the nuclear costs.

Drastically inflated forecasts of electricity consumption and a lack of timely adaptation in the planning and construction of nuclear power plants led to an overcapacity as early as the mid-1980s. The total installed power generating capacity reached 115,900 MWe at the end of 2007, of which nuclear power accounted for 63,300 MWe. The peak demand in 2007 was 89,000 MWe, while the minimum demand was as low as 31,600 MWe.

With this overcapacity, the wasteful use of electricity was stimulated, especially for electric heating in French houses, to improve the economics of French nuclear power plants. Even so, France's baseload electricity production capacity largely exceeds the domestic electricity use, and exporting electricity, therefore, became a means of paying for the stranded investment costs. EDF started long-term contracts of base-load electricity supply to Belgium, Switzerland, Germany, Italy, Spain and the UK in the mid 1980s, at low prices and offering a very high guarantee of supply.

Dubious claims by EDF and the French government of the profits made from these contracts have never been substantiated by commercial data. Independent assessments, in fact, show that the official income from exports does not cover the costs of nuclear generation in the first place. This indicates that power exports incurred major losses for France, estimated at between € 0.8 billion and € 6 billion per year through 1995 to 2001[3]. The prospect is not much better; base-load exports from France like nuclear energy are dropping, while the much more expensive peak-rate imports are rising. Additionally, nuclear power has not prevented France's energy costs from rising sky-high in the current oil crisis: the energy bill has risen from around € 10 billion in the early nineties to €44.8 billion in 2007 mainly due to expensive oil imports.[4]

A main factor in nuclear economics is the high capital costs of nuclear power plants as opposed to other energy sources. The French government – both the regulator of electricity prices and the dominant owner of EDF – has been able to plan at liberty the return of capital costs, and consequently overcome one of the main obstacles to the construction of nuclear reactors in deregulated economies. Given that the French state also owns the nuclear research body CEA and Areva, this framework has allowed for large public funding in support of the nuclear industry, from financing extensive R&D programmes to guaranteeing low-rate loans.

The true costs of nuclear power

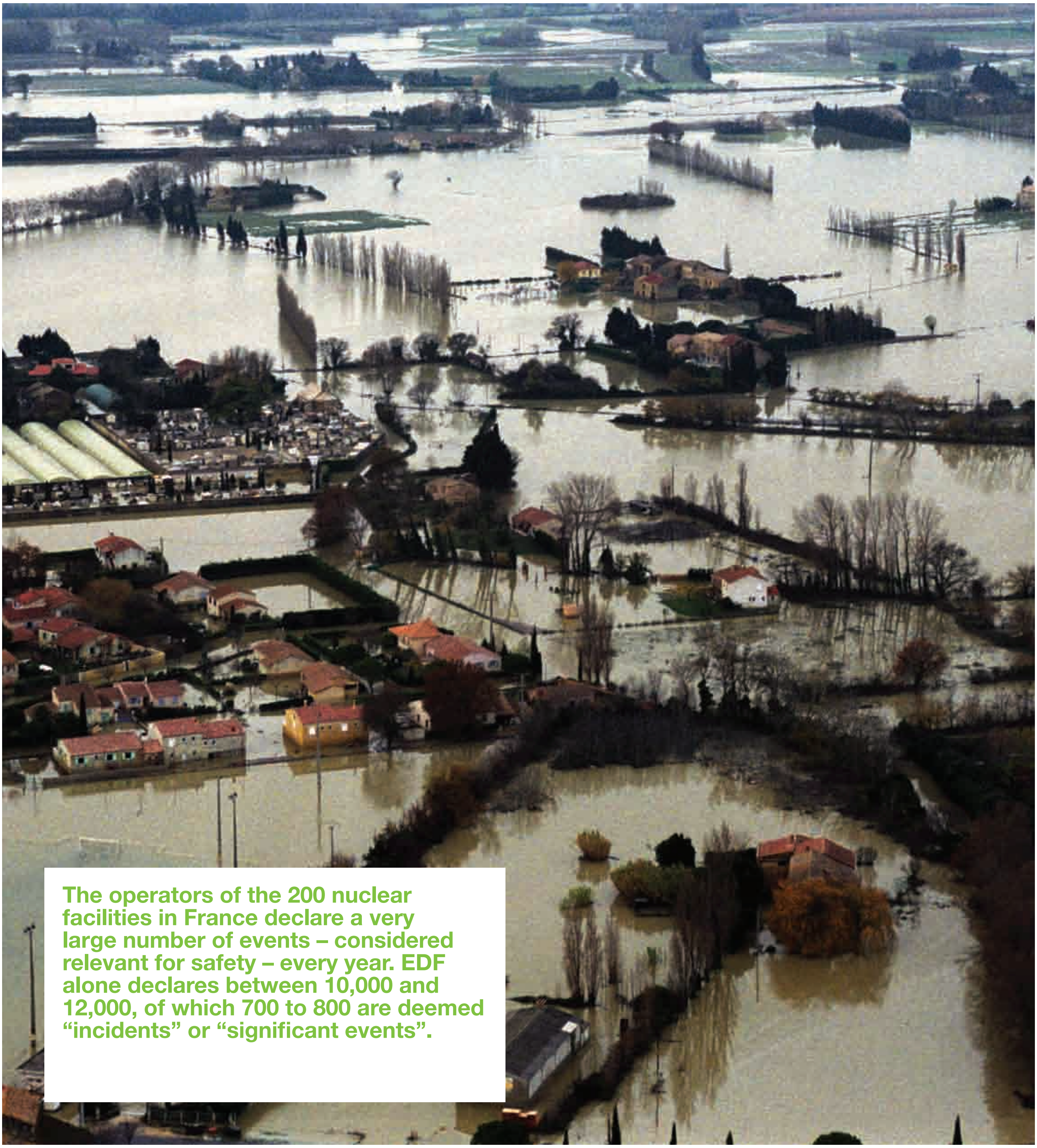
From the very beginning, the nuclear industry has promoted itself as one of the cheapest options for electricity. However, the true costs of nuclear power have been and still are systematically underestimated. Actual costs for construction and operation of nuclear power plants have almost always proved to be higher than those projected. Official cost estimates tend to neglect or downplay hidden costs associated with the nuclear industry. These include extra costs linked with the fuel cycle, waste management, decommissioning of nuclear facilities, security, infrastructural changes and state guarantees for risk liabilities. All in all, nuclear power poses an economic risk that is ultimately borne by the government and taxpayer.

Alongside investment costs, construction times have proven to be problematic. The last four reactors that were built in France, two units in Chooz and two in Civaux, were only connected on average 10.5 years after construction work began, and subsequent safety problems caused further delays. Their official industrial service only started in 2000 and 2002 respectively, some 15.5 and 12.5 years after construction started.

Cost estimates rarely include financial implications of waste management and decommissioning. Sticking with the reprocessing of spent nuclear fuel has a strong impact on projected costs for radioactive waste management in France. In 2003, Andra, the French agency for radioactive waste management, estimates a total cost for final waste storage of between € 15.9 billion and € 58 billion. Decommissioning cost estimates are constantly rising. In 2004, the overall long-term costs related to dismantlement of reactors in France for the three main nuclear operators, EDF, the CEA and Areva, was estimated to add up to € 65 billion.

Structural costs, for example to warrant safety and security, also factor in, but are difficult to grasp. In France alone, hundreds of millions are dedicated annually to public expertise and advisory work on radiation protection, nuclear safety and security issues, also providing for the nuclear safety authority ASN. On top of that, the costs of security forces required to protect nuclear facilities and transports must also be considered.

Safety:
lessons learned or lessons still to come?



The operators of the 200 nuclear facilities in France declare a very large number of events – considered relevant for safety – every year. EDF alone declares between 10,000 and 12,000, of which 700 to 800 are deemed "incidents" or "significant events".

image Aerial view of a flooded village near the Marcoule nuclear facility in southern France, 2003.

Numerous incidents have occurred in nuclear power plants over the years without triggering a major accident. This seems to have given the industry a feeling that the lessons learned from the accidents at Three Mile Island in 1979, and then Chernobyl in 1986 have improved nuclear safety up to an acceptable level.

However, these lessons came too late to bring in-depth modifications in the designs of the 58 reactors currently operating in France, since they were already planned for more than 25 years ago. If these were to be constructed today, they would not be regarded as sufficiently safe. Authorities have admitted since 1995 that the French nuclear fleet no longer meets evolving safety standards.[5]

Still these reactors are said to operate at an acceptable level of safety. The significance of incidents that may not have direct radiological consequences but represent a "near-miss" scenario is often not acknowledged. In reality, a closer look to incidents over the last 20 years reveals serious alerts concerning design faults, equipment failure, inadequate procedures and human errors. It also shows the weakness of the method used to predict the probability of a nuclear incident or accident. This approach separately considers the probability of certain events, but the possibility of those events taking place simultaneously is not sufficiently taken into account, as was seen in the Blayais-2 incident in 1999 (see Box) and in Forsmark, Sweden in 2006.

Many incidents highlight the puzzle of predicting, when designing a nuclear reactor, the whole range of probabilities of possible events during its entire lifetime. Particularly, the probability of severe climatic events now, such as long-term drought or heavy storms, must be reassessed to take into account the increasing risks of ongoing climate change. Progress in methods of assessing seismic hazards has already led to reassessments of safety implications of major seismic events at some nuclear sites.

In addition to these problems, the ageing of the French nuclear fleet and the increasing demands of profitability further boosts nuclear risks. The time is long gone when French official safety experts could pretend that the risk of a major accident was negligible. There are an amounting number of events at existing nuclear installations – the operators of France's 200 existing nuclear facilities already declare a very large number of events every year. As new potential events – such as those related to climate change or deliberate acts of malice - are identified, a worrying light is shed on the real safety level of the French nuclear industry.

A potted history of French nuclear near-misses

13 March, 1980: A defect of the cooling system on the gas-cooled unit of Saint-Laurent-A2, due to the fatigue of internal components, leads to the total fusion of two fuel elements and the partial fusion of two others. Molten fuel elements can reach the critical mass for an uncontrollable nuclear reaction, which would lead to a melt-down - the most severe accident in a nuclear power plant.

14 April, 1984: A defect in the design of electric cables linked to the control-command system at Bugey leads to a failure causing a complete blackout of one of the plant's units. The safe shutdown of the plant requires use of two diesel engines, one of which will not start when needed, leaving the second engine as the last and only safety line before a melt-down accident.

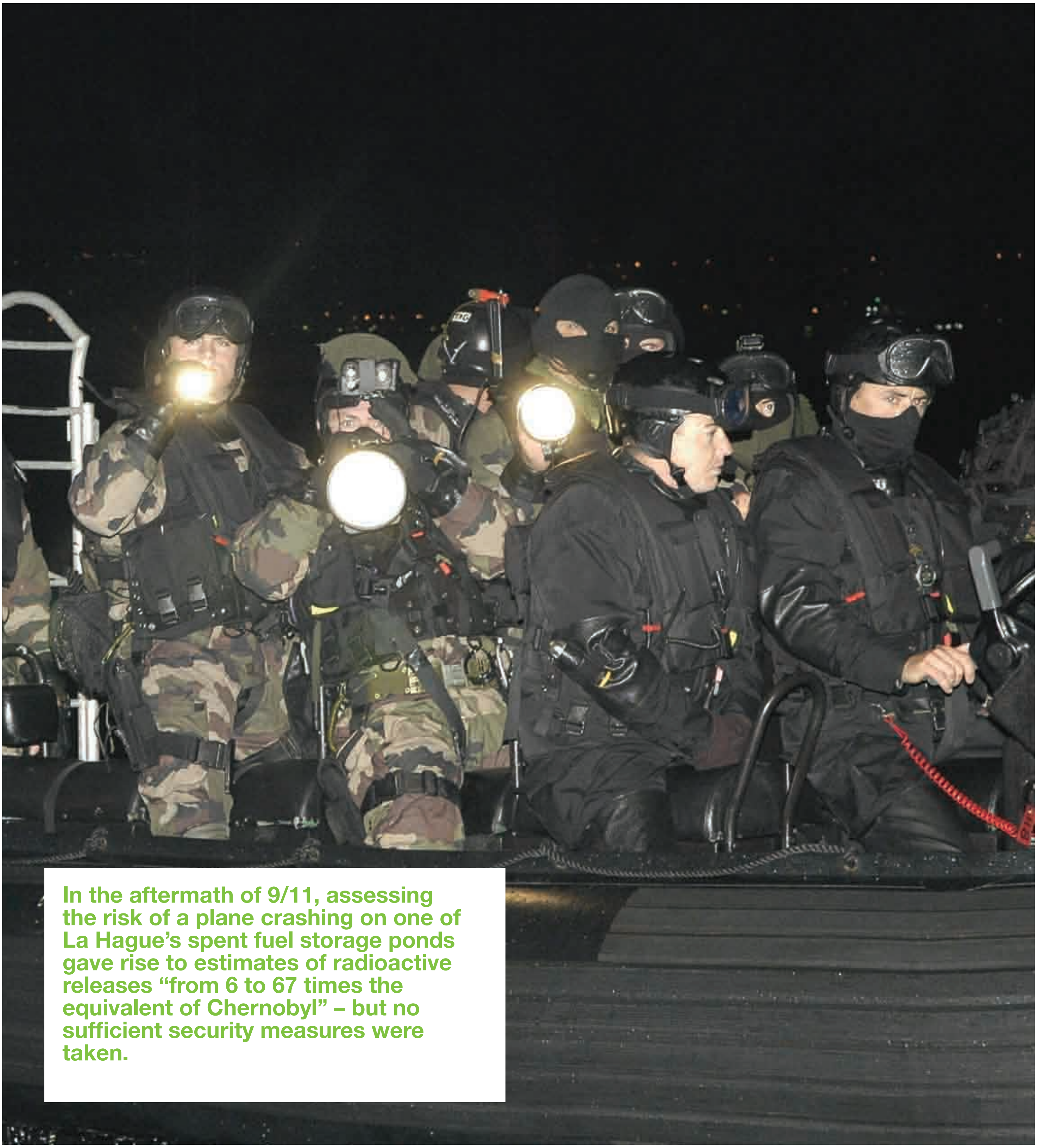
27 December, 1999: The unexpected strength of a storm leads to two critical conditions: the flooding of the Blayais-2 plant, and the loss of the external electricity supply, leading to an emergency shutdown while key safety equipment (injection pumps, containment safety systems) did not work and the storm made human intervention precarious.

21 January, 2002: Installation of inappropriate condensers at Flamanville-2 leads to the simultaneous loss of several control command boards and systems while the unit is operating, and to the destruction of two significant safety pumps during the shutdown process.

16 May, 2005: At Cattenom-2, sub-standard cabling leads to a fire in the electricity funnel, necessitating the disconnection of one of two safety circuits. Although the authorities trigger their emergency plans, details of the event are not published.

30 September, 2005: During a restart of the Nogent-1 reactor, material failures and human error leads to hot water and steam penetrating four rooms containing the control command boards of the reactor's protection system. Normally, these rooms should never be endangered simultaneously; in this case, it would have been difficult to ensure the safety of the reactor in case of any further accident. EDF and the ASN activate emergency plans.

Security:
secrecy and unpredictable scenarios



In the aftermath of 9/11, assessing the risk of a plane crashing on one of La Hague's spent fuel storage ponds gave rise to estimates of radioactive releases "from 6 to 67 times the equivalent of Chernobyl" – but no sufficient security measures were taken.

image French security guards a shipment of 140kg of weapons-grade plutonium that has just arrived from Los Alamos USA via several locations on a UK-flagged commercial nuclear cargo ship, the Pacific Pintail, Cherbourg, France, in 2004. Greenpeace believes the shipment unnecessary and highly vulnerable to accidents or deliberate attack.

Unlike accident scenarios, malicious acts are, by definition, intended to produce a significant level of damage. A key issue in nuclear risk assessment, therefore, is to identify threats by evaluating the interest of groups or individuals in targeting a nuclear installation and the means that could be employed. Again, the nuclear industry runs up against the fundamental problem that – while threats evolve over time – the degree of protection for installations is essentially fixed for their entire lifetime only at the point when they are actually being designed.

After the World Trade Center attacks on 11 September 2001, any scenario involving people prepared to sacrifice their lives has to be considered as plausible. Obviously, this includes the use of hijacked airliners to hit installations, which – whether reactors, fuel manufacturing, reprocessing or waste storage plants – have not been designed to withstand such an impact. Also the numerous transports of radioactive materials – transports of extremely radiotoxic plutonium cross France every week – form potential terrorist targets. Transport containers will not be able to withstand the impact of a rocket.

No public evaluation exists of the potential consequences of an airliner crashing into one of EDF's 58 reactors. Following an independent assessment in the debate aroused by 9/11 on the potential consequences of such a crash on the spent nuclear fuel ponds at the reprocessing facility in La Hague, IRSN concluded that it could bring about the release of up to 10% of the radioactive inventory of the fuel in one pond. Only 1.5% of the caesium contained in one fuel pond corresponds to the caesium released during the Chernobyl accident.[6]

However, this is not the only scenario that needs to be taken into account; intruders must also be considered, as must insider collusion. Several incidents have shown how vulnerable nuclear installations are – one of which, at the Bugey power station in 2003, went largely unnoticed. In June 2003, during a strike at the plant, the closing of a hatch triggered a sequence of security system activations culminating in the automatic shutdown of unit 2; such an action is potentially very dangerous if the perpetrator intended to cause serious harm.

The large variety of nuclear installations throughout the nuclear chain make it even more complicated to develop a thorough assessment and control of all relevant risks in all facilities. The French decision to develop reprocessing and plutonium re-use resulted in more manipulation, transport and storage of more dangerous materials – all of which could be at risk of malicious acts.

In France, a major problem with nuclear security is secrecy – the authorities use secrecy as a pretext for creating a heightened level of security, while the problems in the industry are not addressed. As the French Nuclear Safety Authority explained in 2001, counter-terrorist protection methods cannot, by their very nature, be publicly communicated.[7] Having become the first line of defence, in the eyes of the industry secrecy must be protected at all costs. No internal analysis is disseminated, and any external criticism is immediately denounced as playing into the hands of potential terrorists. More worrying, it also blocks any democratic debate on the nuclear and security issue.

EPR: 60 years of risky future

The EPR (European Pressurised Reactor) is a new reactor, developed jointly by France and Germany, which will contain more radioactive materials in its core than any operating reactor. Consequently the waste it produces is more radioactive and harder to contain. Although the EPR seeks to reinforce safety by adding supplementary features, it does not deeply review fundamental design. Therefore, it is based on the assumption that it would be possible to identify and incorporate, at the time of conception, the whole range of internal and external events that could happen throughout a reactor's entire lifetime – in the case of EPRs, projected to be 60 years.

Secrecy about its resistance to new terrorist threats is considered more important than discussing how to address these threats better at the design stage. A study carried out on resistance to an airliner crash outside of the design process has not been made publicly available. EDF simply stated that the EPR would be capable of withstanding most airliner crashes. A leaked provisional confidential document confirmed that this did not mean "all crashes"[8]; in other words, depending on the type of "crash", the EPR may not be able to withstand the kinetic shock. Finnish authorities required additional strengthening of the containment, as they did not consider the original design sufficiently robust.

No information exists regarding evaluation of the combined effect of impact and heat, or many other threats. Conceived at the end of the 20th century, the EPR does not seem ready to face the dangers of a new century ushered in by the collapse of the Twin Towers in New York.

Waste and decommissioning:
complex issues, unresolved problems

Reprocessing creates extra safety risks by increasing the complexity of waste management, so the industry's claim of reducing waste volumes is misleading.

image Greenpeace activists demonstrate their opposition to the transportation of plutonium in Cherbourg harbour in 2001, beside the ship Pacific Pintail, which was due to take MOX fuel to Japan.
©Greenpeace / Morgan

Large amounts of radioactive waste arise from the French nuclear programme. In total, close to 890,000 m^3 of radioactive waste had been produced by the end of 2004[9]. Almost 40% of this amount is linked to reprocessing. This total does not account for some 12,000 m^3 of waste from the reprocessing plant in Marcoule that was dumped into the sea in 1967 and 1969. Neither does the inventory include any of the “reusable materials” currently in stock – thousands of tonnes of spent nuclear fuels stored at La Hague, separated plutonium and uranium, scrap MOX – nor the two cores of the closed fast-breeder reactor in Creys-Malville, still stored on the reactor site.

Radioactive waste management presents a very complex issue. There are always large volumes of long-lived low level waste such as uranium mill tailings and depleted uranium to deal with. In the case of direct disposal of spent fuel from a nuclear reactor (without further reprocessing), there is basically one type of high-level waste to deal with – spent fuel assemblies – and one type of intermediate-level waste – irradiated reactor components.

In France, where spent nuclear fuel is reprocessed after use, many more waste streams need to be considered. Firstly, there is the hazardous high-level vitrified waste from the reprocessing itself, containing long-lived and highly radioactive isotopes. In addition, there are different types of intermediate-level wastes: process waste, such as sludge from liquid effluent, and structural wastes, such as hulls and nozzles from fuel assemblies. If the separated uranium and plutonium recovered from spent nuclear fuel are re-used, even more new irradiated material and waste streams are produced, each with their own characteristics and hazards.

While reprocessing is presented as a means to reduce the volume of highly-radioactive long-lived wastes in final disposal, it actually increases the complexity of waste management, and thereby the danger for the population and environment. Reprocessing comes with numerous extra nuclear facilities and transports, each creating extra safety risks. But also ‘normal’ radiation exposure arising from routine operations increases, for example by the radioactive discharges of La Hague reprocessing plants, with authorised discharge levels up to 1000 times higher than those applying to the nearby Flamanville nuclear power station.

And even France, the country of nuclear expertise, has no long-term solution for its nuclear wastes. Meanwhile, its radioactive waste inventory grows in both size and complexity, which goes hand in hand with increased risks. Large quantities of waste are accumulating in often inadequate storage conditions, while decisions regarding long-term management of French radioactive waste still remain to be taken.

A second long-lived legacy

Waste isn’t the only legacy of nuclear technology. The difficulties encountered during the dismantling operations at the end of a nuclear installation’s useful life give little grounds for optimism. The theoretical goal of dismantling is to get a site “back to grass”– in other words, removing every last trace of the installation, and returning the land it occupied to unrestricted use. There are no existing examples of large-scale dismantling operations that have been carried through to this stage successfully.

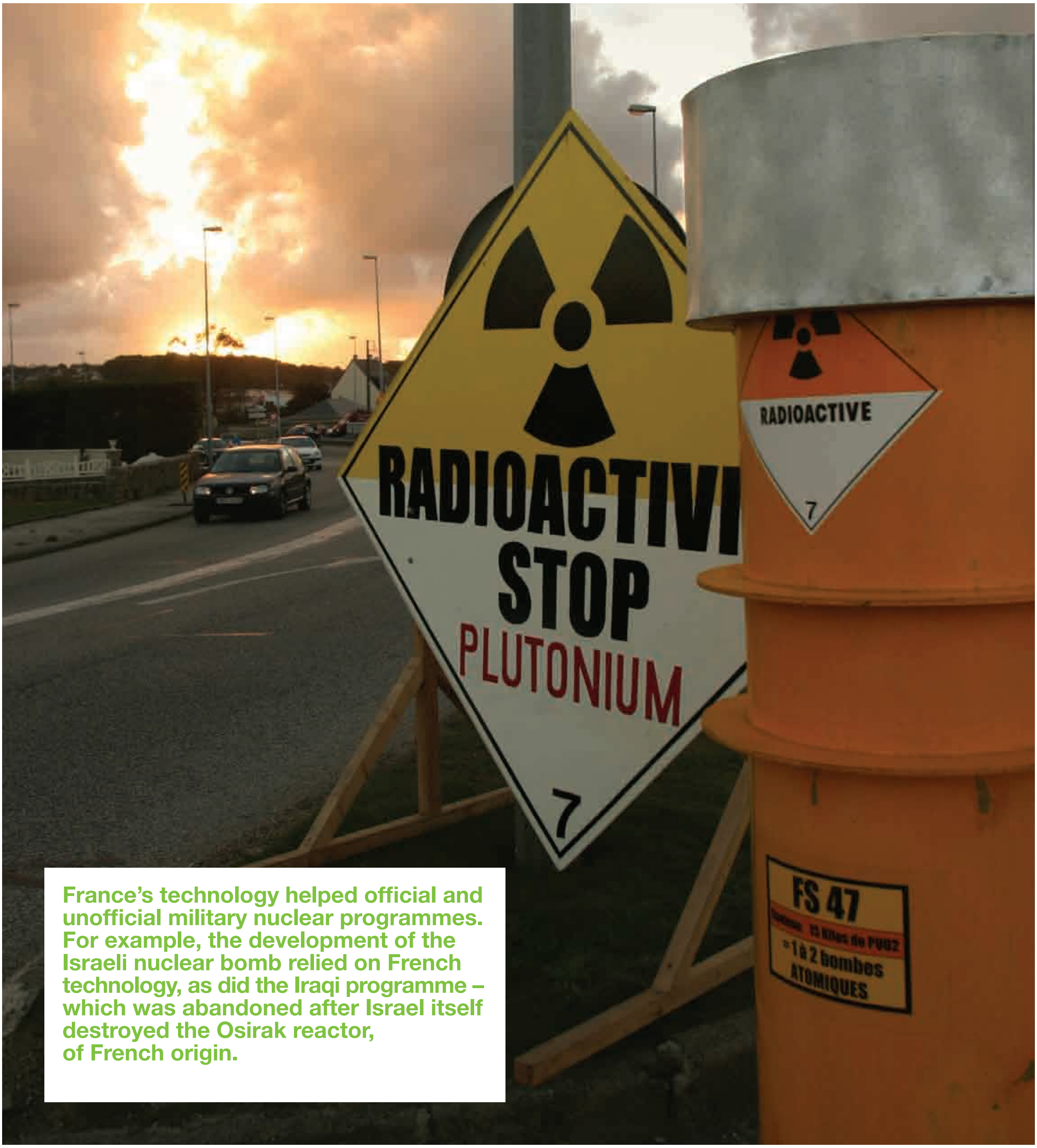
The dismantling of the Brennilis heavy water reactor, for example, was rife with problems. Initial demolition was halted, and the process revised, when it was discovered that the concrete base was harder than anticipated. Inspections regularly highlighted problems and, at the end of 2007, the Council of State cancelled the decree authorising the reactor’s final shutdown.

At the Superphénix fast-breeder reactor in Marcoule, shut down in 1997, inert rods had to replace, one by one, the fuel rods extracted from the reactor’s core, to maintain its geometry and avoid the danger of collapse. With work not anticipated to be complete until 2027, the most delicate stage is being carried out at present; the emptying of approximately 5,500 tonnes of liquid sodium from the cooling circuit and back-up reservoirs. This product is highly inflammable and explosive upon contact with air and water. Previously, 0.1 tonne of liquid sodium being emptied from the Rapsodie breeder reactor prototype caused an explosion that lifted up a concrete slab weighing several tens of tonnes and resulted in the death of an operator.

In 2006, the Cour des Comptes assessed the cost of dismantling Brennilis at €482 million (20 times the sum originally envisaged by the reactor’s developers). At the end of 2004, the estimated overall long-term costs related to dismantlement for the three main nuclear operators, EDF, the CEA and Areva, is as high as €65 billion.[10]

Projected costs invariably increase as the beginning of the work approaches, and actual costs increase once work has begun. Only in 2006 did France commit to a dedicated mechanism intended to build up and safeguard the necessary future financial provisions. But, while dismantlement becomes increasingly important, and as more and more difficulties arise, France’s policy on the issue is still not fixed, and the real problems may only just be beginning to appear.

Proliferation:
putting the world at risk



France's technology helped official and unofficial military nuclear programmes. For example, the development of the Israeli nuclear bomb relied on French technology, as did the Iraqi programme – which was abandoned after Israel itself destroyed the Osirak reactor, of French origin.

image Signs and barrels with radioactive symbols at roadside Cherbourg, France, 2004. The road will be used for transporting the dangerous cargo, which Greenpeace believes is highly vulnerable to accidents or deliberate attack.

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The risk of proliferation – the uncontrolled spread and misappropriation, for military or terrorist purposes, of nuclear infrastructure, technologies and materials – is rarely a subject of debate where French nuclear export projects are concerned.

Public opinion and political decision-makers, anxious about the risk of nuclear arms escalation at the global level, disconnect the issue from the development of the French nuclear industry. For example, few French people know that, since 1974, Iran has had, and still has, a 10% share in the Eurodif uranium enrichment plant at Tricastin; in the midst of the Iranian enrichment crisis, when this state of affairs was recalled in detail in a report on proliferation[11], the matter was largely ignored by politicians and the national media.

In the past, French technology has helped to develop official or unofficial military nuclear programmes (for example in Israel, Iraq and South Africa). Today, President Sarkozy is willingly acting as a salesman for the French nuclear industry. He has pursued a policy of actively promoting nuclear reactors, reprocessing and enrichment facilities in countries in North Africa and the Middle East, and now he expands the French nuclear market to China, India and Latin-America. The President and his government seem to consciously ignore a connection between this policy of encouraging the development of nuclear power in some of the most unstable parts of the world, and the problem of proliferation.

France's attitude in this respect is all the more open to criticism given that the choice for nuclear power in some of the countries concerned is questionable. A reactor such as the EPR is too large for the needs and grid capacities of countries like Jordan and the UAE – both of whom have entered into nuclear cooperation agreements with France. These countries undoubtedly have access to other energy options more in keeping with their capacities and needs, and without the collateral risks.

Aside from Jordan and the UAE, France also signed nuclear agreements with Algeria, Morocco and Tunisia. All of these countries lack a solid regulatory system for control and inspection of nuclear safety and security. Still, opinion was only aroused for the first time when France offered to deliver an EPR reactor to Libya, with Colonel Gaddafi being received with great ceremony at the Elysée Palace in autumn 2007 to sign the agreement between the two countries.

The real intentions of both France and its new nuclear partners are bound to raise concerns. Also, the international community should recognise the potential for political destabilisation in these countries, including the risks of sensitive material or equipment falling into the hands of terrorist groups or the control of installations being seized by hostile political movements.

Plutonium Stockpiling

The total quantity of civil plutonium stored in France, in all forms, stood at 294.2 tonnes at the end of 2006[12], and has probably exceeded 300 tonnes since then. This includes unprocessed plutonium in the stock of irradiated fuel stored to await future reprocessing, and separated plutonium.

The IAEA estimates that the "significant amount" of plutonium (taking into account the conversion processes necessary) from which production of a bomb can no longer be technically ruled out is 8.5kg. The stock of plutonium at the reprocessing facility in La Hague – in oxide powder form – is around 50 tonnes; equivalent to nearly 5,900 bombs. EDF, the main producer of separated plutonium in the world, has stock of 26 tonnes unused plutonium powder at La Hague alone.

The nuclear industry has long allowed this plutonium stock to build up. By ignoring this aspect of proliferation, while promoting the expansion of reprocessing internationally, the French authorities and nuclear industry are sending out an extremely dangerous message to the rest of the world.

Conclusions

Greenpeace's conclusions based on the Global Chance report

Climate policies

France's structural overcapacity of nuclear power presents an obstacle to the development of renewable energy and energy efficiency measures. France is trapped in a nuclear "quicksand", causing the country to seriously fall short on policies for energy efficiency and clean energy solutions.

Energy security

Its nuclear programme did not reduce France's oil dependence. Nuclear power contributes only about 14% to France's final energy consumption, while France consumes more oil per capita than the European average. Controlling energy demand and renewable energy are more crucial in achieving energy security and greenhouse gas emission reductions than nuclear energy.

Economics

Though largely invisibly, French taxpayers bear a large part of the nuclear costs. The French government, as both the regulator of electricity prices and the owner of the utility EDF, has been able to overcome the main obstacle to nuclear power by planning, at liberty, the return of capital costs from nuclear investments. French public funding is widely supplying for the nuclear industry, from financing extensive R&D programmes to guaranteeing low-rate loans.

Safety

New potential events are identified, related to climate change or deliberate acts of malice, shedding a worrying light on the safety level of the ageing French nuclear installations. The French nuclear industry, which includes every step of the fuel chain, brings about a wide range of safety hazards. The operators of France's 200 nuclear facilities declare a very large number of events every year; EDF alone declares 10,000 to 20,000 events, of which 700 to 800 are deemed 'incidents' or 'significant'.

Security

Nuclear installations – whether reactors, fuel-manufacturing, reprocessing, waste storage plants or transports – have not been designed to withstand the impact of the use of hijacked airliners. A plane crashing on one of La Hague's spent-fuel storage ponds can cause radioactive releases more than 6 times the equivalent of Chernobyl. At the same time, secrecy blocks any democratic debate on the issue. Also, the EPR does not seem ready to face the new dangers; the lessons of 9/11 have not led the authorities to review basic design requirements.

Waste

France, the country of nuclear expertise, has no long-term solution for its nuclear wastes. Its radioactive waste inventory keeps growing in size (890,000m^3 by 2004) and complexity. Reprocessing, presented as reducing the volume of highly-radioactive wastes, instead increases the complexity and danger of waste management. Dismantlement of nuclear installations is also set to cause major, but as of yet unappreciated, costs and problems.

Proliferation

France is dramatically worsening the problem of proliferation of nuclear weapons by its policy of promoting nuclear power in some of the most unstable parts of the world. France sends out an extremely dangerous message to the rest of the world by ignoring the build up of a large stockpile of plutonium - a key component in nuclear weapons - while promoting the expansion of reprocessing internationally.

Greenpeace recommendations

We should learn our lessons from the failures of the French nuclear industry, and push for a renewable energy future:

- Divert state funding for energy research into nuclear and fossil fuel energy technologies towards clean, renewable energy and energy efficiency
- Set legally-binding targets for renewable energy
- Adopt legislation to provide investors in renewable energy with stable, predictable returns
- Guarantee priority access to the grid for renewable operators
- Adopt strict efficiency standards for all electricity-consuming devices

Global Chance

About Global Chance

This Greenpeace briefing is based on the report produced by Global Chance, 'Nuclear power, the great illusion: promises, setbacks and threats' (French title: 'Nucléaire: la grande illusion – Promesses, déboires et menaces')*. Global Chance is a non-profit organisation gathering scientists and experts who share the strong belief that a better balanced development of the world can and must arise from growing awareness of the threats weighting on our global environment.

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12 According to France's latest official declaration to the International Atomic Energy Agency (IAEA).

Greenpeace is an independent global campaigning organisation that acts to change attitudes and behaviour, to protect and conserve the environment and to promote peace.

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