NUCLEAR POWER:
MYTH AND REALITY

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Nuclear Power – Myth and Reality

The risks and prospects of nuclear power

Nuclear Issues Paper No. 1

BY GERD ROSENKRANZ

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1 Introduction

The deep divide over nuclear power is nearly as old as its commercial use. The early dreams of its proponents have faded, whereas the high risks have remained, as well as the danger of misuse by military interests. Terrorism has introduced dramatic, concrete threat. Global warming and the finite nature of fossil fuels do not dispel the major safety issues associated with nuclear power. And the "accident-proof" reactor has remained an unfulfilled promise now for decades.

Artificial warming of earth's atmosphere will surely pose one of the greatest challenges of the 21st century. But there are less hazardous ways to deal with this problem than by using nuclear power. Nuclear power is not sustainable, because its fissile fuel materials are as limited as fossil fuels such as coal, oil and natural gas. Moreover, its radioactive by-products must be isolated from the biosphere for periods of time that defy human imagination.

Nuclear energy is not only a high-risk technology in terms of safety, but also with respect to financial investment. Without state subsidies, it does not stand a chance in a market economy. Yet companies will continue to profit from nuclear energy under special, state-controlled conditions. Extending the licences of older reactors is an attractive option for operators – but disproportionately increases the risk of major accident. And there will always be regimes that view and promote civilian use of nuclear fission as a stepping stone to acquiring an atomic bomb. Moreover, as has been clear since 11 September 2001 at the latest, these vulnerable and very hazardous sites represent an additional target for unscrupulous and violent non-governmental forces. For this reason as well, nuclear power will continue to divide public opinion for as long as it remains in use.

2 A reminder: The persistent risk of forgetting

Events late in the evening of 10 April 2003 in the fuel assembly storage tank of the nuclear power plant in Paks were reminiscent of two incidents that have filled the history of civilian nuclear power with foreboding, namely the nuclear disasters at Harrisburg in March of 1979 and at Chernobyl in April of 1986.

Inexcusable design flaws, sloppy monitoring, incorrect operating instructions, poor judgment under stressful conditions, and not least of all, a naive trust in highly sensitive technology – all of these problems were well known before that Thursday evening in Hungary, not only from Harrisburg and Chernobyl, but also from the reprocessing plant at the British site in Sellafield, from the Monju breeder reactor, from the Japanese reprocessing plant in Tokaimura, and from the German Brunsbüttel plant on the Elbe River. Wherever people work, they make mistakes. And they can be fortunate that the chain of errors, invariably labelled "inexplicable", does not always produce consequences as grave as for the Ukraine and its neighbours back in 1986. In block 2 of the Paks nuclear power plant, which is located 115 kilometres south of the Hungarian capital Budapest, damage remained at the level of overheating and destruction of 30 highly radioactive fuel assemblies that were transformed into a radiating mass on the floor of a steel tank flooded with water. It remained at the level of a massive release of radioactive inert gas that flowed into the reactor room, from which the operators had fled in panic, and which was later blown unfiltered into the outside air at full ventilator strength for a good 14 hours to make the room accessible to personnel in radiation protective gear.

The name Paks stands for the most serious accident at a European nuclear reactor since Chernobyl. Moreover, the highly radioactive material was overheated outside the concrete-walled safety containment. Beyond the borders of Hungary, however, the world took hardly any notice of a nascent nuclear inferno brewing inside a mobile cleaning facility for fuel elements. To their horror, the Hungarian and foreign specialists who reconstructed the chain of events later that night realised that the outcome could have been much worse. The lack of worldwide concern about the accident at Paks was not the only new part of the story. This dramatic incident represented yet another premiere. For the first time, Western and Eastern European reactor teams had jointly and virtually single-mindedly caused a serious failure via a cascade of nonchalance, management error, and careless routine. Participants included design engineers and operators from the German/French nuclear energy group Framatome ANP (a subsidiary of the French Areva and the German Siemens corporations), operating teams at the Soviet-style nuclear power plant in Paks, and experts from the Hungarian nuclear regulatory authority in Budapest. They are all partially responsible – and got off lightly.

The 30 fuel assemblies, which constituted about a tenth of a full reactor core load, did not cool down sufficiently following the chemical cleaning process. They first brought the cooling water in the cleaning tank to a boil, then boiled off all the water, heated up to 1200 degrees Celsius, and finally crumbled like porcelain as the overtaxed operators, after failed attempts to circumvent a catastrophe, unleashed a torrent of cold water on them. According to reactor physicists, a nuclear explosion could have occurred, i.e. a limited but uncontrolled chain reaction. This would have had disastrous consequences for the vicinity of Paks and beyond.

3 Safety: The crucial issue for nuclear power

Proponents of nuclear energy are visibly pleased that debate over its use has subsided. Influenced by climate change and the explosion in oil prices, the tone has become more "sober and composed". Friends of nuclear-based electricity production are especially gratified about one thing: Discussion of nuclear policy has shifted from the fundamental problems of safety and security to issues associated with the economy, environmental protection, and resource conservation. They would like to see a shift in public opinion toward viewing nuclear power as one technology among many, to be weighed like coal-fired power plants or windmills. Nuclear fission is settling into the triangle that economists use to frame the debate on energy policy, namely economic feasibility, reliable supply, and environmental compatibility. Its supporters are not particularly disturbed by the fact that even within this framework, many questions remain about the advisability of nuclear power. They are pleased. As far as they are concerned, the main point is that it has become increasingly possible to conceal nuclear energy's unique potential for catastrophe beyond a wall of arguments that distract from the basic issues of safety and security. This development is no coincidence. It is the result of a deliberate and tenacious strategy pursued for years by operators and vendors in the major nuclear power-producing countries.

Successful diversionary tactics may calm public debate. But they do not reduce the probability of a major disaster. The risk of a major accident, i.e. one that exceeds the greatest anticipated accident that the safety system is designed for, combined with the fact that it can never be excluded, will always remain the primary source of conflict about nuclear energy. It is ultimately the basis for all arguments against this form of energy conversion. Acceptance – regional, national, and global – stands or falls with it. Since Harrisburg, and even more so since Chernobyl, the nuclear industry has held out the promise of accident-proof nuclear reactors in an effort to regain public acceptance. A quarter of a century ago, reactor builders formulated this promise in the coded terms of an "inherently safe nuclear power plant". The Americans called these future plants "walk-away" reactors, claiming that the possibility of a core melt or similarly serious accident could be physically excluded. "Even if the worst of all conceivable accidents takes place," enthused the vice president of a US reactor vendor at the time, "you could go home, eat lunch, take a nap, and then return to take care of it – without the slightly concern or panic."[1] This grandiose statement has remained today what it was then – an unredeemed pledge against the future. In 1986, the German historian of technology Joachim Radkau was already suggesting that the accident-proof nuclear power plant was "a pie in the sky produced in times of crisis but never achieved.[2]

The European Atomic Energy Community (Euratom) and ten countries that operate nuclear power plants already speak in neutral terms of "Generation IV" when they address the future of reactor technology. This next but one series of reactors, furnished with innovative safety systems, is no longer said to be idiot-proof like its forerunners that never materialised. But it is supposed to be more economical, smaller, less susceptible to military misuse and consequently more acceptable to public opinion. The first reactors of this series are supposed to start providing electricity around the year 2030. That is the official version. Unofficially, even some of the more prominent backers do not expect

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[1] Cited in Peter Miller, "Our Electric Future – A Comeback for Nuclear Power", in National Geo*graphic*, August 1991, p. 60ff. Retranslated from German.

[2] "Chernobyl in Deutschland?" in *Spiegel* 20/1986; pp. 35-36

commercial operation to start "until 2040 or 2045".[3] This promise for the future fatally recalls that made by fusion researchers. Back in 1970, they predicted that nuclear fusion, i.e. a controlled fusion of hydrogen atoms like that which transpires in the sun, would be generating electricity by the year 2000. Today, no one is saying anything about commercialising nuclear fusion before the middle of the 21st century – if at all.

By promising a fourth generation of reactors without *absolute* safety, the nuclear industry has quietly abandoned its past guarantees. In the meantime, routine discussion is even satisfied with *relative* safety, specifically the blanket assertion improperly understood but gladly repeated by non-specialists that "our nuclear power plants are the safest in the world". The veracity of this statement – especially popular in Germany – has not really been substantiated. Nor is it especially plausible that nuclear power plants whose construction was launched in the 1960s and 1970s, which means they were designed on the basis of knowledge and technology from the 1950s and 1960s, can in fact provide an adequate level of safety. But as long as no one prevents the advocates of nuclear power in France, the USA, Sweden, Japan, and South Korea from claiming exactly the same thing about their own reactors, everyone is satisfied. There is no national "nuclear community" that does not place its own power plants at the forefront of world technology – or at least publicly claim this distinction. In Eastern Europe as well, claims circulate with ever greater frequency that the retrofitting programs of the past 15 years have boosted Soviet-style reactors up to Western safety standards and in certain respects even beyond. For example, they are said to be less sensitive to failures in the reactor's physical processes. There is no need for formal agreement on these official versions. The common message is that there is no reason for alarm.

And the level of alarm is indeed declining, both nationally and internationally. The crucial question therefore remains the price that humanity is ready to pay for this calm on the nuclear front. What does it mean for international reactor safety if near-disasters like that at Paks are only discussed among closed circles of specialists? Advocates of nuclear power have even been known to ascribe the comparatively high level of safety at German plants to, among other things, the strength of the anti-nuclear movement in West Germany and a stubbornly sceptical attitude toward reactors on the part of a well-informed public. According to this view, probing queries and the growth of "critical informed public opinion" were what enabled nuclear plants to acquire the most sophisticated safeguards against accidents and incidents in the history of technology, which they still have today. If this is so, however, the converse might apply as well. If public awareness declines, so too will safety.

Twenty years after Chernobyl, what does a realistic safety review now look like? After the surge in attention to risks following the core melt in the Ukraine, have real advances been made in reactor safety? Or is the opposite the case, namely is the next major accident already in the cards?

Nobody can deny that the nuclear sector, like everything else, has benefited from general advances in technological development. The revolution in information and communications technology that has occurred since most of the world's commercial reactors were built has made control and monitoring processes clearer, and routine operations more reliable. When the older plants still operating today were being designed, computers were still at the punched-tape stage. Modern control systems have been and are being retroactively installed into many plants, including older ones. Computer simulations and experiments can shed light on the physics and other complex factors in normal

[3] Then EDF President Francois Roussely on 23 November 2003 to the Economic and Environmental Committee of the French National Assembly, cited in Mycle Schneider, *Der EPR aus französischer Sicht. Memo im Auftrag des BMU*, p. 5.

reactor processes, all the more so in the event of malfunctions. These days, reactor operators use their simulators to practice accident responses that could not even be modelled twenty or thirty years ago – some of which were not even known. Safety technicians also benefit from advanced probability analyses and further developments in testing and monitoring systems, which are gradually being retrofitted into older plants as well.

Reactor operators are also determined to learn from the mistakes of the past. They point to the founding of the World Association of Nuclear Operators (WANO), which organises an exchange of information as well as rapid transmission of accident data to its members. Operators can make use of experience from over 11,000 reactor operating years worldwide. But this is no assurance of a "new level of safety" for nuclear power plants. The fact that there have been no accidents involving core melts since Chernobyl and Harrisburg does not mean that they cannot happen again. Paks was the sharpest reminder in recent years. Approximately three out of four reactors currently in use were also operating back in 1986. The nature of probability calculations is precisely that a serious accident can happen today, or not until one hundred years from now. Eleven thousand reactor operating years are therefore no evidence to the contrary. When the nuclear industry suffered its first core melt at the Harrisburg commercial plant in 1979, antinuclear protesters in southern Germany distributed flyers that mocked the engineers' big safety assurances with bitter irony: "An accident only once every 100,000 years – how quickly time flies!"

Managers such as Harry Roels, the CEO of the German energy group RWE, call efforts to extend reactor licences around the world "completely tenable in terms of safety technology".[4] And Walter Hohefelder, CEO of the nuclear power plant operator E.ON Ruhrgas and president of the German Atomic Energy Forum, explained in all seriousness that extending reactor licences makes "electricity supply more secure".[5] The astonishing thing about such statements is that large segments of the public no longer question them. For reactor operators to convey the impression that nuclear power plants – in contrast to cars or airplanes – become safer with age is an audacious undertaking. Not only does common sense mitigate against it, but also unfortunately the laws of physics.

The global reactor fleet is "ageing". This innocuous term is like a facade that covers an entire edifice of expertise about material and metal technology. These disciplines do not just deal with simple "wear", but rather with highly complex changes to the surface and the substance of metallic materials. These processes and their consequences are very difficult to calculate on an atomic level. It is also very difficult for monitoring systems to identify them reliably, and above all promptly, when high temperatures, strong mechanical loads, aggressive chemical environments and ongoing neutron bombardment from nuclear fission are all working simultaneously on components that are crucial to safety. Corrosion, radiation damage, and fissuring of both surfaces and the welded seams of central components have all taken place over the past decades. Serious accidents are often avoided because damage is discovered in time by monitoring systems or by routine checks during down times and repairs. Sometimes these discoveries are made purely by chance.

We must also consider the effects of deregulated electricity markets in many of the countries that have nuclear power plants. Deregulation leads to higher "cost awareness" in every individual plant with very concrete consequences, such as personnel layoffs, longer intervals between checks, and shorter deadlines with the attendant time pressure for repairs and fuel rod replacements. None of this enhances safety.

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[4] *Frankfurter Rundschau*, 12 August 2005, p.11
[5] *Berliner Zeitung*, 9 August 2005, p. 6

In summary, if reactor operators have their way and succeed in having plant licences extended to 40 or even 60 years, the current worldwide average reactor age of 22 years will double or even triple in the future. This will substantially increase the overall risk of serious accident. Constructing new plants of the so-called "Generation III" will change little. For decades, they will make up only a small percentage of the world's reactor fleet. And they are not physically immune to serious accidents either. Critics say that the European Pressurized Water Reactor (EPR) under design since the late 1980s, for example – whose prototype is being built in Finland – is a half-hearted further development of the pressurized reactors operated in France and Germany since the 1980s. The EPR is designed to stem the consequences of a core melt by means of a sophisticated containment unit ("core catcher"). Because this design entails considerable extra costs, the dimensions had to be progressively enlarged in order for the plant to be more economical than its predecessors at least. Whether the containment, which is based on standards from the latest German series (KONVOI), could withstand the deliberate crash of fully tanked passenger jet remains at least open to question.

Not even reactor operators believe that greater operating experience and the longer operating lives of individual plants reduce the likelihood of serious accident. At a 2003 meeting of the World Association of Nuclear Operators (WANO) in Berlin, participants listed eight "serious incidents" in the preceding few years that had raised concern – albeit primarily among reactor experts alone, as was the case with the above-discussed accident in Paks. The list of incidents with potentially disastrous results included the following:

- Leaks on the control rods of the newest British reactor Sizewell B (started operating in 1995);
- Insufficient boron concentration in the emergency cooling system of the Philippsburg-2 reactor in Baden-Württemberg;
- Fuel assembly damage of a type never seen before, in block 3 of the French Cattenom power plant;
- A serious hydrogen explosion in a pipe at the Brunsbüttel boiling water reactor, in the immediate vicinity of a reactor pressure vessel;
- Massive corrosion on a reactor pressure vessel at the Davis-Besse plant in the USA, long overlooked, where only the thin stainless steel liner prevented a massive leak;
- Falsification of safety data at the British reprocessing facility in Sellafield;
- Similar data falsification associated with the Japanese operator Tepco

These types of incidents and negligence – and especially their greater frequency in the recent past – are making operators noticeably more worried and problem-conscious than political advocates of a renaissance in nuclear energy. Those in charge of running the reactors fear the consequences of a phenomenon deeply rooted in human nature, namely susceptibility to the gentle poison of routine, which makes it nearly impossible to perform the same activities over years with the same maximum degree of concentration. At the WANO conference in Berlin, speakers complained not only about the considerable financial consequences of malfunctions (around 298 million US dollars by October 2003 for the incidents in Philippsburg, Paks, and Davis-Besse alone; 12 of the 17 boiling water reactors run by the Japanese operator Tepco were shut down in connection with data falsification investigations), but even more so about carelessness and complacency by operators. Both "threaten the continued existence of our business",[6] warned a Swedish participant at the expert meeting. The Japanese president of WANO at the time, Hajimu Maeda, even diagnosed a "terrible malaise" that threatened the business from within. It starts with the loss of motivation, complacency, and "carelessness in upholding a culture of safety due to severe cost pressures resulting from deregulated electricity markets." This malaise must be acknowledged and countered. Otherwise at some point "a serious accident... will destroy the entire industry".[7]

[6] *Nucleonics Week*: 6 August 2003. Retranslated from German.
[7] *ibid*.

4 Suicide attacks: A new dimension of threat

The preceding considerations have not addressed the new dimension of threat evident from the terrorist attacks of 11 September 2001 in New York and Washington as well as from admissions by Islamists apprehended afterwards. But precisely this threat makes it necessary to reconsider the use of nuclear power.

Confessions by two imprisoned al-Qaida leaders indicate that nuclear power plants were definitely among the targets considered by the terrorists. According to these statements, Mohammed Atta, who later piloted a Boeing 767 into the North Tower of the World Trade Center, had already selected the two reactor blocks at the Indian Point power plant on the Hudson River as possible targets. In fact, there was already a code name for attacking the plant located only 40 kilometres from Manhattan, namely "electrical engineering". The plan was only discarded because the terrorists feared that a plane headed for the power plant might be blown up beforehand by anti-aircraft missiles. Earlier and even more monstrous plans by al-Qaida leader Khalid Sheik Mohammed, which called for ten passenger jets to be hijacked simultaneously, included by his own admission several nuclear power plants on the target list. It is therefore absolutely essential to take terrorist attacks more seriously when assessing the risks of nuclear power plants. Such attacks have become several orders of magnitude more probable in the aftermath of 11 September 2001.

It seems certain that none of the 443 reactors in operation at the end of 2005 could withstand a deliberate crash by a large jet with a full tank of fuel. The reactor operators themselves unanimously confirmed this shortly after the attacks in New York and Washington. Their rapid admission also contained a tactical element, however. The idea was to prevent debate about older and particularly vulnerable nuclear sites which might have come under public pressure to close down. In the meantime, however, scientific studies confirm the managers' early statements. Many nuclear plants in Western industrial countries were designed with an eye to random crashes of small or military aircraft. Some planning scenarios even accounted for terrorist attacks using anti-tank rocket launchers, howitzers, or other weapons. A random crash by a fully tanked passenger jet was considered so improbable, however, that no country took effective countermeasures for this scenario. The notion of a deliberate attack by which a passenger craft is transformed into a missile simply surpassed the imaginative capacity of the reactor engineers.

Immediately after the attacks in the USA, the *Gesellschaft für Anlagen- und Reaktorsicherheit* (GRS), a Cologne-based association concerned with the safety of nuclear reactors and other facilities, launched a comprehensive study of the vulnerability of German nuclear plants to air attacks. Commissioned by the German government, the study examined not only the structural strength of typical plants. Using a flight simulator at the Technical University in Berlin, half a dozen pilots crashed thousands of times at different speeds as well as points and angles of impact into German nuclear power plants, shown as detailed videos in the simulator cockpit. The test pilots – like the terrorists in New York and Washington – had previously flown only smaller propeller craft. Even so, approximately half of the simulated kamikaze attacks were said to be hits.

The results of this study were so alarming that they were never officially published. They only later reached the public as a classified, confidential summary. According to this document, every crash risked a nuclear inferno, especially at the older reactors, regardless of the type, size, or speed on impact of the passenger aircraft. The enormous shock on impact or the subsequent kerosene fires would either penetrate the containment directly or destroy the pipe system. In any event, a direct hit would very probably lead to a core melt and a large-scale release of radioactivity. The internal temporary storage facilities, in which spent fuel rods with enormous radioactive content cool down in tanks of water, are also at great risk. True, reactors from later series in most countries feature more stable containment. But according to the GRS study, the possibility cannot be excluded for these reactors either that a direct hit at high speed would cause a major nuclear accident that would contaminate a large surrounding area.

The terrorism scenario of a targeted air attack does not eliminate other fears which already existed around the world before 11 September 2001. Rather, it lends them a more concrete and realistic basis. Certain industrialised countries with nuclear industries had already carefully examined the possibility of terrorist attacks on nuclear facilities by means of weapons or explosives from outside, or by means of violent or concealed entry to restricted areas. But they had not examined this possibility in light of the assailants being deliberately prepared to die. The staggering possibility that individuals might attack a nuclear facility and expect to be the very first victims opens up dozens of scenarios that have yet to be taken into account.

From the perspective of extremist suicide bombers, an attack on a nuclear facility is anything but irrational. On the contrary, they know that a "successful" attack would not only cause an immediate inferno and suffering to millions, but probably also cause many other nuclear power plants to be closed on precautionary grounds – thus triggering an economic earthquake in industrial countries against which the commercial consequences of September 11 would pale in comparison. As monstrous and unprecedented the attacks on the World Trade Center and the Pentagon were, they were largely concerned with the symbolic aim of striking and thus humiliating the US superpower at its economic, political, and military heart. An attack on a nuclear power plant would dispense with all such symbolism. It would hit the generation of electrical power, and thus the nerve centre and the entire infrastructure of an industrial society. Radioactive contamination of an entire region, possibly entailing long-term evacuation of hundreds of thousands if not millions of people, would finally erase the distinction between war and terror. No other attack, not even on the petroleum harbour of Rotterdam, would have a comparable psychological effect on Western industrial countries. Even if it failed in its objective of triggering a major nuclear accident, the results would be horrific. Public reaction would enflame debate over the catastrophic risks of nuclear power to a degree never seen before, and lead to the closure of many, if not all, plants in a number of industrial countries.

5 Nuclear power plants: Radioactive targets in conventional warfare

The new type of terrorism is also refuelling debate on the "peaceful use of nuclear energy" and warfare. This is still largely a taboo topic in the nuclear community. In tense areas such as the Korean peninsula, Taiwan, Iran, India, or Pakistan, existing reactors can have consequences as fatal as they are unintended. Once these plants are operating, enemy forces do not need their own atomic bombs to cause radioactive destruction. A conventional air force – or artillery – will suffice. In light of this, those who attempt to link nuclear energy to the notion of a "secure energy supply" have clearly not thought far enough. There is no other technology for which a single event can trigger the collapse of an entire pillar of energy supply. An economy that depends on this type of technology has the opposite of a secure energy supply. In the event of war, it is more vulnerable to conventional attacks than an economy without this technology.

In explaining his decision to shift from supporting to opposing nuclear power, physicist and philosopher Carl Friedrich von Weizsäcker said in 1985 that "worldwide proliferation of nuclear power requires a radical worldwide change in the political structure of all cultures existing today. It requires transcending the political institution of war, which has been in existence at least since the beginning of high culture."[8] Von Weizsäcker concluded, however, that the political and cultural foundations for world peace are not in sight. In times of "asymmetric violence", in which highly ideological extremists prepare for war against powerful industrial states or for that matter for a comprehensive "clash of cultures", sustainable world peace has receded even further than when von Weizsäcker was formulating his insights in 1985.

Threats to nuclear power plants in the course of armed conflict are not merely hypothetical. In the Balkan conflict in the early 1990s, for example, the nuclear reactor in the Slovenian city of Krsko could have become a target on a number of occasions. Yugoslavian bombers flew over the reactor to demonstrate a potential escalation of hostilities. It is by no means certain that Israel would have refrained from its 1981 air strike on the construction site for the Osirak research reactor in Iraq if the 40-megawatt plant had been in operation. The attack was defended as a pre-emptory strike against Saddam Hussein's attempt to build the first "Islamic bomb". American bombers renewed the attack on the construction site during the 1991 Gulf War. In retaliation, Saddam Hussein aimed his Scud missiles at the Israeli nuclear headquarters in Dimona. And finally, there was talk in late 2005 of Israeli plans to strike alleged secret nuclear facilities in Iran.

Thus there are a number of plausible scenarios in which parties involved in warfare or armed conflict decide to attack nuclear facilities in their enemies' countries. One possibility is a pre-emptory strike against the enemy's presumed ambitions to build a bomb, often closely linked to nuclear facilities in developing and transitioning countries. Another is the intention to unleash the greatest possible degree of fear. It is a brutal fact that a state whose actual or potential enemies have nuclear power plants can spare itself the arduous path of building its own atomic bomb. Attacking the enemy's civilian power stations is as good as having a bomb of one's own. Because a commercial nuclear power plant holds an order of magnitude more radioactivity than is released by exploding an atomic bomb, long-term radioactive contamination from a "successful" attack on a power plant would be much more drastic than that from a bomb.

[8] Cited in Klaus Michael Meyer-Abich and Bertram Schefold, *Die Grenzen der Atomwirtschaft*, (Munich, 1986), pp.14/16

6 Siamese twins: Civilian and military nuclear power applications

Ever since the idea arose of harnessing nuclear power to generate energy by controlled means, the possibility always existed of abusing the same technology for military purposes. This should surprise no one. After all, the atomic bombs dropped on Hiroshima and Nagasaki in August of 1945 created a human trauma that resonated around the world. The "Atoms for Peace" programme announced by American President Dwight D. Eisenhower in 1953 was intended to launch "peaceful use of atomic energy". His venture was born of necessity and concern. With its generous offer of what was still largely classified knowledge about nuclear fission, the USA wanted to prevent more countries from pursuing their own nuclear weapons programmes.

With the bomb now the ultimate demonstration of US superpower status, the deal that the president offered the world could not have been simpler. All interested countries could benefit from the peaceful use of nuclear energy, as long as they relinquished any ambitions to build their own nuclear weapons. This was intended to halt developments that would give the Soviet Union, Great Britain, France and China nuclear weapons within a few years after World War Two. Other countries, including some which then as now are considered deeply peace-loving – such as Sweden and Switzerland – were working more or less intensively and clandestinely on developing the ultimate weapon as well. The Federal Republic of Germany – which from the end of World War Two until 1955 was not strictly speaking a sovereign state – developed similar ambitions during the term of Franz-Josef Strauss as Nuclear Energy Minister.

The Nuclear Non-Proliferation Treaty, which finally went into effect in 1970, was a result of the Eisenhower initiative, as was the International Atomic Energy Agency (IAEA). The job of this Vienna-based agency, which had been founded back in 1957, was to promote nuclear technology for generating electricity around the world, yet at the same time to prevent an increasing number of countries from developing atomic bombs. Nearly half a century after its inception, the achievements of the IAEA are as ambivalent as its original agenda. By monitoring civilian nuclear facilities and the fissile materials they use, it has significantly discouraged proliferation. For this, the Agency and its director Mohamed El-Baradei received the Nobel Peace Prize in 2005. But it has not succeeded in preventing proliferation. By the end of the Cold War, three additional states had acquired nuclear weapons, namely Israel, India and South Africa, in addition to the five "official" nuclear powers. South Africa subsequently destroyed its nuclear arms at the end of the apartheid system in the early 1990s. Following the 1991 Gulf War, inspectors discovered a secret nuclear weapons programme in Saddam Hussein's Iraq, itself a signatory to the NPT, which was very advanced despite strict monitoring by the IAWA. In 1998, India and Pakistan, which like Israel had consistently declined to sign the NPT, shocked the world by testing their weapons. In 2003, communist-controlled North Korea terminated its commitment to the NPT and declared itself in possession of nuclear weapons.

According to many experts, precisely this latest development has the potential to encourage other authoritarian regimes. While the assumption leading up the US invasion of Iraq in 2003 was that the country was attempting to acquire an atomic bomb but did not yet actually have it, the North Korean communist government announced that they had already achieved their aim. And while Saddam Hussein's government toppled under the force of the superpower's conventional bombs and cruise missiles, the no less authoritarian dictator Kim Jong-il was spared this fate. In addition to already existing US military interests promoting action in Iraq and Afghanistan, it seems plausible that part of the reason for sparing North Korea was fear that it could retaliate with nuclear weapons if attacked by conventional means. Even the retroactive assumption that this fear played a role can spur other countries hostile to the USA to follow in North Korea's footsteps. A current example of such ambitions is Iran, even though its rulers insist that all nuclear facilities in the country serve exclusively civilian purposes.

All these developments derive from a fundamental problem associated with nuclear technology: With the best will in the world and supported by cutting-edge monitoring systems, civilian and military developments in this area cannot be cleanly differentiated. In particular, the fuel or fission cycles for peaceful and non-peaceful applications run largely parallel. Technologies and expertise are often suited for dual use – with fatal consequences. Every country that possesses civilian nuclear technology promoted by the IAEA and the European Atomic Energy Community (Euratom) will sooner or later be capable of building its own bomb. Again and again over the course of the past 50 years, unscrupulous ambitious heads of government have set up clandestine military tracks in parallel to their civilian nuclear programmes. But even without specifically clandestine programmes, the major steps in the civilian nuclear chain are extremely vulnerable to military abuse:

- Enrichment plants for the fissile uranium isotope U-235 produce fuel for light-water reactors, i.e. the most common type of reactor in the world. Continuing the process yields highly enriched uranium (HEU), a fissile material that can be used for research reactors – or for atomic bombs of the type dropped on Hiroshima.
- Both research and commercial reactors can serve their officially intended purposes – or be deliberately used to produce weapons-grade plutonium (Pu-239) for atomic bombs of the type dropped on Nagasaki. This applies even more so to fast breeder reactors.
- Reprocessing plants are primarily intended to separate plutonium reactor fuel from other radioisotopes produced earlier in reactor fission processes – but can also be used to separate the plutonium isotope PU-239, which makes a suitable explosive for atomic bombs.
- Reprocessing technology can also be used to treat radioactive fissile material in insulated "hot cells" as part of a fuel cycle for civilian purposes – or to process and treat components for atomic bombs.
- Interim storage depots for plutonium, uranium and other fissile materials can serve either as fuel depots for nuclear power plants – or as depots of explosive materials for building atomic bombs.

Civilian components of the fuel cycle can be converted to military components – sanctioned by the respective state – in parallel clandestine military programmes. By secretly diverting fuel intended for civilian purposes, these programmes can evade national and international monitoring. Another fear is of outright theft – of these substances, the corresponding know-how and the relevant military technology.

At the end of the Cold War, many people initially hoped that the nuclear powers would act on their shared interest in restricting the dissemination of sensitive technology and materials in order to reduce the risk of nuclear weapons proliferation. At the same time, however, there was a growing threat of "leaks" in what had been strict security measures for both military and civilian nuclear facilities, especially as the Soviet Union fell apart. Fuelled by shady profiteers as well as criminal groups, a veritable black market arose for all types of nuclear paraphernalia. Most of the radioactive materials on offer for exorbitant prices in primarily criminal circles, especially in the early 1990s, were not suited for building bombs. But the fact that radioactive material was now suddenly available from what had been hermetically sealed depots was worrying.

No one disputes the fact that with every new country beyond the current total of 31 that acquires civilian nuclear technology, it will become all the more difficult to prevent military proliferation. Another nuclear energy boom like that in the 1970s, which would boost the total number of countries possessing fission technology up to 50, 60 or more, would pose overwhelming monitoring problems for the overworked and chronically underfinanced IAEA. And this does not begin to address the new threat by terrorists, who presumably would not hesitate to employ "dirty bombs". Detonating a conventional explosive packed with radioactive material of civilian origin would not only claim a large number of victims and greatly exacerbate fear and uncertainty in potential target countries, but also render the site of the explosion uninhabitable.

7 The open cycle: Leaks at the front and back

The "nuclear fuel cycle" is an astonishing piece of terminology that has established itself in common parlance over the past decades although it is constantly refuted by reality. The myth of the nuclear fuel cycle is based on an early dream of nuclear engineers, namely that the fissile plutonium produced by commercial uranium reactors could be separated out in reprocessing plants and then used in fast breeder reactors – creating in effect a *perpetuum mobile* from non-fissile uranium (U-238) to plutonium (Pu-239) for more breeder power plants. The idea was to create a gigantic industrial cycle with more than a thousand fast breeder reactors and dozens of reprocessing plants on a large civilian scale such as that found today only at La Hague in France and Sellafield in Britain. In the mid-1960s, nuclear strategists were forecasting that Germany alone would possess a fleet of breeders with an overall capacity of 80,000 megawatts by the year 2000. But the plutonium route in nuclear technology, which German expert Klaus Traube who once directed the Kalkar reactor project on the Lower Rhine later called the "utopian solution of the 1950s" (*Erlösungsutopie der 50er Jahre*),[9] became possibly the greatest fiasco in economic history. Breeder technology is exorbitantly expensive, technically undeveloped, even more controversial with respect to safety than conventional nuclear plants, and especially vulnerable to military exploitation. It has yet to gain ground anywhere in the world. Only Russia and France each operate a single breeder reactor stemming from the early development period. Japan (whose prototype breeder in Monju has been idle following a severe sodium fire in 1995) and India are officially pursuing development in this area.

Without prospects for further developments in breeder technology, the main historical motivation for separating out plutonium at reprocessing plants now no longer applies. In addition to France and Great Britain, however, Russia, Japan and India operate smaller reprocessing plants for the retroactively declared purpose of re-using the plutonium thereby generated in conventional light-water reactors in the form of so-called mixed oxide (MOX) fuel rods. When they are not shut down due to technical problems, reprocessing plants generate horrendous costs along with their plutonium and uranium. They also produce highly radioactive nuclear waste that requires permanent disposal, as well as radiation levels exceeding those of light-water reactors by a factor of several ten thousands. Reprocessing also requires frequent precarious transports of highly radioactive materials, some of which are suitable for military or terrorist purposes. It thus greatly increases the number of possible targets for terrorist groups.

Because a comparatively small proportion of the highly radioactive nuclear waste generated in commercial power plants is reprocessed, and because spent MOX fuel rods are generally not recycled again, the only part of the nuclear fuel cycle that remains is the name. In the real world, this cycle is open. In addition to electricity, nuclear power plants generate waste products that cover the spectrum from highly to weakly radioactive, and which furthermore are highly toxic. They require secure disposal sites for enormous periods of time. This time depends on the natural, so-called half-time periods of the radionuclides, which differ greatly. The plutonium isotope Pu-239 loses half its radioactivity in 24,110 years; the cobalt isotope Co-60 does so in 5.3 days.

Half a century after nuclear power plants started producing electricity, there is not a single authorised and operational final disposal site for highly radioactive waste – a state of affairs that recalls the well-known image of the atomic airplane taking off without any-

[9] Klaus Traube: *Plutonium-Wirtschaft?* (Hamburg, 1984), p. 12

one thinking about where it is going to land. In some countries – such as France, the USA, Japan and South Africa – comparatively short-term and weak to medium radioactive waste is stored in special containers near the earth's surface. Germany has prepared the "Konrad" former iron ore shaft in Salzgitter in the state of Lower Saxony for underground storage of non-heat-generating waste from nuclear plants, as well as from research reactors and nuclear medical applications. However, storing nuclear waste in this former ore pit continues to be the subject of legal dispute.

The initial lack of concern about nuclear waste can be seen in a 1969 statement by the above-mentioned physicist and philosopher Carl Friedrich von Weizsäcker. "It won't be a problem at all," he said. "I've been told that all the atomic waste that will accumulate in Germany until the year 2000 will fit in a cubic container measuring 20 metres in length. If that is well closed and sealed and placed in a mine, we can hope to have solved this problem."[10] In the meantime, exotic early proposals such as storing the waste in space, at the bottom of the sea, or in the ice of Antarctica have vanished from public view. Experts cannot decide whether granite, salt, clay or other minerals represent the best substrate for long-term storage of highly radioactive and heat-generating waste. They all cite both advantages and disadvantages for every option.

The question of whether radioactive waste can be safely isolated from the biosphere for hundreds of thousands or millions of years is ultimately philosophical. It defies human imagination. The pyramids, after all, were built a mere 5,000 years ago. But one thing is clear. Because nuclear waste exists, and because the question of long-term storage cannot be answered conclusively, the best technical solution based on the latest state of knowledge has to be sought and found. Attempts to avoid the issue, at any rate, do not help matters. An example of this would be so-called transmutation, whose advocates propose constructing special reactors to split the most hazardous and persistent waste into isotopes that will only be radioactive for a few hundred years. For decades now, only a small number of scientists have considered this prospect seriously. But even proponents presumably do not really believe it can significantly reduce the most hazardous by-products of nuclear technology.

To put transmutation technology into practice, innovative reprocessing plants would first have to be built, in which the highly radioactive isotope cocktail from nuclear power plants would be broken down via complex chemical processes into individual elements using far more sophisticated systems than in existing plants. The plutonium plants at La Hague and Sellafield would be like simple chemical laboratories in comparison. Moreover, a fleet of reactors would have to be developed in which the separated isotopes could be selectively bombarded with so-called rapid neutrons, split, and transmuted into less hazardous radionuclides. Even if it were technically feasible to build these plants, nobody could or would be willing to fund this type of nuclear infrastructure. This disposal method would undeniably carry far greater risks than the final disposal policy currently pursued in many countries, namely in carefully selected underground repositories. The fact that despite these considerations, the notion of transmutation survives primarily in France and Japan has more to do with the breeder visions still nurtured by parts of their respective nuclear communities than with serious prospects of being put into practice.

Gradually and belatedly, the major nuclear-power producing countries are reaching the conclusion that selecting a final disposal site is more than a scientific or technical problem. None of the national site selection programmes, most of which were launched in the 1970s, has yet produced an authorised final repository. This is because the selection procedures have ignored or rejected public opposition, democratic participation and

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[10] Cited in B. Fischer, L. Hahn, et al: *Der Atommüll-Report* (Hamburg, 1989), p. 77

transparency for far too long. In attempting to learn from these mistakes, Germany developed and formulated a multi-stage selection process with public participation throughout. It is not yet clear whether this process, which was agreed by scientists from both the pro and anti-nuclear energy camps in 2002 following years of intensive debate, has a realistic chance of success. The CDU/CSU and SPD coalition government elected in the fall of 2005 has initially postponed the question of whether to seriously consider other final disposal sites than the salt dome in Gorleben prepared back in the 1980s.

Final disposal plans in Finland and the USA are relatively far along at present. The gigantic facility at Yucca Mountain in Nevada, however, has been the object of controversy for decades. The largely finished site in Olkiluoto in Finland has benefited from comparatively high acceptance by local and regional populations. The majority of residents are reassured by the fact that no major failures have occurred for many years at the nuclear power station there, as well as by an already functioning final repository for weak and medium radioactive waste.

The putative fuel cycle is not only open at the back end, however. From the very beginning, it has been highly problematic at the front end as well. Uranium mining operations to acquire the fissile material for the bomb and later for civilian power plants have claimed a huge toll, especially in the early stages. Large amounts of radioactive nuclides, which had been shielded by the earth's crust, have entered the biosphere. Maintaining or expanding nuclear power will considerably increase the health and environmental costs associated with uranium mining.

The search for this heavy metal, which is not particularly rare as such but whose concentrated deposits are few in number, started shortly after World War Two. The horrific effects of the US bombing of Japan did not inhibit but rather spurred Allied ambitions to develop strategic resources. Great efforts were made to expand and secure access to uranium. At the time, miners' health and environmental issues played only a subordinate role. The USA worked mines both on its own territory and in Canada, while the Soviet Union developed uranium mines in East Germany, Czechoslovakia, Hungary and Bulgaria. Thousands of miners met painful deaths from lung cancer after years of heavy labour in poorly ventilated, dusty tunnels contaminated with radioactive radon. Some of the hardest hit were those at the East German "Wismut" facility which at times employed more than 100,000 people. Because uranium concentrations in the earth generally only differ by tenths of a percent, large amounts of excavated earth accumulated. The exposed uranium ore contained relatively high concentrations of radon gas and other radioactive nuclides. This resulted in severe and long-term radioactive exposure not only for the miners themselves, but also for the surrounding area and its residents. The problem was exacerbated by extraction processes using liquid reagents, which contaminated the surrounding land, surface water and ground water.

The situation improved with the boom in nuclear electricity generation in the 1970s. From then on, governments were no longer the sole purchasers of fissile material. A private uranium market developed, which meant that the very harsh working conditions could no longer be ascribed to the special military and strategic status of uranium mining. With the end of the Cold War, conditions underwent another fundamental change. The military demand for uranium declined steeply. Deposits no longer needed by the USA or the former Soviet Union could now feed the civilian market for fissile material. Moreover, as nuclear disarmament proceeded, large amounts of weapons-grade uranium with high fissile content quickly became available from the now superfluous Soviet and American nuclear stockpiles. This may be the most comprehensive programme ever of converting instruments of war to civilian commercial purposes. Large amounts of the highly explosive weapons material are "diluted" with natural or so-called depleted uranium (U-238 from which the fissile U-235 isotope has been extracted) and then used as fuel for conventional nuclear power plants. This completely new development on the market caused international prices for reactor-grade uranium to plummet, which meant that only relatively high-volume deposits were still mined. On into the year 2005, almost half of the uranium split in nuclear power plants around the world was no longer coming from enriched, "fresh" uranium ore, but rather from the superpowers' military stockpiles.

In the foreseeable future, however, uranium supplies from the Cold War will run out. Uranium prices have already begun to rise, and will continue to do so at an accelerated pace. If nuclear power plants are to continue operating at today's level or if the reactor fleet is expanded, old mines will have to be re-opened, as will new deposits with ever lower yields, which in turn will mean ever smaller amounts of uranium and ever greater volumes of waste rock with above-average concentrations of radioactive isotopes – with all the attendant health and environmental risks. Furthermore, the industry needs time to expand its uranium mining capacities, which it will not have if nuclear energy generation is to expand rapidly. As also happens during periods of cheap oil, exploration efforts slowed down greatly after the release of surplus military stockpiles, so we only know of relatively few deposits today. Moreover, it takes an average of at least ten years from the time a uranium deposit is identified to the point when mining can start.

The approaching bottleneck in uranium supplies will be exacerbated by a huge imbalance between supply and consumer countries. Canada and South Africa are the only nuclear-energy producing countries that are not dependent on uranium imports. The major countries that use nuclear power either have essentially no uranium production of their own (France, Japan, Germany, South Korea, Great Britain, Sweden, Spain) or considerably smaller capacities than would be needed to sustain the operation of their reactors over the long term (USA, Russia). As far as its fuel supply is concerned, nuclear power is a domestic source of energy almost nowhere in the world. Russia in particular risks facing a serious uranium supply crisis in 15 years already. This shortage could then be shifted to plant operators in the EU who currently acquire about one third of their fuel from Russia. China and India could also face a fuel shortage if both expand their reactor fleet as announced.

Given the above considerations, the following is clear: Neither fuel supply nor waste disposal for the world's nuclear power plants can be secured over the long term. The new reactors planned and under construction in some countries will exacerbate these problems. With uranium reserves limited or largely accessible only at disproportionate cost, concerted expansion strategies will soon require a permanent switch to plutonium – with reprocessing plants everywhere and fast breeder technology the reactor standard. This development strategy would knock today's problems up to a higher dimension. It would multiply the amount of highly radioactive waste that requires permanent disposal. The search for final spent-fuel repositories would have to be broadened to include more sites with higher total volumes.

8 Nuclear climate protection: Naive proposals

The newly awakened interest in nuclear power seen in some industrial countries is due in large part to its supposed potential to reduce global levels of greenhouse gas emissions. This potential is enabling advocates of nuclear technology to hope and push for a "renaissance" in the sector, following decades of stagnation. Nuclear power plants emit only small amounts of carbon dioxide (CO_2). Proponents of nuclear power thus consider them a crucial part of any campaign to combat global warming. Or to put it the other way around, the greenhouse gas effect fuels the hope that the decades-long lull in nuclear energy can be halted and reversed. Wulf Bernotat, for example, CEO of the E.ON Ruhrgas corporation based in Düsseldorf, asserts that "an energy agenda that looks beyond the short term must address the core conflict between phasing out nuclear power and greatly reducing the volume of CO_2 emissions. It is not possible to have both at once. That is pure illusion."[11] But like many other leading figures from traditional power industries, the head of the world's largest privately-owned power corporation belabours the main argument for continuing to use nuclear-generated electricity. The argument runs that climate protection is doomed to failure without the help of nuclear energy. Those who have good reasons for opposing the renaissance of nuclear power now have to address the question of whether this core conflict exists in the form upheld by proponents of nuclear energy.

An overwhelming majority of experts is now convinced that global warming is a real danger. In order to keep it at a tolerable level for both humans and the global ecosystem – which means a temperature increase of no more than two degrees Celsius over the pre-industrial period – we cannot escape having to dramatically lower CO_2 emissions over the coming decades. Climate experts recommend that industrial countries reduce their emissions by 80 percent by the middle of the 21st century. Transitioning countries at least have to cut back on their massive increase in emissions. In justifiably striving for prosperity, the highly populated countries of the South may not simply imitate the energy-intensive development route based on fossil fuels taken by the older industrialised countries of the North. The question is then the following: Does nuclear energy have the potential to limit greenhouse gas emissions to such an extent and without any alternatives such that the undisputed major risks of this technology should be accepted?

The situation is complicated by the fact that while global warming and the potential for serious accidents at nuclear plants represent different types of risk, each would bring unique and long-term catastrophic consequences in its wake. While global warming will most likely accelerate and trigger different but largely dramatic changes for the worse around the world unless countered in a resolute and comprehensive manner, a major nuclear disaster is based on probabilities that are harder to conceptualise. An accident will also have disastrous, long-term consequences that the affected country will hardly be able to handle alone. The world economy would probably suffer massive repercussions as a result. This was the case after the Chernobyl disaster, which took place at the periphery of major economic zones.

According to statistics from the Vienna-based International Atomic Energy Agency (IAEA), there were 443 nuclear reactors operating in the world at the end of 2005, with a combined electrical capacity of nearly 370,000 megawatts. But expansion has stagnated for decades in many areas, especially in Western industrial countries. The OECD does not expect this trend to change much by the year 2030, forecasting an annual average increase in global capacity of 600 megawatts. Because old reactors are being shut

[11] *Berliner Zeitung*, 3 December 2005

down, this marginal expansion will mean adding around 4,000 to 5,000 megawatts a year, or three to four large plants. According to forecasts from the International Energy Agency (IEA), itself an OECD organisation, worldwide demand for electricity will increase greatly over the same period of time, and thus the share of nuclear-generated electricity will decline from around 17 percent in 2002 to only 9 percent in 2030. The journal *Nuclear Engineering International* published a different calculation in June of 2005. Noting that 79 reactors had been on the grid for more than 30 years at that time, it predicted that it will be "virtually impossible to keep the number of nuclear power plants constant over the next 20 years."[12] Due to shutdowns pending over the next ten years, 80 new reactors would have to be planned, built, and put into operation – one every six weeks – simply to maintain the status quo. In the decade thereafter, 200 reactors would have to join the grid – one every 18 days. It is thus pure illusion to think that nuclear energy can be used over the short and medium term to counter global warming.

Nevertheless, long-term studies have developed scenarios to examine whether nuclear energy can reduce emissions as part of ambitious global efforts to protect the climate. If the amount of nuclear-generated electricity is increased tenfold by 2075, for example, 35 new large reactors would have to be added to the grid every year until the middle of the century. A comparatively modest expansion strategy to 1.06 million megawatts (1060 gigawatts) of electrical capacity by the year 2050 would mean tripling the output of nuclear power plants over the status quo. This could save around five billion tonnes of CO_2 emissions in 2050 as compared to the normal global expansion of electricity generation by coal and gas-fired plants. What these calculations have in common is that they have nothing to do with either nuclear reality or past experience.

Based on IEA forecasts and calls by climate researchers at the Intergovernmental Panel on Climate Change (IPCC), the world would have to save an estimated 25 to 40 billion tonnes of CO_2 in the year 2050. If all available means worldwide were poured into expanding nuclear energy, effective immediately, in order to achieve the above scenario of tripling nuclear-based electricity generation by 2050, for example, this would still account for only 12.5 to 20 percent of electricity generation and alleviate the climate accordingly. Although not marginal, it would also not be enough to eliminate the need for other ways to reduce emissions. And the price for this success would not only be high in economic terms. It would also mean the following:

- Adding a large number of new sites for potential disasters throughout the world;
- Creating new targets for military and terrorist attacks in developing and transitioning countries, including crisis areas;
- Greatly intensifying final disposal problems as well as the danger of unmonitored nuclear weapons proliferation in every region of the world;
- Due to scarce uranium resources, replacing today's standard light-water reactors soon and everywhere by a plutonium-based system featuring reprocessing and fast breeder reactors, which is vulnerable to catastrophic accidents as well as terrorist and military attacks;
- Diverting enormous financial resources from anti-poverty programmes in the world's crisis areas to expanding nuclear infrastructure.

[12] *Nuclear Engineering International*, June 2005

Given the obvious and serious side effects, this type of strategy would only make sense if the climate trajectory could not be countered by other, less problematic means. Based on everything we know now, this is not the case. Realistic estimates state that even ambitious targets of reduced greenhouse gas emissions can be achieved without the help of nuclear energy. According to these estimates, it is possible to reduce carbon dioxide emissions by 40 to 50 billion tonnes (25-40 billion tonnes are required) by the middle of the 21st century if the following conditions are met:

- Improve energy efficiency in buildings;
- Raise industrial energy and material efficiency to the standard of technology already available;
- Increase energy efficiency to a corresponding level in the transportation sector;
- Make better use of efficiency allowances for both generation and application in the energy sector;
- Make greater use of natural gas instead of coal or oil (fuel switch) to generate electricity;
- Systematically expand the use of renewable energies from solar, wind, hydro, biomass and geothermal sources;
- And finally, develop and implement clean coal technology on a large scale (separation and storage of carbon dioxide resulting from coal combustion in power plants).

An extensive study commissioned by the German Parliament in 2002 showed that a series of different strategies and instruments can enable an industrial country such as Germany to reduce its CO_2 emissions by 80 percent by mid-century. This study showed that improving energy efficiency across the board is just as essential as greatly increasing the use of renewable fuels. By contrast, it found no support for the argument that successful climate protection strategies would have to maintain or expand the use of nuclear power. A large or expanding percentage of nuclear-based electricity generation can even undermine climate protection strategies. It is hard to juggle the crucial elements of renewable energy and energy efficiency with large-scale, centralised, base-load power stations such as nuclear power plants. Once they reach a certain level of production, intermittent renewables such as solar and wind sources require plants with flexible capacity control, like modern gas-fired power stations, in order to compensate for fluctuations as well as to reflect changed geographical conditions and a generally less centralised structure of electricity generation.

Moreover, large-scale expansion in nuclear energy – for only expansion, as opposed to the already strenuous task of maintaining current levels, can make nuclear power a real factor in climate control – would bring enormous economic uncertainties. To achieve this expansion, the industry would have to successfully replace today's light-water reactors by breeder technology and reprocessing, at which it has failed once before. Furthermore, no other technology stands under a comparable sword of Damocles: one serious accident or terrorist attack would suffice to permanently puncture acceptance for this technology on national or even international levels. A large number of reactors would probably have to be closed down for precautionary reasons. And finally, interminable debate about nuclear power in major industrial countries only delays the absolute necessity of consistently implementing energy efficiency strategies. All in all, it is both possible and advisable to develop national as well as international policies that minimise the two major risks of global warming and catastrophic nuclear accidents. The specific hazards associated with nuclear energy make every climate strategy that includes it less robust and innovative than strategies without the nuclear option. The oft-mentioned core conflict between nuclear power and climate protection is thus revealed as a creation by nuclear proponents, who are pursuing a different set of interests. The supposed conflict is a contrivance. There is no need to make a senseless choice between the devil and the deep blue sea.

9 Cheap nuclear power: If the state foots the bill

Nuclear power plants play varying yet important roles in the power supply structures of the countries that use them, and thus in these countries' respective economic systems. In the absence of overriding strategic or military interests, therefore, the energy economy itself is what largely determines their future. And it normally does so on the basis of sober economic considerations. The question of whether a nuclear power plant equals a licence to print money or rather a bottomless pit of expenditure is decided on the basis of its individual circumstances. If the reactor has been generating electricity reliably for twenty years and there is reason to believe that it will continue to do so for the same period of time again, then the former metaphor is more appropriate. At least as long as the latent potential for disaster at this plant, like that at all others, does not become reality. On the other hand, if the nuclear power plant still has to be built, and if it will also be the prototype of a series, then it is better to steer clear of the project. Unless, of course, the financial risk can be shifted to a third party.

For investors trying to decide whether to replace or build new power stations under market conditions, nuclear plants are clearly not their first choice. This is amply demonstrated by empirical evidence. In the USA, reactor builders have not been awarded a single new contract since 1973 that was not subsequently cancelled. In Western Europe – with the exception of France – reactor builders waited a quarter of a century before receiving a contract for a new plant in 2004. Now they have one at Olkiluoto in Finland. According to the International Atomic Energy Agency (IAEA), 28 nuclear power plants with a total capacity of around 27,000 megawatts were under construction worldwide in 2005. Almost half of these projects have been plodding along for 18 to 30 years now. As far as a number of them are concerned, no one believes they will ever generate electricity – in fact, the normal term for such projects is "abandoned". The remaining plants which are expected to be completed in the near future are almost all in East Asia, and are being built under conditions that have little or nothing to do with a market economy. In short, the order situation for nuclear power plants is calamitous. All the more so when one considers the competition. Worldwide electricity capacity has increased by around 150,000 megawatts per year since the turn of the millennium, but nuclear plants have accounted for barely two percent of this. In the USA alone, an additional capacity of 144,000 megawatts was added to the grid from 1999 to 2002 from conventional power plants using fossil fuels. From 2002 to 2005 in China, a new coal-driven power plant park with a capacity of 160,000 megawatts was constructed. Even wind energy, which is still in its infancy, managed to contribute an overall new capacity of more than 10,000 megawatts.

As marginal as the role of nuclear energy is compared to the gigantic expansion in power capacities worldwide, operators of nuclear plants are making determined efforts to extend the licences of existing reactors far longer than originally planned. The average age of all the reactors in operation in 2005 was just around 22 years. But this did not prevent former Siemens CEO Heinrich von Pierer during the German election campaign that same year from urging chancellor candidate Angela Merkel to consider extending operating lives to 60 years, despite the formal agreement in Germany to phase out nuclear power plants. After all, most nuclear power advocates in Europe and North America are now calling for operating lives this long. Extensions to the licences of most of the 103 nuclear power plants in the USA have already been approved, applied for, or are expected to be applied for. Von Pierer cited "business sense" as the basis for his position. And it does in fact make sense. As long as there are no serious failures or expensive repairs, and as long as wear or corrosion do not require replacing central components such as the steam generator, electricity can be generated at virtually unparalleled low cost by old reactors of the 1000-megawatt category which have long since depreciated. Extending plant licences also postpones the so-called "fat problem" of ending nuclear power. This means closing and dismantling the big reactors, which poses a real challenge not only to safety but also to financing. In addition, because fuel costs for nuclear plants make up a relatively low share of total costs, operators can expect substantial extra yields. If German reactors could remain in operation for 45 years instead of the 32 years stipulated by the phase-out agreement – 45 being the average operating life for large-scale fossil-fuel plants – the industry could expect handsome additional profits of around 30 billion euros. The magnitude of these figures explains why plant operators are urging discussion of licence extensions in many countries. But this haggling has nothing to do with a potential renaissance of nuclear energy. Rather the converse. The fact that nuclear plant operators are calling for an "overtime" period shows that they shrink from investing in new plants for business reasons. Instead of investing in new nuclear or non-nuclear technologies, these companies are sapping the substance of their reactors without regard for their growing susceptibility to failure.

The decades of decline in the nuclear power industry have by no means come to a halt. There is a single new construction site in the USA and Western Europe combined, namely on the Baltic Sea coast of Finland. This site is treated in more detail below. At the same time, an increasing number of extensive studies in recent years have suggested that new nuclear power plants are more competitive than their fossil-fuel counterparts. The major drawback of these studies is that they convince no one except their authors and publishers – and certainly not potential funders of new plant projects. This is the main reason for the unprecedented degree of uncertainty about what exactly a new generation of nuclear power plants would cost. Hardly any reliable data is available on the large cost blocks, especially construction, waste disposal and decommissioning, or for that matter on operations and maintenance. One reason for this is because analysts greet nearly all published estimates with a high degree of scepticism. After all, these figures generally come from vendors seeking to build power plants, who thus tend to set their estimates on the low rather than the high side. Or from governments, associations and lobbyists who try to sway reluctant public opinion by holding out the incentive of supposedly low electricity costs.

But beyond the special interests, there are also objective problems. Because every new reactor series has been plagued by costly "teething problems" and long shutdown periods, potential financiers view vendors' consistently cheerful and optimistic forecasts with considerable suspicion. It is impossible to predict the "performance" of a new power plant. Even less so for new reactor types that are based on largely new and thus unproven technology. In nearly all technical fields – including those outside the power plant sector – builders can follow a "learning curve" at a relatively consistent and predictable rate to ever lower prices. Yet reactor builders are still starting from scratch half a century after the launch of commercial nuclear fission. In the 1970s and 1980s, reactor vendors therefore offered larger and larger reactors based on the partially justified assumption that bigger plants could generate electricity more cheaply than smaller ones. But this shift to an "economy of scale" has not solved the problem. A clear trend toward less expensive reactors has yet to materialise. In the meantime, the situation is exacerbated by prolonged stagnation on the market, which means that further developed nuclear power plants exist only as blueprints – or more recently as computer animated displays. This in turn increases the imponderables for potential funders. Nuclear energy has therefore become a high-risk technology not only in terms of safety but also with respect to financing.

So building a new reactor certainly means attracting risk capital, with its high attendant costs. Aside from construction, capital costs represent the largest block of funding for these projects. This problem, too, has worsened in major industrial countries with the deregulation of energy markets. Back during the time of large-scale, state-sponsored monopolies, investors could assume that their capital would eventually be refinanced by consumers even if the reactor performed poorly. In today's deregulated electricity markets, however, this is no longer the case. With exorbitant initial investments and payback periods extending over decades, nuclear power is not compatible with deregulated markets. The capital costs explode – assuming financiers do not prefer other technologies that do not have these problems in the first place. Indeed in many countries that have witnessed a boom in highly efficient gas power plants over the past two decades, the construction costs per installed kilowatt hour are significantly lower, periods between contract allocation and start-up are short, and many plant components are made in factories under "controlled conditions". Moreover, due to the relatively low cost of natural gas, which accounts for a higher share of total operating expenses than uranium fuel, nuclear power plants have hardly had a chance.

A series of additional imponderables make nuclear power plants a gamble for any investor. The period from the investment decision to the start of operations is far longer than for all other power plant types. There can be enormous planning problems as well as delays in authorisation because government agencies work especially carefully under public scrutiny, because new safety-related developments lead to changes in the authorisation criteria, or because anti-nuclear interests block progress in the courts. The decision to construct the latest British reactor Sizewell B was made in 1979, for example, and it started commercial operations 16 years later. When a prototype starts up, no one can be sure that it will attain the anticipated performance levels, which of course ultimately determine revenue levels. An even more important factor is the reactor's reliability over the full course of its operating life. Unlike the capital costs, this so-called load factor can be calculated. It is generally known how long a nuclear power plant has been in operation and how long it has been shut down for repairs, fuel rod replacement, or failures. The load factor is the output (kilowatt hours) as a percentage of total possible output for uninterrupted operation. Vendors' load factor forecasts have regularly proven to be high, especially for the first reactors in a series. If a reactor achieves a load factor of only 60 as opposed to 90%, costs increase by one third. Extra maintenance and repair costs also accrue. Only around two percent of all reactors achieve load factors of 90 percent or more; only around one hundred of the world's reactors exceed 80 percent.

Back in the euphoric early days, operators eagerly promised that nuclear power plants would run essentially automatically and thus incur lower costs than other plants with comparable outputs. But this forecast, too, has proven overly optimistic. It is true that fuel accounts for a relatively small share of total operating costs. But this share increases if so-called mixed oxide with an element of reprocessed plutonium is used instead of "fresh" uranium oxide. Operation and maintenance costs are higher, because personnel costs considerably exceed those for gas power plants, for example. Some nuclear power plants were even closed down in the USA in the late 1980s and early 1990s because it was more economical to build and run new gas power plants.

In contrast to other systems, nuclear power plants incur enormous costs even after decades of operation. These include disposing of radioactive waste, guarding closed reactors, and ultimately decommissioning the reactors following a more or less lengthy "cool-down" period. All these investments have to be earned over the course of plant operation as well as put aside for use at a much later period of time. These costs, including accident insurance, differ from country to country. They are all the more difficult to estimate given that normal discount trajectories do not apply to the anticipated time periods. At a discount rate of 15 percent, for example, costs incurred after 15 or more years are negligible. Because they will burden our children in the real world, however, these costs represent another source of uncertainty in reactor financing and in determining the price of generating electricity by nuclear power.

The discussion that has started in some countries about resuscitating the nuclear boom of the 1970s has thus far not been reflected in reality. Little has happened aside from the debate over extending plant licences. Concrete new projects represent an absolute exception. By far the majority of plants currently under construction are based on Indian, Russian, or Chinese technology. Leading Western vendors continue to show completely empty order books. The US American company Westinghouse has received one reactor order in a quarter of a century. For Framatome ANP (66 percent owned by the French nuclear group Areva and 34 percent by Siemens) and its predecessor companies, the Okiluoto reactor in Finland is the first contract in about 15 years. Thus it is politicians and journalists more so than vendors who are promoting the idea of a renaissance in nuclear energy. They believe that adding nuclear power to existing energy policies will make it easier to meet short-term climate control obligations, and to avoid power shortages. This has consequences. For the more forcefully politicians and the public call for a renaissance in nuclear technology, the more baldly potential investors call for state support.

In the USA, the Bush administration is strongly in favour of extending the licences of the country's ageing reactor fleet. Following electricity shortages in major states such as California as well as spectacular power outages, it is also advocating the construction of new nuclear power stations. Discussion is being fuelled by increased concern about global warming, which in turn was triggered by the disastrous hurricanes of 2005. Thus far, however, it has not yet led to the construction of a new reactor, or even a construction permit. Several consortiums are trying to obtain a combined licence for building and operating new reactors. But as they never tire of saying, it will not work without government support. The authorisation process alone for a new reactor series is expected to cost around 500 million dollars. And thus far no one knows how expensive the reactors themselves will be. To remain on the safe side, the companies are calling for subsidies of billions of dollars, which President Bush is now planning. The new energy bill passed by Congress in the summer of 2005 provides 3.1 billion dollars in subsidies for nuclear energy over a period of ten years. Among other risks, the government is thus also supposed to insure against delays. Potential investors had already called for an all-round, care-free package: As conditions for investing, they demanded tax-free financing and subsequent sales of electricity at prices guaranteed by the state. The state is also supposed to assume liability for serious accidents, and not least of all, solve the question of final waste disposal. Following a long delay, the now partially privatised French group EDF named the site for a pilot European Pressurized Water Reactor (EPR) in 2004, namely Flamanville in the departement of Manche. But the usual willingness of the French government to finance such projects has flagged. Former EDF director Francois Roussely has also stated that the reasons for building this type of reactor over the foreseeable future have less to do with generating electricity than with "maintaining European industrial expertise in this field".[13] In other words, the motives for building an EPR pilot plant in France are not based on energy policy but on industrial/political objectives.

Political motives also played a substantial role in the – very controversial – decision by the Finnish Parliament to build a new reactor. The basic thrust came from the country's ever greater appetite for electrical power over the past two decades, which has placed

[13] Francois Roussely, *op.cit.*

Finnish per capita consumption at more than twice the EU average. At the same time, politicians are worried about excessive dependence on Russian gas, and about not being able to meet the country's obligations under the Kyoto Protocol without greater reliance on nuclear energy. The contract awarded to the French/German reactor manufacturer Framatome ANP to build a pilot European Pressurized Water Reactor (EPR) on the Finnish Baltic Sea coast ultimately came from the TWO power utility. The state owns 43 percent of this company. Since construction officially started in August of 2005, the international nuclear community has viewed the Olkiluoto 3 project as proof that nuclear energy is a good investment again, even in a deregulated electricity market. But this position should be viewed with scepticism. It is unlikely that this type of reactor would have had a chance under normal competitive conditions.

Funding was made possible by an agreement which compensated the approximately 60 shareholders, mainly electrical utilities, by guaranteeing that the electricity generated by the reactor would be sold at comparatively high prices. TVO and Framatome ANP also agreed on a fixed price for the finished reactor – "ready for use" – of 3.2 billion euros. This type of contract, as attractive as it is unusual for the purchaser, was made possible because Framatome ANP needed a construction permit at literally any price after more than a decade of development work on the EPR. Even before the first ground was broken, it was clear that the Areva/Siemens manufacturing consortium had made extremely tight calculations in order to boost their prototype reactor out ahead of nuclear as well as fossil fuel competitors.

Reactor capacity steadily increased during the EPR development period in the 1990s. The sheer dimensions were intended to ensure profitability. With a projected capacity of 1,750 megawatts (gross) and an output of 1,600 megawatts, the EPR is by far the most powerful nuclear power plant in the world – which considerably complicates its integration into most electricity grids. A series of additional projections that gave the reactor a competitive edge on paper over other options, including non-nuclear ones, could prove to be a hard pledge to redeem in the future. Promises included a construction period of only 57 months, a load factor of 90 percent, a degree of efficiency of 36 percent, a technical operating life of 60 years, a 15-percent lower consumption of uranium than for earlier reactors, and considerably lower operating and maintenance costs than at existing reactors.

Experts consider every one of these projections to be extremely optimistic. No pilot plant has ever achieved its projected construction period or promised load factor. Nor can this German/French joint venture expect to be spared construction delays, glitches in early operations, or unplanned shutdowns. Despite that, operating and maintenance costs are supposed to be lower than those of existing standard reactors, and that over a service life of 60 years. At the same time, supplementary safety facilities such as the core catcher are supposed to make the EPR safer but not more expensive than its predecessors.

It does not seem possible that all of these promises can be fulfilled in Olkiluoto. Even if all targets are met – such as the construction period – the calculated price of 3.2 billion euros is viewed as massaged. It was originally cited in the context of producing a series of about ten reactors. But this is not even remotely in the cards. In other sectors there is a clear term for this type of pricing behaviour, namely "dumping".

If construction costs should in fact multiply, the project will quickly turn into a financial nightmare for Framatome ANP due to the fixed price agreed with the Finnish customers. A cry for help to the state will not be long in coming. This was already the case in securing the financing. The Bayerische Landesbank played a significant role here. The State of Bavaria owns fifty percent of this bank, and it is headquartered in Munich, as is the reactor builder Siemens. The bank is a partner in an international consortium that is backing a low-interest loan for the Finnish EPR (at a reported rate of 2.6 percent) of 1.95 billion euros. The French government is supporting the Framatome ANP parent company Areva with an export loan guarantee – actually reserved for investments in politically and economically unstable countries – of 610 million euros via the export loan agency Coface. Given these concerted efforts by several countries with special interests in the project, the European Renewable Energies Federation (EREF) has filed a complaint with the EU Commission alleging violation of European rules of competition.

One thing is clear: Without state support, a different decision would have been made about the Finnish reactor as well. In this case, support came from both the builders' and purchaser's countries. Nuclear energy is evidently only competitive where it receives considerable subsidies. Or in countries where nuclear technology is more or less anchored in state doctrine, and consequently where costs play a subordinate role. Thus wherever plans are afoot to build new reactors in functioning market economies, we must expect that investors will rely on state support: to insure against increased construction costs, unanticipated down times, fluctuations in fuel costs, and the difficulty of estimating shutdown, dismantling, and waste disposal costs. Ultimately, governments will have to deal with the consequences of every serious accident involving a massive release of radioactivity. No country in the world can do that alone. While insurance companies issue policies that differ from country to country based on respective anticipated total costs, the share of damages they will assume in every case is ridiculously small.

Nuclear technology thus occupies an absolutely unique position. Half a century after entering commercial markets, fuelled by subsidies in the billions, it still requires and receives state support for every new project – precisely as if it needed assistance to enter the market for the first time. Astonishingly, this extraordinary practice is also advocated and demanded precisely by those politicians who otherwise cannot call loudly enough for "more market conditions" in the energy sector. In many industrial countries, these very same politicians produce market theory arguments to campaign against subsidising the actual launch of renewable energy from solar, wind, hydro, biomass and geothermal sources. But there is yet another essential difference: The future of nuclear energy is past, whereas the future of renewable energies is just beginning.

10 Conclusion: Renaissance of statements

Influenced by growing climate and energy crises, a new round of debate over nuclear energy has opened in a number of the world's major countries. Encouraged by reactor vendors and their amplifiers in the media, the vision of a "renaissance of nuclear energy" is also an expression of the imminent need for far-reaching decisions. Most of the world's plants built during the first and thus far last boom in nuclear energy are approaching the end of their projected service lives. Over the next ten years, and especially in the decade thereafter, rapidly shrinking nuclear power output will have to be replaced. Decisions will have to be made whether to build new, non-nuclear power plants or to extend nuclear-based electricity generation on into the future. Some major countries are already questioning whether they want to keep their ageing reactors on the grid beyond the originally projected operating lives. Extensions are attractive for electrical utility companies which can thus postpone billion-euro investment decisions and profit from the cheap production costs of depreciated old reactors. Managers view the inevitable additional risk in subjective terms. They do not expect a serious accident, surely not at a nuclear power plant run by their own company, and certainly not at one under their own direction. Here is where their interests differ from that of the public. Extending reactor service lives creates a disproportionate risk of disaster. If all or many nuclear power plants are operated for longer periods of time, the total risk rises substantially.

These upcoming decisions on how to sustain global energy supply in a world marked by high population growth and extreme discrepancies in wealth extend far beyond the question of how to deal with nuclear energy in the future. Responsibility is borne by all developed industrial countries and many newly developed countries which have not yet made any or significant use of nuclear power. One thing is clear: The new energy structure will no longer depend exclusively, and probably no longer primarily, on large power plants. Another thing is clear: The future does not lie in resuscitating risky technology from the middle of the last century based on traditional energy economic interests.

There has yet to be a renaissance of nuclear energy. Instead, there is a renaissance of statements about nuclear energy. The upcoming twentieth anniversary of the Chernobyl disaster has also provoked a renaissance of criticism of this type of energy generation – and for some people, a renaissance of hope. Social and political debate has been rekindled in a number of countries that will shape the future of nuclear energy. The outcome of this debate is unclear. A single nuclear power project in Finland proves nothing. The number of new construction projects announced around the world is not even enough to keep the global share of nuclear power constant, either in absolute terms or even less so in relative terms. New nuclear power plants have thus far only been built where state doctrine supports this type of electricity generation, or where state agencies are willing to provide primary insurance against both safety and financial risks. Those who want to build new nuclear power plants – or are urged to do so by politicians such as in the USA – need government assistance almost as much as did the nuclear pioneers back in the 1960s.

It sounds paradoxical: Nuclear energy was successfully introduced to the market because there was not enough of a market to make it uneconomical. Because of the grid monopoly at the time, electricity supply was considered a "natural monopoly", and it was also considered a basic necessity of life and as such was sustained by state-owned, state-supported, or at any rate monopoly-like companies. This meant that in most industrialised countries, the state also set the tone for the introduction of nuclear energy, initially for either overt or covert military reasons and later for partially or exclusively industrial reasons. The government assumed the enormous costs for researching, developing and introducing the new technology to the market, either directly or by shifting the costs to consumers via its ability to influence prices charged by the utility companies. To this day, building new nuclear power plants is not an attractive option for these companies in deregulated electricity markets.[14] There are less expensive options that do not carry anywhere near the same type of economic risks. This is why no new nuclear power plants will be built under market conditions even if overall demand for electricity as well as overall power capacities increase – unless governments again assume the major risks as they once did to introduce nuclear power. This is the route the Finns are taking. Another reason why this route is not generally available is because in a functioning plant vendors' market, competitors from other branches will not stand on the sidelines for long and simply watch the state provide one-sided support for technology half a century old. The Finnish project is also unique because nearly twenty years after launching development on the European Pressurized Water Reactor, the Framatome ANP builder finally needed to demonstrate its technology in an actual reactor, and its parent companies Areva and Siemens were apparently willing to assume considerable financial risks in order to do so. If we recall, in 1992 Siemens and Framatome called the reactor a "German/French nuclear power plant for Europe and the global market", which would first serve the "home markets" on either side of the Rhine, and later take over "third countries". Construction was supposed to start on the two pilot reactors by 1998. And in 1990, the German magazine *Wirtschaftswoche* had already announced the end of nuclear stagnation under the headline "Nuclear Renaissance".

At the start of the 21st century, balanced assessment of all aspects of nuclear energy continues to yield a clear conclusion. It is essentially the same conclusion as that of 30 years ago. The risk of catastrophic accident, which made nuclear energy the most controversial form of electricity generation back then, has not disappeared. New risks from terrorism categorically prohibit the prospect of extending this technology to unstable regions of the world. Expanding nuclear electricity generation on a global basis would lead to a shortage of uranium fuel even faster than will maintaining the status quo – or it would require widespread conversion to breeder technology. A technical re-orientation of this type would be effectively the same as a permanent switch to plutonium systems. It would raise the risk of catastrophic accidents, terrorist attacks, and weapons proliferation to a higher and more critical level. After all, almost all countries have already abandoned the breeder route following setbacks in the past. With or without breeder technology, the final disposal problem also remains to be solved. It will have to be solved, because the problem – which is to say the waste – is already in the world. But it can only be a relative solution. This alone would be sufficient reason not to exacerbate a major problem for humanity by increasing the volume of waste.

Nuclear energy cannot solve the climate problem either. Even tripling global nuclear capacity by the middle of the 21st century would only modestly ease the strain on the climate. And it would be as unrealistic as it is irresponsible, due to insufficient industrial capacities, enormous costs, and far greater risks. It is much more likely, and early indications are already present, that due to the age structure of existing plants, global reactor output will decline significantly over the coming decades. At the same time, there are robust estimates that a global energy strategy relying primarily on greater efficiency in energy management, industry, the transport sector and heating, as well as resolute development of renewable energies, is capable of meeting the reductions in CO_2 emissions demanded by climate experts – without recourse to nuclear energy. The associated

[14] Adolf Hüttl: "Ein deutsch-französisches Kernkraftwerk für Europa und den Weltmarkt", speech given at the winter session of the Deutsches Atomforum, Bonn 1992, manuscript.

challenges are admittedly unprecedented and require no less than a global climate policy shared by all major greenhouse gas-producing countries. The purported core conflict of "climate protection or nuclear phase-out" remains – aside from special regional or temporal cases – a chimera spawned by the nuclear energy industry.

We have seen that there will not be a nuclear renaissance in the foreseeable future without massive government subsidies. This does not exclude the possibility. For although utility companies seek to profit from old, depreciated investments, politicians are even more eager to re-open the subject of nuclear energy, as they fear galloping energy prices and anticipate stricter climate controls. These two fears have fuelled debate in the USA for years now, triggered construction of the new reactor in Finland, stalled the nuclear phase-out in Germany, and recently promoted discussion of new plants in Great Britain. Politicians tend to continue working with the structures and the actors that they find familiar. Many of them will therefore not be reluctant to grant start-up subsidies to the nuclear energy industry yet again, more than half a century after the launch of commercial nuclear power plants – as if this were the most normal thing in the world.

Given half a chance, the new reactor debate will heat up. But new reactors will not contribute to a sustained reduction in global warming, nor will they be able to keep energy prices down over the long term. Instead, they will further exacerbate risk of catastrophic accident and divert attention from climate protection strategies that will truly work. In summary: As in the heyday of the first nuclear energy debates in the 1970s and 1980s, anti-nuclear forces will have the better arguments on their side.

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