Nuclear reactor hazards: ongoing dangers of operating nuclear technology in the 21st Century.

Report prepared for Greenpeace International

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Executive summary

This report gives a comprehensive assessment of the hazards of operational reactors, new "evolutionary" designs and future reactor concepts. It also addresses the risks associated with the management of spent nuclear fuel. The first part of the report describes the characteristics and inherent flaws of the main reactor designs in operation today; the second part assesses the risks associated to new designs; the third part the "ageing" of operational reactors; the fourth part the terrorist threat to nuclear power and the fifth and final part the risks associated with climate change impacts – such as flooding – on nuclear power.

The main conclusions are:

- All operational reactors have very serious inherent safety flaws which cannot be eliminated by safety upgrading;
- A major accident in a light-water reactor – the large majority of the reactors – can lead to radioactive releases equivalent to several times the release at Chernobyl and about 1000 times that released by a fission weapon. Relocation of the population can become necessary for large areas (up to 100,000 km²). The number of cancer deaths could exceed 1 million;
- New reactor lines are envisaged which are heralded as fundamentally safe. However, apart from having their own specific safety problems, those new reactors would require enormous sums for their development, with uncertain outcome;
- The average age of the world's reactors is 21 years and many countries are planning to extend the lifetime of their reactors

beyond the original design lifetime. This leads to the degradation of critical components and the increase of severe incidents. The age-related degradation mechanisms are not well understood and difficult to predict;

- De-regulation (liberalization) of electricity markets has pushed nuclear utilities to decrease safety-related investments and limit staff. Utilities are also upgrading their reactors by increasing reactor pressure and operational temperature and the burn-up of the fuel. This accelerates ageing and decreases safety margins. Nuclear regulators are not always able to fully cope with this new regime;
- Highly radioactive spent fuel mostly is stored employing active cooling. If this fails, this could lead to a major release of radioactivity, far more important than the 1986 Chernobyl accident;
- Reactors cannot be sufficiently protected against a terrorist threat. There are several scenarios – aside from a crash of an airliner on the reactor building – which could lead to a major accident;
- Climate change impacts, such as flooding, sea level rises and extreme droughts, seriously increase nuclear risks.

Ageing

There is general consensus that the extension of the life of reactors is of the foremost importance today for the nuclear industry. The International Atomic Energy Agency (IAEA) pointedly sums it up as follows: "If there are no changes in policy towards nuclear power, plant lifetime is the single most important determinant of nuclear electricity production in the coming decade."

Across the world over the last two decades there has been a general trend against ordering new reactors. As a consequence, the average age of nuclear reactors around the world has increased year on year and is now 21.

At the time of their construction it was assumed that these reactors would not operate beyond 40 years. However, in order to maximize profits, lifetime extension offers an attractive proposition for the nuclear operators.

Ageing processes are difficult to detect because they usually occur on the microscopic level of the inner structure of materials. They frequently become apparent only after a component failure, for example when pipe breakages have occurred.

The consequences of ageing can roughly be described as two-fold. Firstly, the number of incidents and reportable events at an nuclear power plant (NPP) will increase – small leakages, cracks, short-circuits due to cable failure etc. Secondly, the aging process is leading to the gradual weakening of materials that could lead to catastrophic failures of components with subsequent severe radioactive releases. Most notable among these is the embrittlement of the reactor pressure vessel, which increases the risk of the vessel bursting. Failure of the pressure vessel of a PWR or a BWR constitutes an accident beyond the design basis for which there is no safety system – inevitably leading to a catastrophic release of radioactive material to the environment. As the world's nuclear power plants get older, there are efforts to play down the role of ageing. Those efforts include conveniently narrowing the definition of ageing. Furthermore, the most basic and severe shortcoming of international regulatory norms resides in the fact that no country has a comprehensive set of technical criteria for deciding when further operation of a nuclear power plant is no longer permitted. As a consequence reactors are being allowed to operate longer. It is clear that the risk of a nuclear accident grows significantly each year, once a nuclear power plant has been in operation for about two decades.

Terrorist Threats to Nuclear Power Plants:

Even before the attacks in New York and Washington in 2001, concerns had been raised over the risk of nuclear facilities from terrorist attacks. Nuclear facilities have been targeted in the past leading to their destruction – such as the attack by Israel on the Osirak reactor in Iraq. The threats to nuclear power plants from terrorist attacks and acts of war can be summarized as follows:

- Because of their importance for the electricity supply system, the severe consequences of radioactive releases as well as because of their symbolic character, nuclear power plants are "attractive" targets for terrorist as well as for military attacks.
- An attack on a nuclear power plant can lead to radioactive releases equivalent to several times the release at Chernobyl. Relocation of the population can become necessary for large areas (up to 100,000 km^2). The number of cancer deaths could exceed 1 million.
- Nuclear power plants could be targets in case of war if a military use is suspected.
- The spectrum of possible modes of attack is very diverse. Attacks could be performed by air, on the ground and from the water. Different means/weapons can be used.
- Protective measures against terror attacks are of very limited use. Furthermore, a number of conceivable measures cannot be implemented in a democratic society.

Reprocessing Plants and Spent Fuel Storage Areas.

The amount of plutonium in storage is steadily increasing. While the US and Russia agreed to dispose each of 34 tons of "excess" weapons grade plutonium, the world's "civil" plutonium stockpile exceeds 230 tons. As of the end of 2002, the largest holder of plutonium is the UK with over 90 tons, followed by France with 80 tons and Russia with over 37 tons. Plutonium has two particular characteristics; it is of high strategic value as primary weapon ingredient and it is highly radiotoxic. A few kilograms are sufficient in order to manufacture a simple nuclear weapon with only a few micrograms inhaled sufficient to develop cancer.

Climate Change and Nuclear Technology

About 700 natural hazardous events were registered globally in 2003. Three hundred of these events were storms and severe weather events, and about 200 were major flood events. These unusual severe weather events impact upon nuclear power operation by causing flooding or draughts affecting the cooling or other safety systems. In addition, storms can directly impact upon nuclear operation or indirectly, by damaging the electricity grids. Heavy storms can lead to multiple damage of the transmission lines, and hence to loss of off-site power.

Every nuclear power plant has emergency power supplies, which are often diesel-driven. However, emergency power systems with diesel generator are notoriously trouble-prone. If the emergency diesel generators fail, the situation at the plant becomes critical ("station blackout"). A station blackout at a nuclear power station is a major contributor to severe core damage frequency. Without electricity the operator looses instrumentation and control power leading to an inability to cool the reactor core. A natural disaster that disables the incoming power lines to a nuclear power station coupled with the failure of on-site emergency generators can result in severe accident.

Ageing, Plant Life Extension (PLEX) and Safety

With very few exceptions, it appears the economy triumphs over safety and PLEX programs are implemented. The situation is particularly grave since such a program generally can only make economic sense for plant owners if the plant is operated for one or two more decades after its implementation.

PLEX therefore creates strong pressure to keep a nuclear power plant on the grid, to get an adequate return on the investment, and to ignore or play down the hazards of ageing. This pressure is strengthened if further money has been spent on power uprating. In addition, there is pressure to keep expenses for PLEX programs as low as possible.

All this is happening in an economic context of liberalization of the energy economy, general cost pressure and increasing competition, which is leading to decreasing safety margins, personnel reductions and reduced efforts for inspection and maintenance – whereas the trend towards an ageing nuclear power plant population would require exactly the opposite.

At the same time, safety margins are further reduced by power uprating and increasing fuel burnup.

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