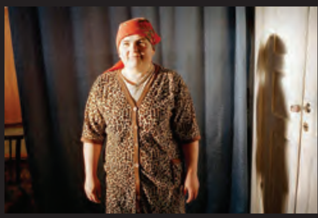

25 years after the Chernobyl catastrophe, some people say that things are getting better. Some people say that there aren't any problems, anymore.
Nadiya doesn't agree.
Chernobyl 25 yrs

Chernobyl 25 yrs

Case Study



Nadiya Fedorivna Ogievych

Date of birth :: 23 April 1967

Family :: A husband, and three children born between 1989 and 1995

Half a litre of milk sampled by the team from Greenpeace International during our 2011 field trip was found to be 6.5 times above the radiological limits permitted in Ukraine. So the team decided to visit the home of the Ogievych family, who had provided this milk for our sampling.

Two tall circular haystacks decorate the front yard of the family's property in Drozdyn, a village in the northwest of Ukraine. As we approached the house, the characteristic beeping sound of our gamma spectrometer was triggered and it would not calm down. The haystacks contained caesium-137 and were exhibiting up to six times higher radiation levels than their background surroundings.

Nadiya Ogievych listens to the sound of the gamma spectrometer calmly, and looks at the food for her cows with regret. She is not surprised.

"This hay was collected from a place close to the village, about six to seven kilometres away. Another place is about a kilometre from here, in a swampy area. But these are the only places, where we can actually collect vegetation during June and July to prepare the hay. We know it's contaminated, that the levels of radiation are high – they've been measured before. But we don't have any other sites where we can collect hay for our cows for the winter."

Swampy areas are places known to accumulate radionuclides. If vegetation collected from these contaminated areas is turned into hay and given to cows on a regular basis, the radionuclides will also accumulate in the animal and be transported into their milk. If people drink this milk, the long-term accumulation of radioactivity in human bodies can lead to many severe illnesses.

"I'm also affected and I'm under treatment for the radiation that's in my body. I have a bladder problem, which is officially certified as a consequence of the Chernobyl catastrophe; I carry the certificate of a Chernobyl Invalid. I lost one of my kidneys; the one that remains is infected with cystitis. For my treatment, I travel to Rivne, the capital of Rivnenska Oblast, from time to time. I stay at the hospital there and I receive medication."

"The Chernobyl catastrophe changed my life significantly. First of all, it affected the health of my three children - all of them are ill and they all suffer from really bad headaches. They also have blood vessel dystonia, which causes blood circulation problems. I'm suffering from the same problems. Every time my family goes to the clinic in Rokytne to have our internal radiation levels measured, we always exceed the doses allowable for the human body."

As subsistence farmers, changing their way of life after the catastrophe wasn't an option.

"We didn't change anything in our daily routine. We grow vegetables and we eat everything we grow, because there's no other way for us to obtain our food. We collect berries and mushrooms, which we eat but we also sell in the market. This is how we live and this is how we can get money.

There are places in the markets where we can check the radioactivity of our food. If the products exceed the limits, they're not accepted for sale. In the past, I used to sell a lot of mushrooms, but I'm not selling many now. Several times, when I brought them to the market, high levels of radiation were detected and they were not accepted for sale. From time to time, we get a list from our sanitation station about the products they're testing for radiation levels. Ours always exceed the permitted levels.

We just cope here as much as we can. This is the situation we live with"

We asked Nadiya whether she remembers when they were informed about the Chernobyl catastrophe. She couldn't remember precisely how long it was before they knew what had happened, but she did remember that there wasn't enough information available at first:

"Everybody was panicking. Everybody thought that possibly, within a year, everybody would die and that something dangerous and horrible had happened here."

25 years after the Chernobyl catastrophe, some people say that things are getting better. Some people say that there aren't any problems, anymore. Nadiya doesn't agree.

For now, Nadiya is looking forward to the end of winter.

"I just accept things as they are. Winter is winter, summer is summer. This is nature and I love every minute of it."

Mykola has received many medals for his work as a liquidator, cleaning up the consequences of the Chernobyl accident.

But these don't help him in everyday life.

Chernobyl 25 yrs

Case Study

Mykola Isaiev

Date of birth :: 29 April 1955
Family :: A wife, and two children born in 1981 and 1985

Mykola Isaiev was one of the liquidators in charge of cleaning up the consequences of the Chernobyl accident in 1986. He worked in Chernobyl from 1977 until 1991. Today he suffers from heavy allergies, asthma, ischemia, pancreatic diabetes and hepatitis. He spends around two months in hospital every couple of months.

"On the day before the accident, my shift ended at 8pm. The next morning, I saw the damaged reactor from my house but I still went to work - everyone thought that we'd be told if something bad had happened. There's a good emergency service in operation."

When Mykola arrived at work, he knew that something bad indeed had happened. He tried to call his family, to tell them to get out, but all of the telephone connections were down.

"On 27 April my family was evacuated from Pripyat by a special evacuation team, who were kitted out in protection suits that scared everybody who saw them. People were told not to take anything with them, since things could be radioactive. My wife told me later that the buses they had been put on stopped at every village along the way, and she was asked whether she wanted to live there."

When he went to Kiev at the end of April to inquire about his family's whereabouts, the names of his wife and their two children didn't appear on any of the lists. Fortunately, the Head of the Chernobyl plant had given him a letter that stated that he was looking for his family and should therefore be allowed to use any means of transport for free. In May, he was able to briefly reunite with his family.

"I was shocked. They hadn't had any health checks. My grandmother had stored their clothes on the balcony. I was angry, I had been forced to sign a document to stay at the plant and help clean everything up. At the same time, it was guaranteed that my family would receive help - but the government provided them with nothing. The hospital gave them some food and vitamins. The doctors suggested keeping the evacuees inside, to prevent a panic -people simply didn't know what the results of being exposed to the radiation might be, and they were afraid of anyone who had been in the area."

Mykola returned to Chernobyl to continue his work. At the end of July, the radiation dose he had received during this work was so high that his eyes, nose and lungs suffered from burns and he was sent away for a while. At this time, he and his family were supposed to get an apartment in Kiev.

"There were large numbers of people waiting for apartments to live in. When Boris Yeltsin arrived, and he saw the huge queues, he said 'They must all be given an apartment immediately, or there will be consequences'. The next day, I had a set of door keys in my hands."

As far as their personal belongings were concerned, he only saved a couple of things – including his favourite book, James Fenimore Cooper's 'The Last of the Mohicans', and the family's fridge. Even though the fridge was determined to be safe, he nevertheless preferred to keep it out on the balcony.

Mykola has received many medals for his work as a liquidator, but these don't help him in everyday life.

"Since 2011, liquidators don't receive free medicine anymore, and we have to pay for our operations. Of the 4,800 liquidators in this area of Kiev, only 1% receives rehabilitation. 45,000 people have still not been allocated a permanent apartment and of those, 15,000 are officially certified as Chernobyl Invalids. The current government wants to cancel all of our benefits. Paragraph 16 of the Constitution states that it is the duty of the state to overcome the consequences of the Chernobyl catastrophe, and this includes taking care of people impacted by Chernobyl. It's a nice law in writing, but in practice it's just not fulfilled."

When he realised that the rights of the Chernobyl victims were not being upheld, Mykola started to work with various NGOs. In 1991, he set up the Union of Chernobyl Victims and became its Head. Today, he is the vice president of the Chernobyl People's Party of the Ukraine, founded in 1998 to exert pressure on the government.

Chernobyl 25 yrs

01

Summary

In the early morning of 26 April 1986, a major nuclear accident occurred in reactor number 4 at the Chernobyl nuclear power station in Ukraine, then part of the USSR. Releasing several hundred times more radiation into the atmosphere than the atomic bombs that were dropped on Hiroshima and Nagasaki, the reactor's explosion and subsequent burning went down in history as the world's worst civilian nuclear accident to date. The consequences were felt across Europe – and persist even today, 25 years later.

26 April 1986, 1:23am

Within moments, a reactor systems test turns into a disaster

What triggered the explosion at the Chernobyl nuclear power plant was initially scheduled as a test. The plant's operating crew had planned to find out whether, in the event of a loss of power, the reactor's turbines could deliver sufficient energy to keep the coolant pumps running until the emergency diesel generator was activated. However, to meet regional power demand - especially around the evening peak - the experiment, which required a substantial decrease in the plant's output, was postponed from its original daytime slot, into the night.

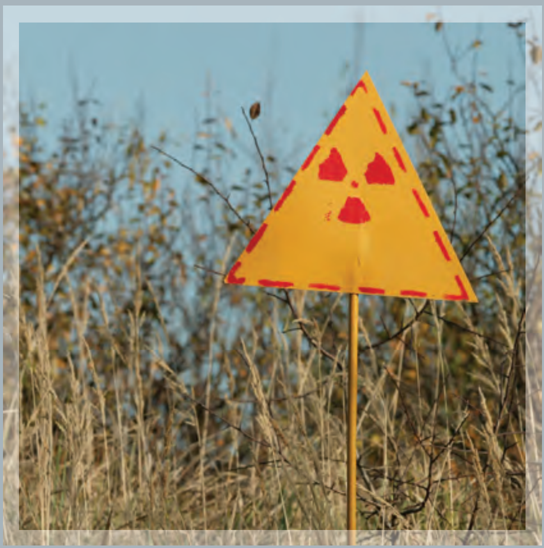
Before the time the test finally commenced, at 1:23am, the specially trained team had already left its shift. Safety systems had also been switched off deliberately. Shortly after the experiment began, the reactor went out of control. Fuel elements ruptured; a violent explosion blew off the building's thousand-tonne sealing cap. Fuel rods melted as temperatures rose to over 2,000°C. Then, the reactor's graphite ignited - the resulting fire burnt for nine days.

© GREENPEACE / STEVE MORGAN

Attempts to extinguish the fire last for days; a 'sarcophagus' is built to contain the damaged reactor

Initial attempts to extinguish the burning reactor involved firefighters pouring cooling water into the reactor. This was abandoned after 10 hours. From 27 April to 5 May, military helicopters flew over the burning site, dropping 2,400 tonnes of lead and 1,800 tonnes of sand to try to smother the fire and absorb the radiation. These efforts were also unsuccessful. In fact, they made the situation worse: heat accumulated beneath the dumped materials. The temperature in the reactor rose again, along with the quantity of radiation emerging from it. In the final phase of firefighting, the core of the reactor was cooled with nitrogen. Not until 6 May were the fire and the radioactive emissions under control.

Eight months after the accident occurred, in November 1986, a concrete 'sarcophagus' comprising 7,000 tonnes of steel and 410,000 cubic metres of concrete was built around the stricken reactor, in order to halt the release of further radiation into the atmosphere. Three years after the nuclear accident, the Soviet government halted construction of the fifth and sixth reactor units at the Chernobyl nuclear power complex. After prolonged international negotiations, the entire complex was closed on 12 December 2000, 14 years after the accident.



01

Widespread contamination, resettlements, long-term health impacts – the consequences of the worst civilian nuclear accident to date

It has been estimated that the accident at Chernobyl released several hundred times more radiation into the atmosphere than the atomic bombs that were dropped on Hiroshima and Nagasaki. This resulted in the contamination of vast areas of land and affected millions of people. Most radiation was released during the first 10 days. Variable weather conditions in the days following the accident led to contamination falling over large parts of Scandinavia, Greece, central and eastern Europe, southern Germany, Switzerland, northern France and the UK. Between 125,000 and 150,000 square kilometres of land in Belarus, Russia and the Ukraine were contaminated to levels requiring the evacuation of people or the imposition of serious restrictions such as land use and food production. The land area affected is roughly equivalent to the area of Bangladesh, or nearly five times the size of the Netherlands. At the time of the accident, 7 million people (including 3 million children) were living in these areas. About 350,000 of them were resettled or left the affected area.

From a long-term perspective, the most significant form of contamination is with caesium-137. Given its half-life of 30 years, it will take several centuries for the radioactive pollution to decay. Levels of radioactive caesium high enough to require state intervention can still be found as far away from Chernobyl as Scotland, Lapland and Greece. Along with continued radioactive contamination, the related health impacts will also persist for several decades. A study commissioned by Greenpeace in 2006 - to coincide with the 20th anniversary of Chernobyl -estimated, based on Belarus national cancer statistics, that approximately 270,000 cancers and 93,000 fatal cancer cases will be caused by Chernobyl[1].

25 years after the explosion – what is the situation in the area surrounding the Chernobyl reactor today?

There are few significant signs of improvement of the situation. Although at first sight nature in the area surrounding the reactor appears to be recovering, scientific research has shown continuing impacts on flora and fauna in the most contaminated areas. People have started to move back to the villages and fields they had abandoned – despite evidence that they continue to be dangerous places to live in. In 2006, Greenpeace took samples in the village of Bober, outside the exclusion zone, and analysis revealed levels of radioactive contamination 20 times higher than the threshold used in the EU to define dangerous radioactive waste.

There are plans to use the Chernobyl site as a central 'temporary' storage area for spent nuclear fuel – a form of highly radioactive nuclear waste. The nuclear industry refers to this contaminated area as a 'sacrifice zone'. Plans have been mentioned to dump dangerously radioactive nuclear waste where people continue to live with, and suffer from, the effects of Chernobyl.

Soviet scientists estimated the lifetime of the 'sarcophagus' that contains the reactor at between 20 and 30 years when it was built, but its rapid deterioration could lead to its collapse into the melted reactor core, precipitating a second massive release of radioactivity.

A new sarcophagus costing around $1.2bn US dollars is now in preparation, but the project has already run into trouble. The European Commission has admitted that parts of the project are already running at double the initially estimated costs, partly due to 'some delays'. Governments around the world are being asked to find up to €750m to help the building effort, but – given the ongoing financial crisis and strained national budgets – many appear somewhat reluctant. The European Bank for Reconstruction and Development, which has been overseeing the spending on Chernobyl, admitted squeezing out more money at this time was a 'big challenge'.

1 http://www.greenpeace.org/international/en/press/releases/greenpeace-new-study-reveals-d/

Chernobyl 25 yrs

02

Nuclear reactors - a ticking time-bomb

Chernobyl was the world's worst civilian nuclear accident to date. Yet, it is by no means the only one. The history of nuclear energy is a history of accidents, right up to today – from partial meltdowns to radioactive leaks to internal system failures. Records show that these accidents are not confined to a particular time, country or reactor type. This underlines what Greenpeace has been warning for decades: Nuclear energy is inherently dangerous.

Serious accidents have occurred since Chernobyl, also in 'western-type' reactors

Since Chernobyl, nearly 800 significant leaks accidents have been officially reported to the International Atomic Energy Agency (IAEA). The agency developed a mechanism, the INES system, to classify the problems[1]. Problems are classified and distinguished on a scale of 0 to 7, on the basis of the level of impact they have on people and the environment, as well as which safety or security systems were breached.

While the Chernobyl catastrophe remains the only accident of the highest 7th level, there have been a number of other accidents and incidents officially reported:

- 4 at level 4 occurred in Japan, India, Belgium and Egypt
- 31 at level 3 (of which 12 occurred at nuclear reactors) in 19 countries including Sweden, US, Russia, China, Spain, France and the UK
- 254 at level 2 (of which 132 occurred at nuclear reactors) in 34 countries

1 For overview see: www.iaea.org/Publications/Factsheets/English/ines.pdf

Chernobyl was a combination of human failure and technological malfunction, and the disaster reached its high rating due to a sequence of smaller failures. Similar patterns can be observed in other historical accidents. There has always been a mix of numerous factors; political or economic pressure on the operator often playing a role. Therefore, it is only a matter of chance whether the combination of smaller mistakes and failures leads to a major disaster, or a limited incident. Below are several examples of recent nuclear accidents that happened long after Chernobyl, and long after its lessons were supposed to have been learned by the industry.

Recent nuclear accidents – the industry hasn't learned from Chernobyl

Shika (Japan), 1999 – During routine testing of the safety systems, three control rods dropped out of the reactor core and triggered uncontrolled nuclear reactions. The emergency system subsequently failed and operators had to manage the problem manually, which took them 15 minutes. This happened during refueling and with a reactor vessel being opened, leaving doors open to potential leakage of radiation. The accident was kept under carpet and only reported to national nuclear regulator eight years later.

Tokai Mura (Japan), September 1999 – There was a serious accident at the facility for nuclear fuel production. Three workers grossly violated safety procedures: they used uranium enriched to 19% instead of the required 3% to 5%, and they poured an entire 16 kg - instead of the prescribed 2.4kg - of its solution into the container. As a result, it reached criticality and an uncontrolled nuclear reaction was triggered. Intensive radiation was emitted, hitting not only the workers but also the local area, where thousands of unsuspecting citizens were living. It took nearly an hour for the company to realise and admit to what had happened, and to inform authorities. It was several hours before households were evacuated. The radiation at the fence of the facility exceeded normal levels more than 15,000 times. The characteristics of the accident were similar to those at Chernobyl: a gross violation of safety protocols, a sequence of human errors and a failure to promptly inform authorities and the public about the risk. Investigations also showed that the company was bypassing technological procedures in order to speed up the production, and that there was no emergency protocol for such a type of accident, because nobody thought it was possible.

David-Besse (US), March 2002 – The US, with the world's largest fleet of nuclear power plants, only just avoided a catastrophic accident at the David-Besse reactor in 2002, when it was discovered that corrosion had come very close to penetrating the vital pressure vessel. This was an accident scenario that could eventually have led to a meltdown of the reactor. The vessel was supposed to be inspected regularly, but the corrosion progressed undetected for a decade, with responsible workers convicted of falsifying the inspection protocols and reporting.

Kozlody (Bulgaria), March 2006 – At a modern pressurised water reactor, more than a third of the reactor control rods got stuck and failed to drop, which means that in case of an emergency they would fail to stop the reactor. It took several months for authorities to report the accident, and they tried to downplay its seriousness. Former chair of the Bulgarian nuclear safety authority, Georgi Kaschtschiev, said that significance of the incident was similar to 'driving a train at full speed without functioning breaks'.

Forsmark (Sweden), July 2006 – A nuclear power plant found itself close to a meltdown, following multiple failures. After a short circuit outside the plant, the supply of electricity needed for the reactor operation (such as safety systems and cooling pumps) failed and the reactor at unit 1 was shut down[2]. But a large nuclear reactor, even if shut down, still requires lots of power to actively cool the hot nuclear fuel, and to keep the control systems running. In this case, two of the four back-up diesel generators failed. This resulted in partial blackout inside the power plant, during which the operators were struggling to keep the reactor under control, as many of the measuring devices did not work and control screens went blank. It took 22 minutes before they managed to get the situation under control again. If it had continued any longer, a meltdown could have occurred. A former employee at Forsmark, Lars-Olov Höglund, said that without power the temperature would have been too high after 30 minutes and the reactor would have been damaged. Within two hours there would have been a meltdown. The Swedish Nuclear Power Inspectorate puts that limit at eight hours instead of two. Subsequent checks found that also other Swedish reactors suffered from a similar problem that had previously gone undetected.

Kashiwazaki-Kariwa (Japan), July 2007 – An earthquake reaching 6.7 on the Richter scale hit the largest nuclear power plant in the world, consisting of seven large reactors on the Japanese western coastline. None of the reactors was design to withstand such a strong earthquake, as the location was claimed to be free of large tectonic failures and such a scale of movement was considered impossible. The damaged roads and infrastructure also meant that it took firefighters several hours before they could get the situation under control, and a large=scale emergency evacuation could have been impossible. Damage to the nuclear power plant resulted in its long-term shutdown. Several of its reactors are still not in operation today.

New generation of nuclear reactors still not safe

Nuclear reactors may have undergone modernisation since the Chernobyl accident, but the root causes of the technology's vulnerability to accidents remain the same: unexpected technological failures, operator error, lack of transparency in the industry as a whole, economic or political pressures, and potential terrorist attacks.

The new 'third generation' nuclear reactors are intended to be passively safe but their development already shows signs of turning into a fiasco. The French EPR reactors being built in Flamanville 3 (France) and Olkiuloto 3 (Finland) were promoted as flagships of a new nuclear boom. However, four years into the construction of Olkiuloto 3, the Finnish nuclear safety authority already identified over 3,000 quality and safety defects. Construction defects aside, nuclear regulatory authorities in several countries are raising concerns even about the blueprint of the reactor. Some of these could increase the risk of a severe accident. Similarly, numerous issues were already raised about the newest US reactor design, AP1000 – although there is not yet any reliable experience with its construction.

Apart from design and construction problems, these new generation nuclear reactors present safety hazards; higher levels of radioactivity that could be released in case of a major accident due to the reactors' unprecedented size and their usage of high burn-up nuclear fuel, both of which are driven by the desire to improve their economics.

2 See note from the Swedish Nuclear Training and Safety Center: http://www.analys.se/lankar/Engelsk/Publications/Bkgr1-07%20Forsmark%20Eng.pdf

03

The conflict between nuclear and renewable energy

Nuclear energy is sometimes portrayed as a useful instrument in combating climate change, mainly by the nuclear industry itself. This is not the case. On the contrary, as research by Greenpeace and others shows, the continued operation of nuclear power plants prevents a large-scale integration of renewable energy into the electricity grid, and channels investment away from where it can actually make a difference to the climate.

There is another conflict emerging between renewable energy and dirty energy (which includes nuclear energy and CCS - carbon capture and storage); access to subsidies for so-called 'low-carbon technologies'. Especially in the UK, the government and nuclear lobby is arguing for a 'level playing field' between low-carbon technologies, so that nuclear and CCS get similar support as renewable energy.

The fight against climate change requires a transformation of the energy sector

Supporters of nuclear energy like to portray the sector as a climate-friendly alternative to fossil fuels. They refer, mainly, to a nuclear power plant's relatively low carbon dioxide (CO_2) emissions, compared to a coal-fired power station for example. Some even believe nuclear energy to be the only credible and realistic alternative. Yet, were the entire global fleet of nuclear power plants to be quadrupled in number, a totally unrealistic pro-nuclear vision given the continued decline of nuclear power in the global energy mix, it would at best lead to only a 6% reduction in CO_2 emissions. This would occur long after 2020, the date climate scientists see as the deadline for the reductions that need to be made to keep climate change under control. Besides that, the nuclear industry has still not solved its intrinsic problem of radioactive waste or dealing with the risks from a possible accident, which is shown by the example of Chernobyl.

There is another, more structural problem with nuclear energy as part of the world's energy future. It is now widely agreed that only a restructuring of the world's energy systems - including a transformed electricity grid and a massive uptake in renewable energy - will allow us to keep producing energy while protecting the climate. One such scenario is outlined in Greenpeace's *Energy [R]evolution* report[1], developed in conjunction with more than 30 scientists and engineers worldwide. By competing directly with renewable energy sources – both for access to the electricity grid and for financing – nuclear energy hinders the growth of renewable technology, essentially blocking the way into a climate-protecting, sustainable energy future.

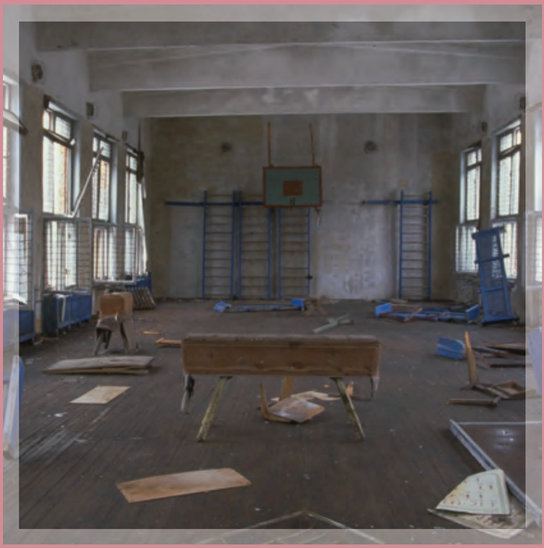
Inherently inflexible, nuclear energy stands in a direct conflict with renewable sources

Generally, nuclear power plants run as so-called 'baseload'. This means that they work most of the time at maximum capacity regardless of how much electricity consumers actually need. For technical and safety reasons, nuclear plants cannot easily be 'turned down'. The fall in electricity demand that accompanied the recent global economic crisis revealed a system conflict in Europe between inflexible 'baseload' power, especially nuclear, and variable renewable sources. Wind operators were told to shut off their generators to give priority to nuclear power plants; an economic and ecological mistake.

In northern Spain and Germany, this uncomfortable mix is already exposing the limits of the grid capacity. If Europe continues to support nuclear energy alongside a growth in renewables, clashes will occur more and more, creating a bloated, inefficient electricity system.

The world needs an energy system based on energy efficiency, a gradual phase-out of fossil fuels - beginning with the most polluting, such as lignite and coal - renewables and state-of-the-art decentralised power stations, as outlined in the *Energy [R]evolution* report. Together these solutions have the potential to reduce CO_2 emissions quicker and cheaper than nuclear power can, while being safer, reliable and globally applicable.

1 http://www.greenpeace.org/international/Global/international/publications/climate/2010/fullreport.pdf



A new grid – replacing a wasteful patchwork of ageing electricity lines with a powerful new network

The base for such a new system would be a highly flexible so-called 'smart grid', as outlined in the 2011 Greenpeace report, *Battle of the Grids*[2]. Such a grid would replace today's uneconomical patchwork of national grids – characterised by big, polluting power stations pumping out constant energy, regardless of consumer need, along wasteful, ageing A/C (alternating current) lines – with a powerful new network. A 'smart grid' would guarantee supply despite extreme weather conditions, delivering green energy across Europe via efficient, largely underground DC (direct current) cables.

To function properly – and to allow the maximum exploitation of the increasingly speedy growth in renewable energy technology – such a grid would have to give priority access to renewable energy sources, such as wind and solar power. Inflexible 'baseload' power, such as nuclear power, would become an obstructing force. In fact, keeping nuclear close to today's levels would have a significant negative economic impact on the overall electricity system, with losses each year estimated to stand at 316TWh, or €32bn.

While some nuclear utilities argue that technical adaptations of nuclear reactors could improve their flexibility in the future, doing so decreases the safety of a reactor and there are clear technical limitations to the speed and frequency of changes in a nuclear system's power output. Furthermore, assuming that nuclear plants would theoretically fully 'fit in' and complement variable renewable sources, as argued by energy utility E.ON, the economics of nuclear would deteriorate dramatically, as detailed in *Battle of the Grids*. This leaves only one option: the urgent phase-out of nuclear energy.

A continued phase-out of nuclear energy is the only genuinely climate-friendly way forward

In Europe, the nuclear energy is declining. Over the last decade, more plants were closed than new ones were added to the mix. Two 'flagship' nuclear power projects being built in Finland and France are facing severe technical problems, causing major delays and cost overruns of some €3bn every year. Large nuclear utilities such as RWE and E.ON are now calling for massive subsidies in the UK before engaging in another expensive nuclear reactor project. Countries that have decided to phase out nuclear energy, such as Sweden and Germany, have reached their greenhouse gas emission reduction targets for 2010 much better than those countries such as Finland who are continuing to invest in new nuclear reactors.

With the right backing, renewable energy technologies could supply 50% of global energy by 2050, as Greenpeace's *Energy [R]evolution* shows in more detail. Renewable technologies are the fastest growing part of the energy sector, already accounting for nearly 17% of the world's energy needs compared to the 2% share from nuclear energy. However, given the finite amount of investment money available, every dollar invested in nuclear energy means a dollar less invested in renewable energy sources. As *Battle of the Grids* shows, these renewable energy sources have been proven capable of replacing several times more carbon for the same cost and at a much faster rate than nuclear energy.

2 http://www.greenpeace.org/international/Global/international/publications/climate/2011/battle%20of%20the%20grids.pdf

03

Renewable energy successes

They don't carry the risk of potentially disastrous accidents. They don't produce dangerous waste. There are no climate-harming carbon dioxide (CO_2) emissions, once they're up and running. Renewable energies are a clean, sustainable alternative to nuclear energy – and they're not just growing faster every year, they're also becoming ever more economically viable.

Predictions by Greenpeace and others show that, if the right decisions are taken, global renewable sources could cover 40% of the energy demand by 2030 and 80% by 2050. For electricity, renewables could deliver close to 100% by 2050.

Rising stars – the growth figures for solar, wind and geothermal power speak for themselves

The renewable energy sector has seen unprecedented growth in the past 25 years. The technologies for solar, wind and geothermal are all advancing rapidly. Both the wind and the solar industry have shown that it is possible for them to maintain growth rates of between 30% and 35% a year. No other part of the energy sector is growing as fast. Examples and illustrations for the sector's current success can be found in countries and regions around the world.

Here are a few selected examples:

- In 2010, new solar photovoltaic (PV) installations of approximately 16,000 MW were added to those in operation, taking the world's PV capacity to almost 40,000 MW
- Nearly 2 million single installations are producing photovoltaic power today. Cumulatively, these installations produced electricity equal to more than half of the demand in Greece in 2010
- On 9 November 2009, Spain generated more than half its electricity demand with wind energy. In the same year, wind overtook coal as the third-largest producer of power in the country
- China built roughly one windmill every hour during 2010
- Global wind power installations increased by 35.8 GW in 2010 - this brings total installed wind energy capacity up to 194.4 GW, a 22.5% increase on the 158.7 GW installed at the end of 2009. The new capacity added in 2010 represents investments worth €47.3bn ($65bn US dollars)
- For the first time in 2010, more than half of all new wind power was added outside of the traditional markets in Europe and North America. The continuing boom in China, which accounted for nearly half the new wind installations (16.5 GW), was the main driver for this. China now has 42.3 GW of wind power, and has surpassed the US in terms of total installed capacity,
- Geothermal power already provides 10% of New Zealand's electricity needs
- In the space of just five years, Portugal's electric grid leapt from 15% to 45% renewables

From here to 2050: How renewable energy can meet the world's energy demand

Greenpeace has long argued that renewable energy has the potential to meet a substantial share of our future energy demand. Our *Energy [R]evolution*[1] scenario details how – combined with energy efficiency and a transformed electricity grid – renewable energy could produce 95% of electricity by 2050. Other studies have made predictions for different time frames or regions. PricewaterhouseCoopers, for example, predicts that Europe and North Africa could run on 100% renewable energy by 2050. The bottom line is always the same.

1 http://www.greenpeace.org/international/Global/international/publications/climate/2010/fullreport.pdf

04

And the world's progress towards such targets looks promising. According to the 2011 European PhotoVoltaic Industry Association (EPIA) and Greenpeace report, *The Solar Generation 6*, PV could already account for 12% of European power demand by 2020, and up to 9% of the global power demand by 2030. At the same time, global investments in the technology could double from €35-40bn today to over €70bn in 2015. Both predictions are strong indicators that the technology is on the brink of an economic breakthrough, making it ever more competitive with more established methods of production. The cost of PV has already dropped significantly in the last few years. By 2015, it is expected to fall by another 40% compared to current levels.

According to *Global Wind Energy Outlook 2010*[2], published by the Global Wind Energy Council and Greenpeace, wind energy could meet 12% of global power demand by 2020, and up to 22% by 2030. The benefits are clear. The 1,000 GW of wind power capacity projected to be installed by 2020 would save as much as 1.5bn tonnes of CO_2 every year. These reductions would represent 50-75% of the cumulative emissions reductions that industrialised countries committed to with their pledges made at the Copenhagen climate conference in 2009. By 2030, a total of 34bn tonnes of CO_2 would be saved by 2,300 GW of wind power capacity.

Meanwhile, governments around the world continue to invest heavily in the sector. In 2009, China overtook the US to become the largest investor in clean energy, investing a staggering $34.6bn US dollars. Today, renewable energy sources still only account for 13% of the world's primary energy demand. The share of renewable energies for electricity generation is 18%, while their contribution to heat supply is around 24%. About 80% of the primary energy supply today still comes from fossil fuels. If the above outlined growth of renewable energy is sustained, however, a very different picture could start emerging very soon.

2 http://www.gwec.net/fileadmin/documents/Publications/GWEO%202010%20final.pdf

3 http://www.greenpeace.org/international/Global/international/planet-2/report/2010/2/renewables-24-7.pdf

4 http://www.greenpeace.org/international/Global/international/publications/climate/2011/battle%20of%20the%20grids.pdf

Cost, risk, waste, time – compared to renewable energy, nuclear energy shows its weaknesses even more obviously

It seems remarkable that, 25 years after Chernobyl, the world is still relying on a costly method of energy production that carries with it the risk of potentially disastrous accidents. In addition, a way to safely dispose of its highly radioactive waste has still not been found. The alternatives are not only available, but also economically viable and experiencing steady economic growth around the world. Compared to renewable energy, the unsuitability of nuclear energy – a stagnating industry that is in decline – to play a role in meeting the world's future energy demands becomes particularly obvious.

In addition to issues of cost, risk and waste, there is the issue of time. Even in developed countries with an established nuclear infrastructure, it takes at least a decade from the decision to build a reactor to the delivery of its first electricity, and often much longer. Even if the world's governments decided to implement strong nuclear expansion now, only a few reactors - if any -would generate electricity before 2020. Renewable energy installations, on the contrary, can often be added within a matter of months.

It is now widely agreed that a sustainable future energy scenario will need to combine ambitious energy efficiency measures, a transformed electricity grid (as outlined in the Greenpeace *reports Renewables 24/7*[3] *(2010)* and *Battle of the Grids*[4] (2011)), and a massive uptake in renewable energy. Together, these solutions have the potential to reduce CO2 emissions faster and more cheaply than nuclear power, while being safer and globally applicable. As detailed in Greenpeace's *Energy [R]evolution* - which has been developed in conjunction with more than 30 scientists and engineers worldwide - there is no place and also no need for nuclear energy in such a low-carbon future energy scenario.

GREENPEACE Greenpeace International, Ottho Heldringstraat 5, 1066 AZ Amsterdam, The Netherlands

Accident liability protection

Conservative estimates put the overall costs of Chernobyl at tens of billions of euros.

25 years after the Chernobyl catastrophe, the nuclear sector is still covered by a confusing patchwork of international liability regimes. Weak or non-existent liability rules are a particular cause for concern in developing countries. Meanwhile, legislation typically caps the liability of reactor operators at a minuscule fraction of the likely cost of a significant nuclear accident. These caps act as implicit subsidies to the nuclear industry and distort the electricity markets.

Nuclear accident liability protection exists because reactor vendors, suppliers and operators believe that Chernobyl-scale accidents are a real possibility. The extent and nature of nuclear accident liability protection varies internationally. As the impacts of a severe nuclear accident can easily cross borders, there are many questions about how – or even if - victims would be compensated in the event of an actual accident.

'The limitation of the amount of this liability is clearly designed as an advantage for the operator, in order not to discourage nuclear-related activities.'

IAEA Explanatory text to the Vienna Convention[1]

Liability limits in context: The costs of Chernobyl

Assessing the actual costs of a disaster such as Chernobyl is no easy task. Estimates vary depending on the scope and interpretation of data, while long-term costs only become apparent over time. Nevertheless, available estimates show the financial responsibility of nuclear operators to be minuscule in comparison to the costs of a large-scale accident.

- Belarus estimates that the cost of Chernobyl on its economy will be $235bn US dollars by 2016.
- The cost to Ukraine by 2000 was $148bn.[2]
- In 2002, Belarus was still spending 6.1 % of its budget on addressing Chernobyl's impacts.[3]
- In the 1980s, the Research and Development Institute of Power Engineering (of the former USSR) estimated the cost of Chernobyl would be $358bn. This institute noted that this cost exceeds the value of all nuclear generated electricity in the USSR until 1986.[4]

The global patchwork of nuclear liability regimes

Following the Chernobyl disaster, efforts were made to strengthen the international framework for nuclear liability. Until then, two basic conventions had formed the international regime on liability – the Vienna and Paris conventions, both of which were originally negotiated in the 1960s.

Chernobyl revealed how inadequate liability limits were in relation to the impacts of a severe accident and the potential for international fallout. The liability caps for both regimes were subsequently increased from approximately £700m to £1,500m, which is still significantly below the costs of a Chernobyl-scale accident.

There is, however, no comprehensive, unified international legal approach for nuclear accidents and compensating victims. Not all countries adhere to the same conventions. Even when they do, countries tend to adapt the conventions quite differently in their domestic legislation.

1 http://www-pub.iaea.org/MTCD/publications/PDF/Pub1279_web.pdf

2 Report commissioned by UNDP and UNICEF with the support of UN-OCHA and WHO. January 2002. The Human Consequences of the Chernobyl Nuclear Accident – A Strategy for Recovery, pg. 63.

3 The Chernobyl Forum, IAEA. 2003-2005. Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts and Recommendations to the Governments of Belarus, the Russian Federation and Ukraine: The Chernobyl Forum: 2003–2005, pg. 33.

4 Dr. S Upton Newtan. Nuclear War I and Other Major Nuclear Disasters of the 20th Century. AuthorHouse, p 144

05

In North America, for example, there is no bi-lateral agreement on nuclear liability between the US and Canada, which means that US victims of a nuclear accident in Canada could make a claim for full compensation. As a result, GE Hitachi Nuclear Energy has insulated itself from its Canadian division for fear of being sued in US courts in the event of an accident it had serviced in Canada.[5]

The result is a highly confusing, complicated patchwork of national approaches to nuclear liability. In 2000, less than half of the world' existing reactors were covered by an international agreement.[6] This poses an enormous potential for conflict in the event of a transboundary accident. Victims, for example, may not be able to claim compensation in the event of an accident if it happens in a country adhering to a different liability regime.

Nuclear liability caps: another way of saying 'Subsidies'

Economic analysts have frequently pointed out that putting considerable limits on the liability of nuclear operators can be seen as a subsidy to the nuclear industry. Indeed, without explicit, fixed-number guarantees not to be liable for the full costs of a potential future accident, nuclear operators can be expected to not become active in any given country.

As noted, certain reactor suppliers and vendors avoid the Canadian market for fear of exposure to lawsuits for full, unlimited liability in US courts. Likewise, reactor vendors would not enter India's newly opened market for reactor sales until the government passed legislation capping liability.

The subsidy to the nuclear industry provided liability limits is significant. It has been estimated that, if the French utility EdF was required to fully insure its nuclear power plants with private insurance using the current internationally agreed limit on liabilities of approximately €420m, it would increase EdF's insurance premiums from 0.0017 eurocents per kWh to 0.019 eurocents, thus adding around 0.8% to the cost of generation.[7] If there was no cap on liabilities in place and the operator had to cover the full risk of a worst-case scenario nuclear accident, it would increase the insurance premiums to 5 eurocents per kWh, tripling the generation costs.

Nuclear liability limits therefore provide a significant subsidy to the nuclear industry and distort the electricity markets.

Some references on cost of accidents

Date	Cost of nuclear accident	Source
1979	$21.3bn to $695bn US dollars	Sandia National Laboratories (USA)[8]
1987	$67m to $15.5bn US dollars	General Accounting Office (USA)[9]
1990	$613bn to $652bn US dollars	Pace University Centre[10]
1992	$6.8 trillion US dollars (worst-case)	Prognos AG (Germany)[12]
2004	€5,000bn	HJ Ewers and K Rennings[13]

5 M Mittelstaedt. US firm sheds liability for Canadian nuke peril. The Globe And Mail

6 B McRae. Overview of the Convention on Supplementary Compensation," in Reform of Civil Nuclear Liability, OECD, p. 175.

7 Taking into account that the French nuclear power plants are entirely depreciated and thus not including the capital cost. CE DELFT, Environmentally harmful support measures in EU Member States. January 2003. Report for DG Environment of the European Commission.

8 Sandia National Laboratory, produced for States Nuclear Regulatory Commission. Following the Three Mile Island (TMI) accident in 1979, Sandia estimated for each nuclear plant then in operation, how many people would die and be injured within the first year due to their radiation exposure and how many people would later die from radiation-induced illnesses like cancer. Early fatality estimates ranges from 700 for a small reactor to 100,000 for one of the larger ones. Cancer death estimates ranged from 3,000 to 40,000. Injury estimates ranged from 4,000 to 610,000. see: IEER, The Price-Anderson Act: The Billion Dollar Bailout at www.ieer.org/sdafiles/vol_9/9-1/nrcrisk.html

9 United States General Accounting Office. 1987

10 Pace University Center for Environmental Legal Studies prepared for United States Department of Energy and New York State Energy Research and Development Authority, 1990.

11 Prognos AG, prepared for Federal Ministry of Economics, 1992.

12 HJ Ewers and K Rennings. 1992. Economics of Nuclear Risk – a German Study: in O Homeyer and R Ottinger (eds.), Social Cost of Energy, Present status and Future Trends, Springer-Verlag, Berlin, pgs. 150-166; cited in A Froggatt. April 2004. The EU's Energy Support Programmes, page 24.

06

Food for thought

The accident at Chernobyl resulted in the large-scale release of radioactivity. Vast swathes of land in parts of today's Ukraine, Belarus and Russia were contaminated. Twenty-five years later, the world's attention has moved on.

Contamination doesn't disappear overnight, however. In March 2011, Greenpeace sent a team of researchers to one region in Ukraine to test food samples. The small pilot investigation showed that key foods sourced in the region are still subject to contamination with radioactivity today.

The radioactivity released as a result of the explosions at the Chernobyl nuclear power plant caused severe problems that affected many countries. In Ukraine, 18,000 km2 of agricultural land was contaminated. It is estimated that some 40% of the country's woods were contaminated, totalling 35,000 km^2.

Radioactivity cannot be seen. As was their custom, many inhabitants simply continued to eat fruit and vegetables, fish, mushrooms and berries cultivated in areas that had become contaminated following the accident. This meant that their intake of radioactive elements was between two and five times higher than acceptable under regulatory limits.

One of the greatest concerns was the release, transport and subsequent deposition of caesium-137, a long-lived radionuclide, which is able to pass through the food chain and hence contaminate milk, fish and other food products. Over the years following the accident, the Ukrainian government undertook regular analyses of foods produced in contaminated areas, and the Ministry of Emergencies and Affairs of Population Protection published the data. However, for the last two years this monitoring has not been performed. Accordingly, an important long-term data set is no longer being added to.

A pilot investigation into the current situation: In March 2011, a Greenpeace research team visited Ukraine to test food product contamination

In order to gather a more up-to-date picture of the situation, Greenpeace designed and carried out a small pilot investigation into radionuclide contamination of food in one region of Ukraine. In March 2011, a Greenpeace research team visited several places in Rivnenska Oblast and Zhytomyrska Oblast to collect samples of food produced in those areas that comprise a significant component of the local diet. Samples of food were also obtained from several other locations in Kiev and its surrounding areas, for comparative purposes. A total of 114 samples of food products were either purchased from the public food markets or provided for analysis by local farmers.

The study targeted selected areas of Ukraine where contamination has been found in past surveillance monitoring programmes. While the study was not intended to represent a comprehensive description of either the scope of the food contamination by radionuclides throughout Ukraine or in any particular region of Ukraine, it nevertheless provides some insight into ongoing problems with several categories of food products. These are important components of the basic diet of the population in areas contaminated by radionuclides released from the Chernobyl accident in 1986.

The results suggest there is no time for complacency. Key foodstuffs are still subject to contamination with radioactivity

Following their field trip, the Greenpeace scientists concluded that the results of their analysis showed that key foods sourced in the region are still subject to contamination with radioactivity. Caesium-137 appears to be the most important component of this contamination, but at least one of the samples suggested that other long-lived radionuclides could be present. The following is a selection of the findings[1], specifically reporting those foods in which high levels - exceeding the Ukrainian norms published by the Ministry of Health in 2006 - were found.

Milk and milk products

- Fourteen out of fifteen milk samples (93%) from the village of Drozdyn, Rivnenska Oblast, exceeded Acceptable Levels for Children for caesium- 137 by factors ranging between 1.2 and 16.3 times.
- One sample from Rudnya Zherevetska, Zhytomyrska Oblast showed activity of 60 becquerels per litre (Bq/l). If this milk were to be given to a child, it would exceed the Acceptable Levels for Children for caesium-137 of 40Bq/l by half as much again.

Wild mushrooms and berries

- Two samples of dried mushrooms from Zhytomyrska Oblast were above the regulatory limit, particularly the sample from Narodichi with a caesium-137 content of 288000 Bq/l, which is 115 times the limit for this food product. This sample had the highest caesium-137 content of all the samples considered in this study.
- Dried mushrooms obtained from Demydiv market, Kyivska Oblast, were 4.4 times the acceptable levels for caesium-137, and dried mushrooms obtained from Novi Sokoly, Kyivska Oblast were 1.2 times the limit of 2500Bq/kg, which has been set for wild dried mushrooms and berries
- Berries from Zhytomyrska Oblast also showed elevated content of caesium-137, including frozen blueberries, blueberry jam and dried blueberries with 1.5, 4.4 and 4.8 times the regulatory limit for these products respectively.
- Of the seven dried mushroom samples obtained from Drozdyn village in Rivnenska Oblast, six exceeded the acceptable levels for caesium-137 by a factor ranging between 1.3 and 7 times.

Root vegetables and other food products

- One of eight carrot samples from Drozdyn village considered in this study exceeded acceptable levels for caesium-137 by a factor of 1.3 times.
- Four of fifteen potato samples from Drozdyn village considered in this study exceeded acceptable levels for caesium-137 by factors between 1.2 and 1.7 times.

Greenpeace maintains that affected communities need ongoing support. The end of monitoring might be premature

Greenpeace has identified numerous samples that exceeded the regulatory limits both for adults and children. This result suggests that the ending of a regular monitoring programme is premature and dangerous.

Greenpeace maintains that there is an urgent need for thorough, scientifically based evaluation of radionuclide contamination of agricultural land, and adequate remedial treatment of all lands proposed for a return to agricultural use. Moreover, there is a need to remediate contaminated cattle pastures, where possible, to prevent further threats to the health of the Ukrainian population, which has for 25 years consumed radioactively contaminated food.

Without taking all necessary measures, returning contaminated land to agricultural use is potentially dangerous for public health. Chernobyl is not simply the land covered by the current exclusion zone; a much wider area was affected – and continues to be affected to the present day. Greenpeace maintains that support is needed by communities in all areas that were subject to contamination as a result of the Chernobyl disaster. This support should continue until they are able to return to a normal life in a clean environment.

1 The full results are available at www.greenpeace.org/field-findings-chernobyl-25.

Chernobyl 25yrs

Fukushima fall out

07

As of 28 March 2011, the situation at the Fukushima 1/Daiichi nuclear power plant in Japan was still unfolding, and it could still become worse. The exact radiological impacts are as yet unknown but more information on radioactive fallout and contamination of food and water continues to emerge.

Serious problems remain with the cooling of the three reactors that were shut down after the earthquake. Reactor cores need to be cooled continuously to prevent further meltdown of the fuel rods and radioactive releases.

The spent fuel pools of all six reactors at Fukushima 1/Daiichi remain problematic. These pools contain large amounts of highly radioactive material and if not cooled for a longer period of time, explosions and melting of the radioactive fuel rods can occur, potentially leading to serious radioactive releases.

If cooling is restored to all of the reactors and spent fuel pools further disaster can be avoided. It might take weeks or months to get the situation completely under control, and to end all radioactive releases from the plants, since there is suspected damage to the containment of the reactors and the spent fuel pools are in direct contact with the environment due to earlier explosions.

Since the crisis in Japan began, our thoughts have been with the people of Japan, and with the nuclear industry workers who are heroically risking their lives attempting to control the situation. It has been a race against time to avoid an even greater catastrophe, and we hope that the worst can be avoided.

System failures

Although the reactors withstood the earthquake and tsunami, vital cooling systems failed as a result. Backup systems also failed. This allowed the reactors to overheat, causing the spread of radiation.

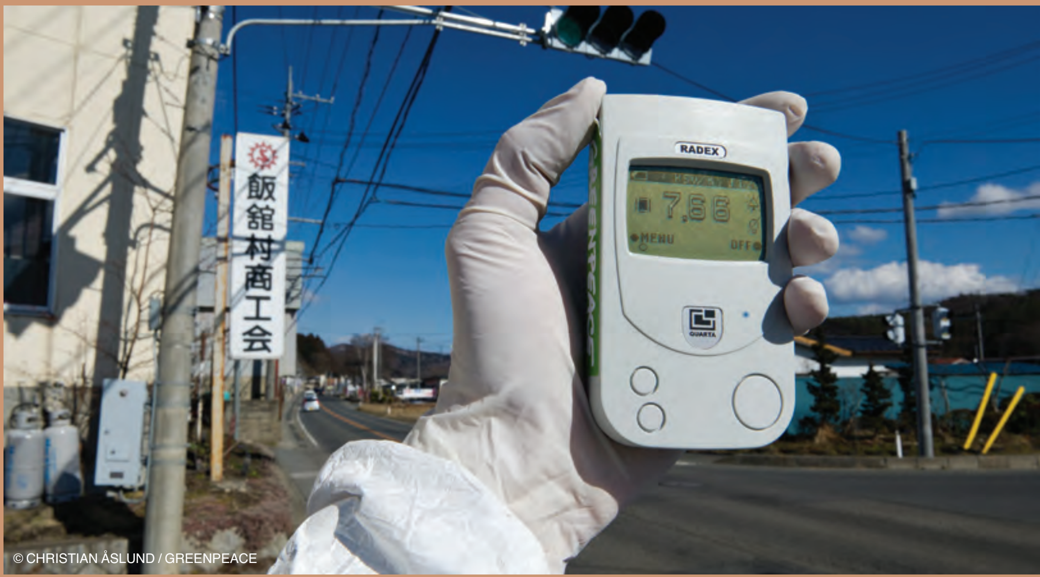
Despite the robustness of the reactors, there are factors that make them extremely vulnerable during natural disasters. One of the weakest points of all light water reactors – the majority (361 out of 442) of reactors that are in operation globally today - is a loss of electricity supply, leading to sudden failure of cooling and reactor control systems. This seems to have been the case in Fukushima, caused by the flooding of the plant. But there were also other examples of near accidents from this cause (the most serious one happening recently at Forsmark in Sweden, 2006)[1].

Radioactive releases

Dose rates of a few hundred milliSieverts an hour have been reported at the Fukushima nuclear plant. At a distance of 30km, dose rates up to 150 microSieverts an hour have been measured.

The radioactive materials released into the air from the plant have spread over a large area in the form of radioactive 'clouds'. The precise source of the releases, the distance, the altitude of the cloud, the wind direction and the weather conditions determine the dispersion of the radioactive cloud and how and where it deposits radioactive particles on the ground. This is very difficult to predict, but impacts have already been detected up to Tokyo, 250km south of the Fukushima plant.

1 For more information, please see factsheet #2: Nuclear Reactors – a ticking time-bomb



© CHRISTIAN ÅSLUND / GREENPEACE

The total amount of radioactivity that could theoretically be released over the course of the crisis is linked to the total amount of radioactive material in the damaged reactor cores and spent fuel pools. Radioactivity can be released in separate 'batches' depending on the developments in each part of the power plant. This would result in separate release-events of radioactive clouds that could be produced over several days or weeks. Each release event has the potential of a radioactive cloud being transported in different directions depending on weather conditions.

If the contamination is above a certain level, some areas will become uninhabitable or will have to be decontaminated. Deposited radioactive materials on the soil or vegetation can enter the food chain, which has already been seen in some cases, indirectly posing health risk to people and animals.

The accident can also contaminate groundwater, due to discharges of water used to cool reactors and spent fuel ponds in addition to radioactive materials deposited from the air. Low-level contamination with iodine-131 and caesium-137 has already been detected in the tap water in up to 12 prefectures, including Tokyo, at levels above the recommended limit for infants.

Fukushima and Chernobyl

As of 28 March 2011 and based on the radioactive releases of the Fukushima accident so far, various experts have estimated that the accident should already be ranked at Level 7 on the International Nuclear Event Scale (INES). This is the scale's highest level, and equal to the 1986 Chernobyl nuclear disaster. The current official evacuation zone is 20km around Fukushima. In the area lying between 20km and 30km people are advised to stay indoors. However, high levels of radiation from the stricken Fukushima nuclear plant have spread far beyond the official evacuation zone to places like Iitate, 40km northwest of the plant, and 20km beyond the official evacuation zone. Despite this, the authorities have not yet taken any action to properly protect people or keep them informed them about the risks to their health.

Although Greenpeace hopes it will not happen, the situation could still become worse, resulting in additional vast releases of radioactivity. In the Chernobyl accident, a cloud travelled thousands of miles across the northern hemisphere. In Fukushima, we can expect the cloud to be more concentrated, with most of the radioactivity being deposited over a smaller area.

The information available at this moment in time is insufficient to determine if people will be able to return to the evacuation zone. In any case, the Fukushima area will require long-term remediation and special measures will need to be taken, potentially for a long time to come, to protect the local population and the environment from radiation risks.