MS as amended by IF and DS
Version 2 March 28

The Other Report on Chernobyl (TORCH)
April 2006

An independent scientific evaluation of the health and environmental effects of the Chernobyl nuclear disaster with critical analyses of recent reports by the International Atomic Energy Agency (IAEA) and the World Health Organisation (WHO)

Summary and Conclusions

On 26 April 2006, twenty years will have passed since the Chernobyl nuclear power plant exploded and large quantities of radioactive gases and particles were spread throughout the northern hemisphere. While the effects of the disaster remain apparent particularly in Belarus, Ukraine and Russia, where millions of people are affected, Chernobyl's fallout also seriously contaminated other areas of the world. The disaster not only resulted in an unprecedented release of radioactivity but also a series of unpredicted and serious consequences for the public and the environment.

The TORCH report aims to provide an independent scientific examination of available data on the release of radioactivity into the environment and subsequent health-related effects of the Chernobyl accident. Thousands of studies have been carried out on the issue but many are only available in Ukrainian or Russian. These constraints inhibit a full international understanding of the impacts of Chernobyl, and the authors draw attention to this difficulty and to the need for it to be tackled at an official level. It is noted that some scientists from Belarus, Russia and Ukraine are highly critical of official versions of the impacts of the Chernobyl accident.

The Report critically examines recent official reports on the impact of the Chernobyl accident, in particular two reports by the "UN Chernobyl Forum" released by the International Atomic Energy Agency (IAEA) and the World Health Organisation (WHO) in September 2005[1] which received considerable attention by the international media.

Many uncertainties surround risk estimates from radiation exposures. The most fundamental is that the effects of very low doses are uncertain. The current theory is that the relationship between dose and detrimental effect is linear without threshold down to zero dose. In other words, there is no safe level of radiation exposure. However the risk, at low doses, may be supralinear, resulting in relatively higher risks, or sublinear, resulting in relatively lower risks.

Another main source of uncertainty lies in the estimates of internal radiation doses, that is, from nuclides, which are inhaled or ingested. These are an important source of the radiation from Chernobyl's fallout. Uncertainties in internal radiation risks could be very large, varying

[1] IAEA/WHO Health Effects of the Chernobyl Accident and Special Health Care Programmes. Report of the UN Chernobyl Forum Expert Group "Health" (EGH) Working draft[0], July 26 2005. IAEA/WHO Environmental Consequences of the Chernobyl Accident and their Remediation. Report of the UN Chernobyl Forum Expert Group "Environment" (EGE) Working draft[0], August 2005

in magnitude from factors of 2 (up and down from the central estimate) in the most favourable cases, to 10 or more in the least favourable cases for certain radionuclides.

The Accident

Early on April 26 1986, two explosions in Chernobyl unit 4 completely destroyed the reactor. The explosions sent large clouds of radioactive gases and debris 7 - 9 kilometres into the atmosphere. About 30% of the reactor's 190 tons of fuel was distributed over the reactor building and surrounding areas and about 1-2% was ejected into the atmosphere. The reactor's inventory of radioactive gases was released at this time. The subsequent fire, fuelled by 1,700 tons of graphite moderator, lasted for eight days**.** This fire was the principal reason for the extreme severity of the Chernobyl disaster.

How Much Radioactivity Was Released?

The World Health Organisation (WHO) has estimated that the total radioactivity from Chernobyl was 200 times that of the combined releases from the atomic bombs dropped on Hiroshima and Nagasaki. The amount of radioactivity released during a radiological event, is called the 'source term'. It is important because it is used to verify nuclide depositions throughout the northern hemisphere. From these, collective doses and predicted excess illnesses and fatalities can be estimated.

Of the cocktail of radionuclides that were released, the fission products iodine-131, caesium-134 and caesium-137 have the most radiological significance. Iodine-131 with its short radioactive half-life[2] of eight days had great radiological impact in the short term because of its doses to the thyroid. Caesium-134 (half-life of 2 years) and caesium-137 (half-life of 30 years) have the greater radiological impacts in the medium and long terms. Relatively small amounts of caesium-134 now remain, but for the first two decades after 1986, it was an important contributor to doses.

Most of the other radionuclides will have completely decayed by now. Over the next few decades, interest will continue to focus on caesium-137, with secondary attention on strontium-90, which is more important in areas nearer Chernobyl. Over the longer term (hundreds to thousands of years), the radionuclides of continuing interest will be the activation products, including the isotopes of plutonium, neptunium and curium. However, overall doses from these activation products are expected to remain low, compared with the doses from caesium-137.

The authors have reassessed the percentages of the initial reactor inventories of caesium-137 and iodine-131 which were released to the environment. They estimate that:

- 43% of the core's caesium-137 was released[3], 30% higher than official estimates;
- 65% of the core's iodine-131 was released[4], 16% higher than official estimates

[2] Half-life is the time it takes for half of a given amount of a radionuclide to decay.
[3] The estimated range is 37% - 49%.
[4] The estimated range is 54% to 75%.

Dispersion and Deposition of Chernobyl Fallout

During the 10 day period of maximum releases from Chernobyl, volatile radionuclides were continuously discharged and dispersed across many parts of Europe and later the entire northern hemisphere. For example, relatively high fallout concentrations were measured at Hiroshima in Japan, over 8,000 km from Chernobyl.

Rainfall resulted in markedly heterogeneous depositions of fallout throughout Europe and the northern hemisphere. Most ejected fuel was deposited in areas near the reactor with wide variations in deposition density, although some fuel hot particles were transported thousands of kilometres. The largest ***concentrations*** of volatile nuclides and fuel particles occurred in Belarus, Russia and Ukraine. But more than half of the total ***quantity*** of Chernobyl's volatile inventory was deposited outside these countries.

Extensive surveying of Chernobyl's caesium-137 contamination was carried out in the 1990s under the auspices of the European Commission. The results indicate that about 3,900,000 km^2 of Europe was contaminated by caesium-137 (above 4,000 Bq/m^2) which is **40% of the surface area of Europe**. Curiously, this latter figure does not appear to have been published and, certainly has never reached the public's consciousness in Europe.

Of the total contaminated area, 218,000 km^2 or about **2.3% of Europe's surface** area has been contaminated to higher levels (greater than 40,000 Bq/m^2 caesium-137[5]). This is the area cited by IAEA/WHO and UNSCEAR, which shows that they have been remarkably selective in their reporting.

In terms of surface area, **Belarus and Austria** were most affected by higher levels of contamination However, other countries were seriously affected; for example, more than 5% of **Ukraine, Finland and Sweden** were contaminated to high levels (> 40,000 Bq/m^2 caesium-137). More than 80% of **Moldova, the European part of Turkey, Slovenia, Switzerland, Austria and the Slovak Republic** were contaminated to lower levels (> 4,000 Bq/m^2 caesium-137). 44% of **Germany** and 34% of the **UK** were similarly affected.

In terms of total deposition of caesium-137, **Russia, Belarus and Ukraine** received the highest amounts of fallout while **former Yugoslavia, Finland, Sweden, Bulgaria, Norway**, **Rumania, Germany, Austria and Poland** each received more than one petabecquerel (10^{15} Bq or one million billion becquerels) of caesium-137, a very large amount of radioactivity.[6]

Restrictions on Food Still in Place

In many countries, restriction orders remain in place on the production, transportation and consumption of food still contaminated by Chernobyl fallout.

• In the **United Kingdom** restrictions remain in place on 374 farms covering 750 km^2 and 200,000 sheep.

[5] This is to be put into perspective of the Chernobyl exclusion zone, contaminated at levels > 555,000 Bq/m^2.

[6] Cf. the EU limit of 600 Bq per kg of caesium-137 in dairy foods

• In parts of **Sweden** and **Finland,** as regards stock animals, including reindeer, in natural and near-natural environments.

• In certain regions of **Germany, Austria, Italy, Sweden, Finland, Lithuania** and **Poland** wild game (including boar and deer), wild mushrooms, berries and carnivore fish from lakes reach levels of several thousand Bq per kg of caesium-137.

• In **Germany**, caesium-137 levels in wild boar muscle reached 40,000 Bq/kg. The average level is 6,800 Bq/kg, more than ten times the EU limit of 600 Bq/kg.

The European Commission does not expect any change soon. It has stated[7]:

> "The **restrictions** on certain foodstuffs from certain Member States must therefore continue to be **maintained for many years to come**." (emphases added)

The IAEA/WHO reports do not mention the existing comprehensive datasets on European contamination. No explanation is given for this omission. Moreover, the IAEA/WHO reports do not discuss deposition and radiation doses in any country apart from Belarus, Ukraine and Russia. Although heavy depositions certainly occurred there, the omission of any examination of Chernobyl fallout in the rest of Europe and the northern hemisphere is questionable.

The Health Impacts – So Far…

The immediate health impact of the Chernobyl accident was acute radiation sickness in 237 emergency workers, of whom 28 died in 1986 and a further 19 died between 1987 and 2004. More premature deaths may occur amongst this group.

The long-term consequences of the accident remain uncertain. Exposure to ionising radiation can induce cancer in almost every organ in the body. However, the time interval between the exposure to radiation and the appearance of cancer can be 50 to 60 years or more. The total number of cancer deaths from Chernobyl most likely will never be fully known. However the TORCH Report makes predictions of the numbers of excess cancer deaths from published collective doses to affected populations.

Thyroid Cancer

Up to 2005, about 4,000 cases of thyroid cancer occurred in Belarus, Ukraine and Russia in those aged under 18 at the time of the accident. The younger the person exposed, the greater the subsequent risk of developing thyroid cancer.

Thyroid cancer is induced by exposures to radioactive iodine. It is estimated that more than half the iodine-131 from Chernobyl was deposited ***outside*** the former Soviet Union. Possible increases in thyroid cancer have been reported in the Czech Republic and the UK, but more research is needed to evaluate thyroid cancer incidences in western Europe.

Depending on the risk model used, estimates of future excess cases of thyroid cancer range between **18,000 and 66,000** in Belarus alone. Of course, thyroid cancers are also expected to

[7] Andris Piebalgs, European Commission, written answer to Question P-1234/05DE by MEP Rebecca Harms dated April 4, 2005

occur in Ukraine and Russia. The lower estimate assumes a constant relative risk for 40 years after exposure; the higher assumes a constant relative risk over the whole of life. Recent evidence from the Japanese atomic bomb survivors suggests that the latter risk projection may be more realistic.

Leukaemia

The evidence for increased leukaemias is less clear. Some evidence exists of increased leukaemia incidence in Russian cleanup workers and residents of highly contaminated areas in Ukraine. Some studies appear to show an increased rate of childhood leukaemia from Chernobyl fallout in West Germany, Greece and Belarus.

Other Solid Cancers

Most solid cancers have long periods between exposure and appearance of between 20 and 60 years. Now, 20 years after the accident, an average 40% increased incidence in solid cancer has already been observed in Belarus with the most pronounced increase in the most contaminated regions. The 2005 IAEA/WHO reports acknowledge preliminary evidence of an increase in the incidence of pre-menopausal **breast cancer** among women exposed at ages lower than 45 years.

Non-Cancer Effects

Two non-cancer effects, **cataract induction** and **cardiovascular diseases,** are well documented with clear evidence of a Chernobyl connection. Lens changes related to radiation have been observed in children and young people aged between 5 and 17 living in the area around Chernobyl. A large study of Chernobyl emergency workers showed a significantly increased risk of cardiovascular disease.

Heritable Effects

It is well known that radiation can damage genes and chromosomes. However the relationship between genetic changes and the development of future disease is complex and the relevance of such damage to future risk is often unclear. On the other hand, a number of recent studies have examined genetic damage in those exposed to radiation from the Chernobyl accident.

Studies in Belarus have suggested a twofold increase in the **germline minisatellite mutation**[8] rate. Analysis of a cohort of irradiated families from Ukraine confirmed these findings. However the clinical symptoms which may result from these changes remain unclear.

Mental Health and Psychosocial Effects

While seeming to downplay other effects, the recent IAEA/WHO reports clearly recognise the vast mental, psychological and central nervous system effects of the Chernobyl disaster: “The mental health impact of Chernobyl is the largest public health problem caused by the accident

[8] Human germline mutations are those that affect sequences of repeated DNA and thus the genes of the germinal or reproductive cells (the egg and the sperm).

to date. The magnitude and scope of the disaster, the size of the affected population, and the long-term consequences make it, by far, the worst industrial disaster on record."

The origins of these psychosocial effects are complex, and are related to several factors, including anxiety about the possible effects of radiation, changes in lifestyle – particularly diet, alcohol and tobacco – victimisation, leading to a sense of social exclusion, and stress associated with evacuation and resettlement. It is therefore difficult to state exactly how much of these symptoms are directly related to Chernobyl related radiation exposures.

Collective Doses

Radiation exposures are mainly measured in two ways: individual doses and collective doses. Individual doses are measured or calculated per person and collective doses are the sum of individual doses to all exposed persons in a defined area, for example a workforce, a country, a region, or indeed the world. The use of collective doses is particularly relevant in cases where large population groups are exposed to relatively low individual doses over long periods of time. The estimation of collective doses is an indispensable tool to evaluate potential future health effects of radiation.

It is necessary to identify clearly the time periods over which a collective dose is estimated. For example, the exposed populations in Belarus, Ukraine and Russia received approximately **one third** of a 70-year collective dose in the first year after Chernobyl. Approximately **another third** was received in the next nine years (ie 1987 to 1996), and the **remaining third** will be received approximately between 1997 and 2056.

The IAEA/WHO reports estimate the collective dose to **Belarus, Ukraine and Russia** is 55,000 person sieverts, which is the lower end of a range of evaluations reaching over 300,000 person sieverts. The IAEA/WHO restrict their time estimate to 2006, and fail to present estimates for European and worldwide collective doses: these are significant limitations.

The most credible published estimate for the total worldwide collective dose from Chernobyl fallout is **600,000 person sieverts** making Chernobyl the worst nuclear accident by a considerable margin. Of this total collective dose, approximately:

- 36% is tothe populations of Belarus, Ukraine and Russia;
- 53% is to the population of the rest of Europe;
- 11% is to the population of the rest of the world.[9]

[9] It is remarkable that the author of these evaluations published in 1995 and 1996 (see hereunder), that have not found their way into the 2005 IAEA/WHO studies, was also the Chairman of the Chernobyl Forum that coordinated the 2005 IAEA/WHO studies.
• Bennett B (1995) Exposures from Worldwide Releases of Radionuclides. In Proceedings of an International Atomic Energy Agency Symposium on the Environmental Impact of Radioactive Releases. Vienna, May 1995. IAEA-SM-339/185
• Bennett B (1996) Assessment by UNSCEAR of Worldwide Doses from the Chernobyl Accident in Proceedings of an IAEA Conference One Decade after Chernobyl: Summing up the Consequences of the Accident, Vienna, 8-12 April 1996.

Estimated Future Excess Cancer Deaths

Excess cancer deaths can be estimated from published collective doses. For Belarus, Ukraine and Russia, published estimates range between 4,000 and 22,000 excess cancer deaths. For the world, published estimates range between 14,000 and 30,000. These estimates depend heavily on the risk factor used: different scientists use different factors. Recent studies indicate that currently-used risks from low doses at low dose rates may need to be increased.

The IAEA, in its 5 September 2005 press release “Chernobyl: The True Scale of the Accident” stated: “A total of up to four thousand people could eventually die of radiation exposure from the Chernobyl nuclear power plant (NPP) accident nearly 20 years ago, an international team of more than 100 scientists has concluded.” The figure of 4,000 fatalities has been quoted extensively by the world media. However the statement is misleading, as the figure calculated in the IAEA/WHO report is nearly **9,000 excess cancer deaths**.

Depending on the risk factor used (ie the risk of fatal cancer per person sievert), the TORCH Report estimates that the worldwide collective dose of 600,000 person sieverts will result in **30,000 to 60,000 excess cancer deaths**. That is 7.5 to 15 times the figure release in the IAEA’s press statement.

Conclusions

The full effects of the Chernobyl accident will most certainly never be known. However, 20 years after the disaster, it is clear that it is far greater than implied by official estimates. Our overall conclusion is that the unprecedented extent of the disaster and its long-term global environmental, health and socio-economic consequences should be fully acknowledged and taken into account by governments when considering their energy policies..

In summary, the main conclusions of the Report are

- about 30,000 to 60,000 excess cancer deaths are predicted, 7 to 15 times greater than IAEA/WHO’s published estimate of 4,000
- predictions of excess cancer deaths strongly depend on the risk factor used
- predicted excess cases of thyroid cancer range between 18,000 and 66,000 depending on the risk projection model
- other solid cancers with long latency periods are beginning to appear 20 years after the accident
- Belarus, Ukraine and Russia were heavily contaminated, but more than half of Chernobyl’s fallout was deposited outside these countries
- fallout from Chernobyl contaminated about 40% of Europe’s surface area
- collective dose is estimated to be about 600,000 person Sv, more than 10 times greater than official estimates
- about 2/3rds of Chernobyl’s collective dose was distributed to populations outside Belarus, Ukraine and Russia, especially to western Europe

- Caesium-137 released from Chernobyl is estimated to be about a third higher than official estimates

Recent IAEA/WHO studies

Our verdict on the two recent IAEA/WHO studies on Chernobyl's health and environmental effects respectively is mixed. On the one hand, we recognise that the reports contain comprehensive examinations of Chernobyl's effects in Belarus, Ukraine and Russia. On the other hand, the reports are silent on Chernobyl's effects outside these countries. Although areas of Belarus, Ukraine and Russia were heavily contaminated, most of Chernobyl's fallout was deposited outside these countries. Collective doses from Chernobyl's fallout to populations in the rest of the world, especially in western Europe, are twice those to populations in Belarus, Ukraine and Russia. This means that these populations will suffer twice as many predicted excess cancer deaths, as the populations in Belarus, Ukraine and Russia.

The failure to examine Chernobyl's effects in the other countries does not lie with the scientific teams but within the policy-making bodies of IAEA and WHO. In order to rectify this omission, we recommend that the WHO, independently of the IAEA, should commission a report to examine Chernobyl's fallout, collective doses and effects in the rest of the world, particularly in western Europe.

ends