Comments from
Professor Philip Thomas, University of Bristol
on the International Commission on Radiological Protection (ICRP) Document:
"Radiological Protection of People and the Environment in the Event of a Large Nuclear Accident", ICRP Ref: 4820-5028-4698 dated 17 June 2019

Personal Statement

I am Professor of Risk Management at the University of Bristol in the United Kingdom. I worked for over 16 years for the UK Atomic Energy Authority, where, *inter alia*, I was in charge of decommissioning to green-field conditions the 100 MWTh/33 MWe Windscale Advanced Gas Reactor, which included remote dismantling and nuclear waste management. I was Professor of Engineering Development at City, University of London before taking up my current position with Bristol in 2015. I am a chartered engineer and was President of the Institute of Measurement and Control in 2001. I am currently Assistant to the Court of the Worshipful Company of Scientific Instrument Makers, one of the London Guilds.

The NREFS Project on Coping with a Big Nuclear Accident.

I was Principal Investigator for the multi-university NREFS project (Management of Nuclear Risks: Environmental, Financial and Safety), which investigated how best to cope with a big nuclear accident under the UK-India Civil Nuclear Power Collaboration. Sponsored by the UK's Engineering and Physical Sciences Research Council, the project involved the University of Bristol, City, University of London, the University of Manchester, the University of Warwick and The Open University. The closing papers formed the NREFS Special Issue of the IChemE journal, *Process Safety and Environmental Protection*. Published on 20 November 2017, the NREFS Special Issue has attracted about 35,000 downloads to date. See: https://www.sciencedirect.com/journal/process-safety-and-environmental-protection/vol/112/part/PA .

The stand-out message from the NREFS project was that relocation is highly unlikely to be an optimal response even after a big nuclear reactor accident. It is likely to do more harm than good.

This conclusion was arrived at through three separate and independent methods of analysis: optimal economic control applied to hundreds of notional reactor melt-down accidents all over the world in countries at different levels of development[1], the UK Health Protection Agency's PACE/COCO2 code combination applied to a big accident at a fictional reactor located midway between London and Southampton[2] and

[1] Yumashev, D., Johnson, P. and Thomas, P. J., 2017, "Economically optimal strategies for medium-term recovery after a major nuclear reactor accident", *Process Safety and Environmental Protection*, Vol. 112A, 63 – 76, November.

[2] Ashley, S., Vaughan, G. J. , Nuttall, W. J. and Thomas, P. J., 2017, "Considerations in relation to off-site emergency procedures and responses for nuclear accidents ", *Process Safety and Environmental Protection,* Vol. 112A, 77 – 95, November; Ashley, S., Vaughan, G. J. , Nuttall, W. J., Thomas, P. J., Higgins, N. J., 2017, "Predicting the Cost of the Consequences of a Large Nuclear Accident in the UK ", *Process Safety and Environmental Protection,* Vol. 112A, 96 – 113, November.

the Judgement- or J-value applied retrospectively to Chernobyl and Fukushima Daiichi[3].

The J-value framework used ICRP figures to calculate the loss of life expectancy incurred from geographically dispersed radioactivity over the next 70+ years if people were to remain in situ after an accident; the loss of life expectancy was weighed against the cost of moving out on a long-term basis. Uniquely, the J-value is able to find an objective balance between life gained from a safety measure and the cost of providing it. Furthermore, the J-value method has been validated against data from the great majority of nations in the world[4].

A retrospective analysis of the information available from Fukushima Daiichi suggested that the loss of life expectancy from all sources of radioactivity (both external and internal dose) would not have been more than a few months even in the worst affected towns, and this made it difficult to endorse large scale and long term evacuation[3]. No quantification was made of some of the wider effects of disruption, but their effect would generally militate further against moving people. Greater emphasis should be placed instead on remediation, which emerged as cost-effective in the studies carried out[5].

Comments on ICRP Ref: 4820-5028-4698

1. Reference Levels

Reference levels for radiation dose rates have been adopted in the document as the basic method of categorising an accident and instituting strategies for coping with it. Very properly, the ICRP flags that these should be used as guidelines and not as limits:

> "The Commission maintains its position that reference levels are not regulatory limits that should not be exceeded, but are values to guide the optimisation process." (lines 763 to 765).

This emphasis on the non-mandatory nature of the reference levels is to be welcomed. There are a number of points to be made, however.

(i) The first is that the report does not translate the meaning of the figures, such as 20 mSv per year, into something that can be understood easily by decision makers and the general public. In fact, if the fallout from a nuclear reactor accident induces a total dose of 20 mSv in the first year, it is possible to say that a person living for the rest of his/her life in such an environment is likely to lose 2 months of life expectancy as the dose level decays to background levels over about 70 years[2]. It is suggested that this information could be digested easily by decision makers (who may well not

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[3] Waddington, I., Thomas, P. J., Taylor, R. H. and Vaughan, G. J., 2017, "J-value assessment of relocation measures following the nuclear power plant accidents at Chernobyl and Fukushima Daiichi", *Process Safety and Environmental Protection*, Vol. 112A, 16 – 49, November.

[4] Thomas, P. and Waddington, I., 2017,"Validating the J-value safety assessment tool against pan-national data", Process Safety and Environmental Protection, Vol. 112A, 179 – 197, November.

[5] Waddington, I., Thomas, P. J., Taylor, R. H. and Vaughan, G. J., 2017, "J-value assessment of remediation measures following the nuclear power plant accidents at Chernobyl and Fukushima Daiichi", *Process Safety and Environmental Protection*, Vol. 112A, 63 – 76, November.

be nuclear experts), by the media and by the general public. This is likely to be something that people would want to know.

To put the figure of 2 months into comparative context, the average person currently living in London is currently expected to lose about 4½ months to air pollution, about twice the figure just mentioned. London's response is, very properly, to look for ways to reduce this burden. But no-one is suggesting moving everyone out of the UK's capital city.

Now that the J-value has been developed, it is possible to use it to state objectively that it would not be justifiable to move people away from their homes on a long-term basis if the level of harm from staying in situ were only 2 months.

(ii) The document suggests that the reference level after a big nuclear accident should be reduced at some point below 20 mSv to 10 mSv:

> "For people living in long-term contaminated areas following the emergency response, the reference level should be selected within or below the Commission's recommended band of 1–20 mSv for existing exposure situations, taking into account the actual distribution of doses in the population and the tolerability of risk for the long-lasting existing exposure situations, and there is generally no need for the reference level to exceed 10 mSv per year." (lines 115 to 119).

But it is not clear when the term "long-lasting" is considered to come into effect. The number of years after the accident when this held to apply will be very important.

It is important to understand the reasoning here, on which the report is currently silent.

(iii) A final but very important point concerning reference levels is the state of the development of the country in question. As implied by the ICRP's concepts of justification and optimisation, economics matter. It is important to realise that both logically and ethically, some differences should exist between the way that a developed country responds to a nuclear accident and the way adopted by a country at a different stage in its development. It would not be right to expect a poorer nation to divert an excessive amount of its precious resource to countering a hazard to its population that the NREFS studies have shown to be relatively low in most cases, at the expense of addressing what may be much higher risks elsewhere in that country. This reinforces the need for reference levels not to be prescriptive, as indeed appears to be accepted by ICRP in lines 763 – 765.

2. The gathering and dissemination of information

Correctly, the ICRP points to the "alarming image" of a big nuclear reactor accident (line 67) that exists fairly general amongst politicians, press and public. However, the suggestion made in the same sentence that the radiological impact has an "unknown character" is questionable after the world has experienced the two major nuclear accidents at Chernobyl and Fukushima Daiichi. The analysis contained in the NREFS study has quantified the probable range of harm to health, which for most if not all of the public living in the vicinity is likely to be limited even in the absence of countermeasures, based on the use of ICRP figures.

What was lacking after those two big reactor accidents was the availability of real-time information on the contamination levels as these were building up in the areas within kilometers of the plant. But technological development means that it is now rather easy to measure radiation levels remotely and so to acquire a clear, evolving picture of the radiological hazard. The well-known physics of radioactive decay, allied to current measurements of isotope levels, make it possible to project from any given time what the radiation hazard will be in ensuing decades. Time profiles of dose may then be translated into the amount of life expectancy that will be lost with and without countermeasures.

This is the information needed by the decision maker, who will then be in a position to make timely rather than rushed decisions. It should also be remembered that the radiation hazard for the low levels of radiation likely to be faced by the public builds up only slowly, which gives the informed decision maker the time to institute an optimal policy.

The information mentioned above is also that needed by the general public. I endorse the ICRP's commitment to getting information out to the general public rapidly using all available channels. This should happen on a continuous basis. Ideally the public should be supplied with analogous information as a matter of course whether or not an accident has happened, so that people can become familiar with the concepts.

3. Future strategies for managing a big nuclear accident

The document does not appear to allow for the growth of new knowledge and new technology, both of which are sorely needed if better solutions causing people less harm (psychological and societal as well as radiological) are to be deployed in the future. Somewhere in the document there should be explicit encouragement for nuclear operators to develop the new technology and new strategies required.

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