House of Commons Select Committee for Science and Technology
Inquiry into **Risk perception and energy infrastructure**

Submission by Royal Statistical Society

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Summary

2. The main points we would like to submit are as follows:

    a. The public is currently desperately ill-served by the lack of ready access to up-to-date balanced and trustworthy information on the possible risks associated with different energy sources. Those that exist appear to be either reassuring propaganda or are limited to a particular hazard.

    b. We suggest some general principles for numerical communications of risks associated with energy sources:
        i. Separate different types of hazards experienced: eg acute short-term from chronic long-term
        ii. Separate impact on individuals, society and the environment
        iii. Include both quantifiable risks and those that are important but are difficult to put numbers on
        iv. For quantifiable risks, to use clear metrics, using whole numbers preferably in comprehensible units
        v. Be clear about the uncertainty attached to numbers, which should only be given to the precision justified by the evidence
        vi. Comparisons may be made with both other sources of risks, but voluntary and involuntary risks should be clearly separated
        vii. Give multiple formats and ways of expressing risks, eg in terms of both rate and impact on a population

viii. Provide a clear warning that the past does not necessarily predict the future, and that we should be wary of being either reassured or scared by historical events
ix. Be clear about the extent to which risk estimates are based on scientific models, and emphasise their assumptions
x. Acknowledge uncertainty and limitations of data and knowledge
xi. Acknowledge any disputed science
xii. Attempt to give a balanced view that does not seek, or appear to seek, to persuade

c. We recommend that public communication acknowledges that there are many relevant issues of concern and does not solely focus on those most easily put into numbers.

d. We recommend that a suitable trusted provider for this comparative information be identified.

Introduction

3. As statisticians, our expertise is in designing studies, evaluating quantitative evidence, and assessing and communicating uncertainty. We shall therefore focus on issue 3) in the call for submissions - *How effectively does local and central Government communicate risk and could it be improved?*

4. It is well-known that nuclear energy ticks most of the boxes for 'fright factors' that influence risk perception: for example, radiation is feared and unknown, appears out of personal control, affects the vulnerable and unborn, is complex and the information sources may be untrustworthy. These important issues of risk perception are not our main area of expertise, but will influence our comments on numerical summaries, comparison and presentation.

5. We shall concentrate on nuclear energy but emphasise that comparisons should be made with other energy sources and hazards. This is not the place to review evidence for the magnitude of the risks, so we will just use illustrative examples from the literature.

What is currently communicated to the 'public' by government?

6. A web search using popular terms does not reveal any communication from the government, or indeed anyone else, which readily permits a comparative assessment of the magnitudes of the various risks associated with different energy sources. In particular the Department of Energy and Climate Change (DECC) website does not appear to contain any readily accessible information.

7. Those communications that exist are aimed at a professional audience, and we shall focus on their use of numerical information. We note that there is not just one 'public', and a range of different stakeholders have different levels of expertise.

8. The information provided by the Health and Safety Executive (HSE) Office for Nuclear Regulation (1) is aimed at an informed audience and, as befits a regulator, is primarily concerned with explaining its framework for assessing and monitoring nuclear facilities. The HSE's *Tolerability of risks from nuclear power stations* is a classic document that, although dating from 1988-1992, provides a good explanation of the HSE's general approach. Individual and societal risk is distinguished, but no attempt is made to quantify societal total 'detriment' of multiple deaths, disaster management, public shame and outrage, land rendered unproductive and so on. Tables of typical doses of ionising radiation are given, and safety standards are expressed in terms of risks per annum: for example, "*we require that a modern plant be so designed as to be able to withstand safely all earthquakes except those of a severity whose chance of occurrence is judged to be less than 1 in 10 000 per annum*". Tables of everyday risks are provided as odds, for example a 1 in 200 chance of death per million km driven. The safety criteria are further explained *Safety Assessment Principles for Nuclear Facilities.*

9. HSE's risk communication has been recently reviewed by Bouder and Lofstedt (2), who supported the HSE's 'consensual' approach to risk communication, but suggested that in highly contested areas it could improve by being more proactive and engaging with people's concerns, exploiting wider expertise, and focusing on becoming a trusted source which is seen as understanding the social context. The HSE's documents, although a clear exposition of their regulatory approach, do not provide the public with a basis for judging the risks.

10. The Health Protection Agency (HPA) provides popular, reassuring information on "Nuclear Emergencies" (3) with a good animation, but focuses on explaining the doses and risks from low-dose ionising radiation (4), providing a comparative table of exposures from different sources, for example a 135g bag of Brazil nuts corresponds to 0.01 mSv (milliSieverts)

What is currently communicated to the 'public' by other sources?

11. The World Nuclear Association is a producers' lobby group whose site on nuclear safety (5) discusses safety (accidents), security (terrorism) and safeguards (proliferation), and a reassuring table of accident fatality rates from different energy sources is given.

12. The International Atomic Energy Agency (IAEA) is concerned with nuclear safety and security but information about relative risks is singularly absent. FAQs from 2006 (6) include the following:

    Q: *Some nuclear power plants are built on sites subject to natural phenomena such as earthquakes or tornados, which can pose a risk for any installation. What has been done to ensure the safety of these plants?*
    A: Extensive experience has shown that this philosophy of conservative design has been sufficient to cope with all of these types of natural phenomena at all nuclear power plants,
    which perhaps should be revised after Fukushima.

13. A recent document from the Intergovernmental Panel for Climate Change (IPCC) (7) (pp 745-747) provides the most comprehensive and comprehensible comparison of the risks from serious accidents from different energy sources, derived from the ENSAD database

at the Paul Scherrer Institut (8). Both fatalities per Gigawatt-year as well as maximum fatalities are given - some of their data are revisited below.

14. The best exposition is given by David Mackay (9), currently Chief Scientific Advisor to DECC, who provides an accessible comparative assessment of different energy sources, including both short-term and long-term impacts. Risks are communicated as fatalities per Gigawatt-year.

15. There are a vast range of other sources of information from academic sources, individuals and pressure groups, including a website of wind turbine deaths (10) (32 up to end of 2010), communicated as fatalities per Terawatt-hour. There are endless conflicts about the impact of Chernobyl, which is of doubtful relevance to any UK nuclear programme.

16. **The public is currently desperately ill-served by the lack of ready access to up-to-date balanced and trustworthy information on the possible risks associated with different energy sources. Those that exist appear to be either reassuring propaganda or are limited to a particular hazard.**

How could communication be improved?

17. **We suggest some general principles for numerical communications of risks associated with energy sources:**
    a. **Separate different types of hazards experienced: eg acute short-term from chronic long-term**
    b. **Separate impact on individuals, society and the environment**
    c. **Include both quantifiable risks, and those that are important but where difficult to put numbers on**
    d. **For quantifiable risks, to use clear metrics, using whole numbers preferably in comprehensible units**
    e. **Be clear about the uncertainty attached to numbers, which should only be given to the precision justified by the evidence**
    f. **Comparisons may be made with both other sources of risks, but voluntary and involuntary risks should be clearly separated**
    g. **Give multiple formats and ways of expressing risks, eg in terms of both rate and impact on a population**
    h. **Provide a clear warning that the past does not necessarily predict the future, and that we should be wary of being either reassured or scared by historical events**
    i. **Be clear about the extent to which risk estimates are based on scientific models, and emphasise their assumptions**
    j. **Acknowledge uncertainty and limitations of data and knowledge**
    k. **Acknowledge any disputed science**
    l. **Attempt to give a balanced view that does not seek, or appear to seek, to persuade**

    The systematic inadequacies in past data as a basis for future predictions means that formal statistical ‘error bars’ have less relevance than an open assessment of deeper uncertainties, so that identifying orders of magnitude may generally be adequate.

18. A wide range of potential hazards related to energy production can be identified that impact on individual people, society and the environment, associated, for example, with routine activities, severe accidents, disposal of waste, climate change, terrorism, proliferation and energy security. All of these enter into the public debate when discussing nuclear energy and making comparisons with other sources. Some may be quantified with greater or lesser confidence – but others are more difficult to model. **We recommend that public communication acknowledges that there are many relevant issues of concern and does not solely focus on those most easily put into numbers.**

19. In principle a matrix could be formed for each energy source, related to each potential hazard. It is crucial that a full picture is portrayed – in many cases a quantitative assessment would not be possible but a qualitative level of severity might be assigned. Some examples are given below.

20. **Routine activities and minor accidents**. These need to be expressed in the same units as severe accidents, separating workers from the general population exposed, for example, to pollution and radiation from traditional power plants. These risks should also be expressed in terms of the total burden on the population – fossil fuels were estimated in a National Science report to lead to 20,000 deaths in the USA each year (11), and the House of Commons Environmental Audit Committee reported that particulate matter reduced life expectancy by 7-8 months (12), which ignores the effect of low-dose ionising radiation from fossil-fuel power stations. The environmental damage from routine coal and oil extraction also needs to be considered.

21. **Severe accidents**. The IPCC report (7) estimates for EU countries the following future risks (these have been translated into fatalities per TWy in order that whole numbers are appropriate): coal (135), oil (99), hydro (85), natural gas (68), biomass (15), offshore wind (6), inshore wind (2), geothermal (2), nuclear (0.4 early deaths, 0.7 later deaths) and photo-voltaic (0.2). This does not include the possibility of ship collisions with offshore wind facilities. These 'average' figures do not address the perceived catastrophic potential of nuclear power. This scenario should be explicitly addressed and justification for the quoted risks needs to be provided. Trusted sources of information, and a continuing period of safe operation, will help this be convincing. The recent Deepwater Horizon accident suggests the vital importance of environmental damage as well as direct harm to health.

22. **Waste disposal.** For nuclear waste, quantitative risk models can be provided, emphasising their sensitivity to any discount rates given to events far in the future. Carbon capture and storage also needs to be addressed, although may be more difficult to quantify.

23. **Climate change.** The impact of alternative technologies on CO_2 production can be well-quantified, and possibly a more cautious assessment made on future climate.

24. **Terrorism, proliferation, energy security.** These are vital issues that need to be specifically addressed, and assessments of the vulnerability of say nuclear installations and oil-pipelines can be provided. Exposure to geo-political forces that deny supplies can be made explicit. However, probabilities of these occurring cannot be given with any precision.

25. To reiterate our recommendations in paragraph 12, it should be made clear when there is disputed science, and numbers should only be given to the precision justifiable by the analysis. The overall confidence in the conclusions could be scored using a qualitative scale such as the GRADE score used in medical evidence reviews (13), or the IPCC's methodology for qualifying its conclusions (14).

26. This is an area of disputed science, in which trust is vital. **We recommend that a suitable trusted provider for this comparative information be identified.**

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