The Application of ALARA in Radioactive Waste Disposal – UK Perspective

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Introduction

In recent years, the UK Government and the Regulators have made a commitment to further improve the operation of the regulatory regime and to its operating within the principles of proportionality, transparency, consistency and accountability which underpin the Government's approach to regulation in general. Particular emphasis was to be placed upon ensuring that there is greater consistency in the treatment of risk and hazard; proportionate and cost effective delivery of public, worker and environmental protection; and an open and transparently applied regulatory system.

This is crucial in the modern regime where, increasingly, there are many more ways of spending money for the public good than there is money to spend – even in developed Western societies – so disproportional application of funding in one area will inevitably lead to greater detriments in another.

This presentation focuses on the practical application of the regulatory regime with particular regard to environmental discharges and disposals. Under the Radioactive Substances Act 1993, Operators within the UK nuclear industry are required to employ Best Practicable Means (BPM) to control and minimise radioactive discharges to ensure that doses from discharges are As Low As Reasonably Achievable (ALARA).

Assessments to date indicate that the human health and environmental harm from discharges at Sellafield would be expected to be limited, and they have not been detected epidemiologically even historically, when discharges have been up to two orders of magnitude higher than current levels. Current discharges result in doses which are a small fraction of those received by the UK population due to natural background radiation, and the absence of detectable harm is supported by independent work which illustrates that the public collective dose from Sellafield discharges is almost all delivered at risks of less that one in a billion per annum.

The limited predicted harm deriving from the very limited level of current discharges would be expected to have lead to proportionally smaller demands from the regulatory regime for further reductions as part of the "Reasonably" part of the ALARP principle. However, not only has this not materialized, but a methodology for judging proportionality continues to be absent. Such methodologies that do exist, indicate that UK Operators have already been driven by the Regulator to go considerably beyond the (subjective) requirements of ALARA with respect to discharges from their sites, and the resources invested to reach the current very low levels of discharges have been, and continue to be, clearly disproportionate to any benefits gained.

Despite this, the UK nuclear industry is under intense pressure from the regulatory bodies to reduce its already small discharges still further. This is not the case in other European countries. The consequences of such socio-political primacy in decision making has been a significant contributory factor in driving the costs of UK nuclear generation and waste management to levels where the economics of nuclear generation in the UK have been artificially skewed to make it more prohibitive.

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This paper questions the practical application of ALARA, especially consistency in the treatment of risk and hazard; and proportionate and cost effective delivery of public, worker and environmental protection. It also suggests means whereby at least some of the predicted detriments can be better assessed.

Background – Health Detriments from the UK Nuclear Industry

The UK has 24 Magnox (uranium metal fueled, graphite moderated, gas cooled) reactors at 10 sites, all scheduled to be shut by 2011, 14 AGR (Advanced Gas-cooled reactors - uranium oxide fueled, graphite moderated) at 6 sites and one PWR.

It has two reprocessing plants at Sellafield and a fully functioning weapons industry. The highest critical group dose in the country is that from Sellafield, at 0.22mSv or 220 microsieverts. The total annual public dose committed by the entire nuclear industry is 6.3 man sieverts, implying (at the current ICRP recommendation of 6% of a statistical fatality pert man sieverts) of some 0.4 fatalities at some time in the future.

It is, however, instructive to look at the level of individual risk at which this detriment will be delivered, and work was undertaken by Westlakes Research Institute[1] [2] for the BNFL National Stakeholder Dialogue, using Sellafield discharges as an example. Collective doses from an example Sellafield discharge scenario were found to be are predominantly delivered at very low levels, as illustrated by the typical Sellafield discharge scenario seen below

Individual dose range (microSv per annum)					
<0.015	0.015-0.15	0.15-1.5	1.5-10	>10	Total
3500 95.8%	110 2.9%	17 0.5%	20 0.5%	12 0.3%	3700

The bulk of the dose is delivered between 0.0015 and 0.000015 microsieverts per annum[3] (or 0.015 – 1.5 nanosieverts), corresponding to an annual risk between one in ten billion and one in 1000 billion. This can be related to the highest critical group dose in the country (also from Sellafield) at 0.22mSv. This means that NO member of the public is exposed to a risk of more than 1 in 100,000 per annum.

The overall UK situation can therefore be bounded by a maximum public risk of one in 100,000, and a predicted detriment of 0.4 theoretical deaths suffered by individuals almost entirely at risk levels in the sub-1 in 10 billion range.

Proportionality, ALARA, and funding of nuclear site cleanup

The assessment of proportionality (or "Reasonableness" in ALARA) should take the form of an assessment of the expenditure of effort and money to effect an improvement, compared to the reduction of detriment which is being achieved. This is brought into focus for the UK, by the creation, in 2004, of the Nuclear Decommissioning Authority. This 'non-departmental public body' (i.e. directly owned and overseen by Government) body has the responsibility for the cleanup of the historic civil UK nuclear sites (the fuel cycle plants and Magnox power stations), a public liability currently estimated at some £70B. This means that, rather than this money being *indirectly* public money via British Nuclear Fuels plc, it is directly public money from Government. This means that spending really *is* a choice between risk reduction, discharge abatement, health provision, education

[1] Reference 1
[2] Reference 2
[3] Reference 3

and transport schemes! What better incentive for the nation to ensure that it gets value for money and that spending is proportional.

Budget limitations will mean that money spent on ALARA of discharges will not be spent on hazard potential reduction, so balancing dose reduction with other factors is actually important.

Comparisons of different detriments are possible using statistical lives and statistical life valuation. There is great controversy on the values to be used, and on whether such valuation is ethical, but there has been a steady increase in the use of detriment valuation to guide regulatory and policy decision making. Nowhere is this clearer than in the provision of healthcare – where the realisation that resources are finite has led to a crucial role for these methodologies – manifested in the UK by the work of the National Institute for Health and Clinical Excellence (NICE). So there is considerable precedent to support the use of these methodologies in the fields of energy and nuclear site cleanup policy assessment.

Comparison of Risks and Detriments

It is instructive to examine how predicted detriments from different sources of radioactivity to the UK population[4] is given in the table:

Source	Collective Dose in Year 2005 (2000 for NORM)	% of Total
Natural background radiation, total environment	131,100 man Sv	83.910
Medical, occupational, fallout	25,035 man Sv	16.024
NORM industries (UK public dose from EC industry)	53 man Sv	0.034
Nuclear Industry	50 man Sv	0.032

A comparison of public dose levels from various sources of radioactivity is also instructive.

Source	Average dose in Year (μSv)	% of Total
Natural background radiation - cosmic, gamma, radon, internal	2,230	82.593
Medical	410	15.185
Sellafield critical group, 2003 (Ref 3)	210	7.7778
Use of natural gas – critical group	'a few tens'	
Use of natural gas – commercial (catering)	19	0.704
Occupational	6	0.222
Fallout	6	0.222
Use of natural gas – average householder	4	0.148
Nuclear Industry	0.9	0.033
Total (rounded)	2,700	100

The figures for natural gas usage will be found in reference 4[5].

Thus the critical group from the use of natural gas is of the same order as that from annual radioactive discharges from Sellafield, collective doses are more than four times the entire UK nuclear industry, but the gas industry is exempt from registration/authorisation. In healthcare, the dose to individuals members of the public sitting unknowingly next to a radiotherapy patient on a bus are up to 300 uSv – which is more than critical group dose from all Sellafield operations. From the same medical sources, sewage treatment workers receive annual doses of up to 238 uSv, and the public doses up to 180 uSv from the sewage outfall[6].

[4] Reference 4
5 Reference 5
[6] Reference 6

Proportionalty, BPEO and BPM

The comparisons above show that doses, risks and detriment from radioactivity from the UK nuclear industry are small. They also show that excessive spending on removing small detriments can actually reduce spending on hazard potential reduction, which is the main aim of nuclear site cleanup. These considerations should indicate that proportionality in BPEO/BPM would ensure that 'cost per detriment avoided'. However, when we examine the cost of dose reduction in the UK nuclear industry is examined, it is found that spends of >£10M per statistical life are commonplace (compared to the £1M or so used in other policy areas like transport and health), and values near £100M have been observed[7].

In another healthcare example, a BPM assessment[8] led to the construction of I-131 holding tanks in new London hospital at a cost £0.5M. Retrospective assessment showed that a critical group dose reduction to sewage workers of around 180 uSv/yr, was being 'paid for' by hospital maintenance workers getting doses of 1500 uSv/yr. The BPM was questioned, the tanks bypassed, and the spend wasted.

Disproportionate attention is being given to 'reducing discharges' no matter how trivial the environmental consequences, and it is notable that UK approaches to the application of OSPAR are very from those used in other EU countries.

The results of using BPEO and BPM without due regard for proportionality, have resulted in several Local Effluent Treatment Plants being planned at Sellafield between now and 2020, at a capital cost of some £500M. The plants will also attract significant operating costs, and will produce primary and secondary waste, which is in considerable. They will also attract some £M spend in sampling and analysis of specific nuclides for each microsieverts of critical group dose saved.

Value for Money and Cost Benefit Analysis in the UK Nuclear Industry

The prospective and retrospective assessments discussed above are not currently taken account of by the regulatory processes, and it is evident that BPEO and BPM are being applied without any formal method of assuring value for money, and hence proportionality. This is much at variance with policy in other areas, where Government, and especially the Treasury, needs to be assured of Value for Money, and places heavy emphasis on Cost Benefit Analysis (CBA) to help to achieve this. As mentioned above, CBA is widely used and generally accepted in fields such as Health (NICE), Road Traffic (DfT), but not in the nuclear area.

The almost total absence of CBA in the nuclear area has weakened the NDA's ability to justify its spending plans, especially in comparison to other potential expenditures which produce defined benefits or avoid defined detriments. This has been reflected in the results of spending reviews. Without a meaningful way of weighting the importance of nuclear site cleanup against other uses of public money – there is a growing risk that the real importance of cleanup could be discovered only after the event.

The worth of nuclear site cleanup must be related to the reduction in the actual and potential doses from normal operations and in accident situations, to public and workforce. Any method of assessing this must give at least a relative importance to dose – both individual and collective. It is conceptually difficult to value critical group dose – and this has generally not been attempted, but can be inferred retrospectively.

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[7] Reference 7
[8] Reference 8

A meaningful measure must surely integrate dose over time and the population affected, and this can be done by the use of collective dose. The key problem is that detriment is delivered at very small doses to very many people over very long times – especially when the isotopes discharged are long-lived, such as carbon 14. This has led to collective dose being used out of context as a stick to beat the nuclear industry with: 'the operation of this plant will kill 1,000 people'. However, the response to this from the industry and from regulators and ICRP has been to undermine Collective Dose as a measure of public detriment – without putting anything else in its place.

This absence of an integrative measure of detriment, and of some form of valuation or otherwise measuring the significance of that detriment, means that proportionality could only ever be achieved by accident. Recent experience shows little sign of this particular accident ever happening. We contend that there is actually nothing wrong with collective detriment valuation that cannot be vastly improved by concentrating on the higher doses.

There are two ways of doing this

1. Disregard low doses – i.e. put in a de minimis dose below which dose and its effects are not measured
2. Calculate collective dose as at present – but vary the valuation of that dose according to the dose, and therefore the risks.

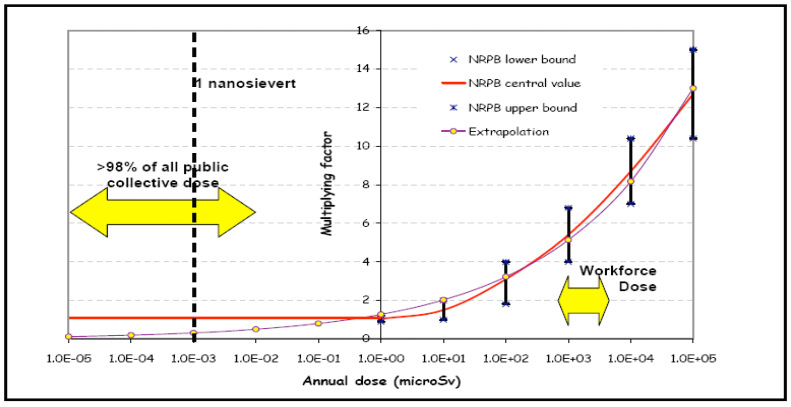
Ignoring low doses is compatible with recent UK advice (HPA-RPS, 2006) that:

> *' ... discharges giving rise to per caput doses of less than a few nanosieverts per year of discharge can be regarded as trivial. Higher annual per caput doses, up to say a few microsieverts per year of discharge can be considered trivial, but may require some consideration of alternative discharge options, particularly if at the higher end of the range.*

The Environment Agency has also begun to report 'average per caput' doses (a few nanosieverts per year of Sizewell B discharges, for example) – and class these as trivial. So the argument of 'less worth at low risk' seems to be gaining ground, but is directed towards *undermining* the collective measure rather than *improving* it

The developing 'low dose is trivial' view does remove some of the problems of the value of societal dose – but creates others. A cut-off below which 'value becomes zero' is difficult to defend and this difficulty has been observed in practice, with de minimis values (e.g. 10μSv/a) being stated in UK policy for many years, but never applied by regulators. Also, as almost all of collective doses are low, using a de minimis value tends to remove 'societal dose' as a discriminator – which is counter-intuitive to most philosophical views.

Surely it is more transparent and defensible to maintain collective dose, but to concentrate its value at the higher risks where it is most significant? A function has been derived which continuously increases the 'value of spend to save a statistical life' with increasing risk - applying a greater value to higher doses, and less value to lower doses caused to wider populations. This can accord a weight or value to collective dose which is concentrated where the effects may become significant.



This method reduces the valuation of collective dose at the current doses, but can be arranged to increase the valuation at higher doses in the region of the highest critical groups. It may also make possible comparisons between worker and public doses: This balance is included in legislation and regulation but has never been attempted in practice, and a potential process has been demonstrated[9].

Work in support of the NDA's Prioritisation Procedure examined the detriment of 'business as usual' discharges from legacy ponds and silos, using the ExternE methodology (an extensive EU-funded project examining the external costs of power generation and transport for valuing detriments. This demonstrated that, using valuation methodologies such as ExtrenE,[10] radioactive discharges contribute less than 1% of the overall detriment of storing radioactive waste in ponds and silos, with the bulk of detriment coming from the detriment due to the environmental discharges from the generation of the power required to run pumps, heating and lighting in the plants. This puts into clear perspective the weakness of concentrating on radioactive discharges without due regard to other possible detriments.

Conclusions

The preoccupation with discharge reductions and doses at trivial levels is hindering a balanced approach to the regulation of nuclear site cleanup. The existing regulatory regime has given no safeguard against disproportionate use of resources on the reduction of discharges.

This lack of proportionality and objectivity makes it difficult to justify spend on cleanup against other Government expenditure, especially where this alternative expenditure is justified by CBA. This increases the vulnerability of the NDA budget to arbitrary spending cuts.

The development and application of a proper methodology in this area would be a major step in allowing the NDA to demonstrate Value for Money. If site cleanup is REALLY important, it deserves to be judged and measured by a methodology, not by articles of faith.

The development of a transparent methodology would give real advantages, it could be done, and a methodology for risk-based dose valuation offers a solution to ensure holistic, proportionate spend.

Society would have much to gain by adding a meaningful onus on Regulators to assess and prove reasonableness, and to audit the results.

None of these measures could gain acceptance without much improved communication of real risks to the public. The money that could be saved by the resulting acceptance of more realistic decision making would dwarf the cost of such a scheme.

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