What Resources Were Needed to Implement ICRP 60, And What Resources May Be Needed to Implement ICRP 103?

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Abstract

National and international organisations are currently considering the implementation of the 2007 ICRP Recommendations, ICRP 103. A survey of resources spent to implement the 1990 ICRP Recommendation (ICRP 60) and anticipated for the implementation of ICRP 103, on behalf of the Committee on Radiation Protection and Public Health of the OECD Nuclear Energy Agency, yielded information from regulatory agencies in 11 member countries and some operators/licensees in four countries. In most countries, the cost of implementing ICRP 60 were regarded as relatively modest (or at least tolerable), both by regulators and after some initial concerns by operators. The cost of implementing ICRP 103 is expected to be smaller where ICRP 60 is already implemented, since the nominal risk and the dose limits remain essentially unchanged. Important factors contributing to this relatively sympathetic perception of the costs appear to be:

- Considerable lead times (up to 10 years or more from initial discussions to legally binding obligations), permitting ample time to explain the recommendations and allowing licensees an orderly and timely re-organisation of their operations;
- Considerable efforts on information, discussions, training, and consultation with licensees and professionals before any binding decisions were taken (however, efforts involving the general public were often less comprehensive than probably expected today);
- At least some stakeholders felt, after the comprehensive consultations, that the recommendations 'made sense';
- Legislation and regulations were often updated in connection with scheduled revisions for other reasons rather than 'ad hoc', thus reducing the administrative costs;
- In some cases, costs were balanced in part by savings due to improved working conditions in areas with high radiation levels;
- Constructive discussions (e.g., on realistic modelling of shielding requirements) between regulators and operators evaded some costs that had initially worried operators.

Key words: Cost, benefit, regulatory impact, recommendations, stakeholders

1. Introduction

For some time, the Committee on Radiation Protection and Public Health (CRPPH) of the OECD Nuclear Energy Agency (NEA) has conducted discussions concerning the resources that were needed to implement the 1990 Recommendations of ICRP, *Publication 60* (ICRP 1991), and the resources that are expected to be necessary to implement the 2007 Recommendations of ICRP, *Publication 103* (ICRP 2007). The present authors were asked to perform a survey of several CRPPH members on this issue.

We developed a questionnaire with assistance from the NEA Secretariat and significant contribution from the US Nuclear Regulatory Commission, who had originally asked for this information. After interviews with representatives of regulatory agencies and of various kinds of licensees (nuclear installations, medical establishments, and non-destructive testing companies) in the United Kingdom and in Sweden, we distributed a refined version to all CRPPH members, requesting replies and also assistance to get in touch with operators in at least some of the countries. The present report summarises the responses received and outlines the conclusions that could be inferred.

2. Methods: The Questionnaire

We received responses from 11 countries. Most replies come from government agencies (regulatory bodies and/or advisory organisations), but there are also replies from nuclear power plant operators, medical establishments, and a non-destructive testing organisation. Table 1 provides an overview of the respondents.

Table 1. Responses received

Country	Response received from
AUSTRALIA	Regulatory/advisory body
CANADA	Regulatory/advisory body – including ICRP 60 RIA/CBA **) NPP operator Medical establishment
CZECH REPUBLIC *)	Regulatory/advisory body
ICELAND	Regulatory/advisory body
REPUBLIC OF KOREA	Regulatory/advisory body
NORWAY	Regulatory/advisory body
SLOVAKIA *)	Regulatory/advisory body
SLOVENIA *)	Regulatory/advisory body
SPAIN *)	Regulatory/advisory body
SWEDEN *)	Regulatory/advisory body NPP operator Medical establishment NDT company
UNITED KINGDOM *)	Regulatory/advisory body – including ICRP 60 RIA/CBA **) NPP operator Medical establishment

*) EU member states **) Regulatory impact assessment/cost-benefit analysis

In addition to contact details, respondents were asked to provide information concerning:

- National legislation and radiological protection organisation, ICRP *Publication 60* (ICRP 1991) incorporation, stakeholder involvement in the implementation of ICRP *Publication 60*, guidance, time-scales, burdens, benefits, and costs;
- Scope of the legislation after ICRP *Publication 60* implementation, reactions from users (if any) that had not previously been subject to regulation;
- Historical and current dose limits, transition experience, and resulting doses;
- ICRP *Publication 60* and specific technical topics including pregnancy, constraints, dosimetry, and radon;
- Training implications of ICRP *Publication 60* implementation for regulators and for stakeholders;
- Anticipated changes (if any) to legislation and radiological protection organisation, and anticipated burdens, benefits, and costs when ICRP *Publication 103* (ICRP 2007) is implemented;
- ICRP *Publication 103* and specific technical topics including pregnancy, constraints, dosimetry, and radon;
- Training implications of ICRP *Publication 103* implementation for regulators and for stakeholders; and
- Any other pertinent topic that respondents wish to raise.

The survey yielded a considerable body of useful information, and a full report comprising all of the questionnaires with the complete replies is available from OECD (NEA 2012).

We also received various kinds of supporting material. In particular, from a large European nuclear power plant operator we received a useful white paper (EdF 1993) summarising their perception of and reaction to ICRP *Publication 60* (ICRP 1991) before its implementation, although not providing any numerical estimate of the anticipated costs of implementing ICRP *Publication 60*.

3. Results

Legislation and organisation. All respondent countries have national laws on radiological protection, delegating regulatory power from parliament to their government. In about half of the countries, the government then delegates the right to issue binding regulations to the licensing authority/ies. Codes of practice and guidance are issued by regulatory authorities and, at least in one country (UK), also by professional/trade bodies. Many countries have more than one regulatory authority with responsibilities divided in different ways (health care vs. other sectors; nuclear vs. other sectors; etc.). Consistency is achieved through consultation and Memoranda of Understanding between the agencies concerned.

Australia and Canada are federations and as such they have the additional complication of regulatory bodies both at the federal level and in the various jurisdictions/provinces. There are mechanisms to facilitate harmonised and aligned regulation. More details concerning the problems posed by having both a federal and a state (jurisdiction, province) level are provided in NEA (2012).

Most respondents expect to make only minor amendments to their ionising radiation protection legislation/rules if and when ICRP *Publication 103* is incorporated in their national systems. If practicable, such amendments are expected to be carried out in connection with 'regular' reviews.

Anticipated amendments frequently include the re-organisation of requirements due to the focus on exposure situations, the new weighting factors, and the added emphasis on optimisation and the use of constraints and reference levels. Several respondents mention new limits on dose to the lens of the eye (technically not a part of ICRP *Publication 103*, but new limits were predicted in ICRP 103). Protection of the environment is mentioned only by Spain.

Incorporation of ICRP Publication 60 into national legislation and regulations. All of the respondent countries revised their laws and regulations after 1990, but rarely as a direct result of ICRP *Publication 60*; instead, when laws and regulations were updated for other reasons, they were also amended to take account of ICRP *Publication 60*. Draft regulations were prepared by regulators in informal consultation with stakeholders, then subjected to formal consultation augmented by information and meetings, then turned into binding regulations (with minor variations because of differing legal systems, etc.)

Apparently, considerable effort was spent on information and consultation. All respondent countries involved ministries and regulatory agencies, major licensees, and professionals. Several responses also mention members of the public, but probably the general public was less involved than it would be today.

Time-scales from proposal to compliance. Table 2 summarises information regarding 8 countries concerning the time of implementation of ICRP *Publication 60* in legislation. The dates of adoption and coming into force of new legislation are unambiguous, but the starting points are less clearly defined. Draft legislation was usually the result of discussions with stakeholders before any formal consultation. Six countries in Table 2 suggested starting dates. For Norway and Spain we assumed that discussions with stakeholders started around 1994, based on the following considerations: The first widely publicised indication that significant changes of the fundamental Recommendations of ICRP were to be expected came with the 'Como statement' (ICRP 1987). ICRP *Publication 60* appeared in print in 1991. In 1996, implementation within 4 years of most of ICRP *Publication 60* became mandatory for European member states (European Commission 1996).

Table 2 shows that total lead-in times for new legal / regulatory requirements appear to have ranged from 3 to about 10 years (or, for selected requirements, even longer). In most countries, the lead time was mainly between first proposal and decision; compliance with new regulations is often

required quite soon after adoption of the regulations (although 'difficult' requirements are often applied only after an additional delay).

Table 2. Dates of legislation and lead-in times

Country	First proposal of new legislation	Legislation adopted	Time until being in force	Lead-in time
Australia	1991 (federal recommendation)	1993 to 2002 (different jurisdictions)	0 – 1 years	3 to 11 years
Canada	Early 1990s	2000	0 years (some requirements 5 years)	9 to 14 years
Czech Rep.	1994	1997	(?)	3 (+?) years
Rep. of Korea	1994	1998	0 years (some requirements 5 years)	4 to 9 years
Norway	(1994?)	2003	2 months (some requirements 3 years)	9 to 12 (?) years
Spain	(1994?)	2001	1 year	8 (?) years
Sweden	1990	1998	2 years	10 years
UK	~1994	1999	1 month (some requirem/s 5 months)	~6 years

Burdens, benefits, costs. Mandatory cost-benefit analyses of the impact of new regulations were not as common at the time of ICRP *Publication 60* as they are now. Cost-benefit analyses that were performed at the time could be retrieved from Canada and the United Kingdom. No respondent reported having fully assessed the 'null alternative', i.e., the costs, savings, or other implications of not implementing ICRP *Publication 60*. The Canadian regulator did assess the health implications, but not monetary cost, of the less stringent limit that was selected for pregnant women.

Regulators and operators agree that the lower dose limits recommended in ICRP *Publication 60*, compared to earlier ICRP Recommendations, have not caused any significant problems per se. Canada and Sweden reported that increased dose monitoring and upgraded dose registries caused added (but apparently acceptable) costs. No respondent had identified any reduction of any kind of cost or effort resulting from the incorporation of ICRP *Publication 60* into legislation.

The 2001 population of Canada was 31M people. The overall costs were estimated to be

(a) Once-for-all cost to implement new requirements: 5.9M CAD of which 46% for new security requirements (i.e., about 3.2M CAD for other new requirements than those relating to security);
(b) Annual incremental cost due to the new requirements: 4.5M CAD of which 56% for new security and 22% (990k CAD) due to ICRP *Publication 60* dose limits;
(c) Training of CNSC staff: direct costs 370k CAD per year for 3 years (covered through re-allocation of existing funds), plus staff time corresponding to 9 full-time employees per year for 3 years (also covered by re-allocation).

The 2001 population of the United Kingdom was 59M people. In January 2000, 1 GBP corresponded to about 2.35 CAD. The overall costs were estimated to be

(a) Once-for-all cost to implement new requirements: 839k GBP (about 2M CAD) of which 78% to operators and 12% to the regulator;
(b) Annual incremental cost due to the new requirements, including salary costs: 1.2M GBP (about 2.8M CAD) of which 99.7% to operators and 0.3% to the regulator;
(c) Some additional, unquantified but probably small, costs.

In 7 of the 10 countries that stated whether their regulatory authority expects to perform a cost-benefit analysis of the implications of any new regulations (regulatory impact analysis), such an analysis is a mandatory part of any new rule-making. In a few European countries, an analysis of the 'null alternative' is regarded in principle as part of a regulatory impact assessment. Nevertheless, there

will be little or no analysis of the cost of not implementing ICRP *Publication 103* since an updated Euratom Basic Safety Directive is expected make the provisions of ICRP *Publication 103* mandatory in member countries.

The cost impact of ICRP *Publication 103* is expected to be limited. Factors that may have some impact include the new weighting factors, w_R and w_T, and the added emphasis on dose constraints. The incorporation of ICRP *Publication 103* into national legislation could also, in theory, lead to reductions of some kinds of cost or effort. However, little is known as yet about such possible cost reductions. The Slovakian regulator points out that dose reductions can also be regarded as a kind of cost reduction. In Spain, where 5-year averaging of occupational doses is regarded as cumbersome and of little use, it is expected that elimination of such averaging of doses may lead to lower costs.

Historical dose limits. Before ICRP *Publication 60* was incorporated into national legislation, the dose limits in most countries were in line with *Publication 26* (ICRP 1977), albeit sometimes with additional provisions (e.g., on doses per shorter periods than a calendar year). At least one country, Korea, adhered to *Publication 9* (ICRP 1966).

Current dose limits. After the implementation of ICRP *Publication 60*, all respondent countries adhere to its fundamental dose limits. However, in Canada pregnant workers are subject to a limit on effective dose of 4 mSv for the balance of the pregnancy, while ICRP *Publication 60* recommended a limit on equivalent dose to the abdomen of 2 mSv. In most respondent countries, 5-year averaging of occupational doses as recommended in ICRP *Publication 60* is an option (albeit only after authorisation in several countries). There is a very wide range of experiences of this flexibility, from Sweden where averaging is seen as easily implemented and quite useful to Spain where averaging is regarded as cumbersome and unnecessary. Most countries report few or no difficulties, but also that the flexibility is rarely used. Five-year averaging was regarded as important by Canadian and Swedish operators; Swedish nuclear operators also came to consider the lower limits as investments that paid in the longer term. In contrast, no respondent seems to regard the possibility of 5-year averaging of public doses as important.

Transition experience. Information to stakeholders was provided well before the formal implementation of ICRP *Publication 60*. This permitted operators to adapt to the new limits before they became mandatory and contributed significantly to a smooth transition.

No significant rebuilding requirements were reported. In a few countries, more realistic occupancy modelling and/or amended access/occupancy control were used to avoid the need for additional shielding. In the United Kingdom, dose rates at radiotherapy establishments were, and are still, an issue. However, shielding was upgraded only in connection with rebuilding for other reasons.

Resulting doses. In general, doses are reported to be much lower since the implementation of ICRP *Publication 60*. This general trend is attributed to more rigorous optimisation of radiological protection, and to the discussion, training, and attention to radiological protection generated by the implementation of the new Recommendations.

However, there are several variations on the general trend. Some dose trends are not linear, because planned investments in dose (e.g., major refurbishment projects) will achieve later dose reductions.

Pregnant workers. The one country with significant problems with the ICRP *Publication 60* level, Canada, stated that female radiation workers protested in view of possible discrimination against them. However, Health Canada Safety Code 20A recommends that the dose to the surface of the abdomen be kept below 2 mSv for the balance of the pregnancy (=the ICRP *Publication 60* level).

ICRP *Publication 103* introduces a limit on equivalent dose to the fetus of 1 mSv during (disclosed) pregnancy, replacing the ICRP *Publication 60* limit on equivalent dose to the abdomen of 2 mSv during (disclosed) pregnancy. EU member countries are already subject to the 1 mSv to the fetus limit (European Commission 1996). Korea and Norway state that the new limit is not expected to cause any problems, and Australia has not provided any comment. However, Canada states that their current limit on effective dose to pregnant workers, 4 mSv, has undergone two major consultations and that therefore, it is not anticipated that the Canadian limit will be changed.

Dose constraints. ICRP *Publication 103* emphasises the use of dose constraints. This is expected to generate some difficulties in Canada and Spain, where constraints have had little or no use so far, and for waste disposal in the United Kingdom. In Korea the regulator resolved some difficulties by recommending constraints in a non-mandatory guide. No difficulties, or only limited problems, are

expected in countries already using ICRP dose constraints (the Czech Republic, Norway, Slovakia, Sweden, and United Kingdom). The Swedish nuclear power plant operator is outright enthusiastic.

4. Analysis

Limitations of the study. The survey is far from all-inclusive, but it does include many different kinds of country and the range is probably sufficient to provide a reasonable basis for conclusions. Most replies were received from regulators, often a nuclear regulator and the replies may be biased towards conditions in the nuclear sector. Perhaps the most serious drawback is that we have relatively few replies from operators.

Consultation and time-scales. All countries surveyed report considerable efforts on achieving 'buy-in' through careful, comprehensive, and unhurried consultation at the time of ICRP *Publication 60*. The lead-in times from first proposal to legally binding requirements were often long (up to 10 years or more). This allowed licensees to adapt their operations in an orderly manner and certainly contributed to the successful implementation.

Costs and benefits. Regulators and licensees appear to agree that the resources needed to implement ICRP *Publication 60* were reasonable and included investments that led to lower costs in the long run. For instance, much of the dose reduction required at nuclear installations was achieved simply by better advance planning of tasks, which also led to cost savings. Investments to achieve lower dose rates at crucial locations in the plants quickly paid back because they permitted safety-related jobs to be performed by fewer and less worried staff working longer hours.

Cost-benefit analyses of the impact of implementing ICRP *Publication 60* were obtained from Canada and the United Kingdom. However, there are a number of reasons why any extrapolation from these analyses to present-day costs in other countries may be invalid.

In both countries, incorporating ICRP *Publication 60* in connection with planned other amendments to legislation will have reduced costs, compared to an update specifically to take account of ICRP Recommendations. Taking the different population sizes into account, the total costs projected in the two countries are, very roughly, in the same order of magnitude (although it is not self-evident that costs are linearly related to the population size).

Extrapolating costs from these assessments is not straightforward. With hindsight, it is clear that the costs were not as high as projected in those analyses. For instance, most of the cost anticipated in the United Kingdom was expected to be due to an increase of the number of 'classified' (monitored) workers. While the increase was estimated to be 5200 workers, the actual increase turned out to be 500 workers. This means that the one-off cost will have been only 20% of that estimated, and the annual cost just some 10%.

Furthermore, neither analysis appears to have given a realistic view of the benefits and savings resulting from the implementation of ICRP *Publication 60*. The UK analysis correctly noted that health benefits were expected to be small since most doses were already below the new limits. However, focusing on health effects overlooks other beneficial effects. Judging from the response by the Swedish nuclear power operator, the positive effects on working conditions, efficiency, and hence economy were considerable. This is at least not contradicted by the white-book from EdF (1993).

Also, neither of the two analyses provides a realistic estimate of the cost of the 'null alternative' of not implementing ICRP *Publication 60*. For instance, radiological protection is an international science, and different rules in different countries would inevitably lead to added costs for operators (and probably to strained labour relations).

While EdF (1993) does not contain any cost assessments, it is interesting in the present context because it emphasises the operator's conviction that it would make sense to comply with ICRP *Publication 60* – even though they doubted the scientific validity of the ICRP model of risk at very low doses. This was because the primary objective of the Recommendations was to improve radiological protection, because there was international consensus, and because optimisation of radiological protection also led to improved efficiency.

These observations by the French operator are in line with the Swedish nuclear power operator's positive attitude to optimisation. An operator will not necessarily be convinced that improved radiological protection is needed because of radiation risk considerations, but improved radiological

protection will be good for the operation as such and therefore it can be regarded as an investment rather than just a cost.

Constraints on optimisation. Constraints are tools provided for operators to use in optimisation. In the context of occupational exposures, ICRP expects operators to take responsibility by setting their own constraints, and operators may be using constraints even if this is not prescribed by the regulator.

There is a considerable range of views on the utility or otherwise of dose constraints in occupational exposure situations. In countries where dose constraints in the ICRP sense are already in use, the tool is now regarded as useful in optimisation (although ICRP may have been less than lucid when explaining it) and valuable as a means to confer responsibility on operators. Other countries express their reservation, perhaps because they envisage or are already using something else: a constraint on dose, perhaps set by the regulator, which would act as an additional limit. Such an alternative constraint may well be a useful regulatory instrument, but it is not the ICRP constraint on optimisation.

In the occupational context, sometimes the lowest collective dose is achieved if a few workers get a fairly high individual dose. This causes a conflict of interest between the interest of individual workers and the interest of society (or at least all concerned workers). The most common purpose of using a dose constraint in occupational contexts is to add protection of the individual (as prescribed by deontological duty ethics) while strict minimisation of collective dose protects society and emphasises utilitarian consequence ethics. The choice of dose constraint decides the balancing of duty versus consequence ethics. At the same time, since operators are supposed to make the choice, it encourages them to assume more responsibility.

In the context of public exposure, ICRP dose constraints on optimisation more frequently serve the purpose of ensuring that the combined exposure from several sources remains acceptable. This usually requires that the dose constraint is set by the regulator. Such use of constraints in public exposure contexts is more unanimously accepted and seems to cause less confusion.

As yet, few countries are using formal risk constraints. The United Kingdom does use risk constraints, which is in line with ICRP experience: ICRP *Publication 76* (1997) provides genuine (albeit simplified) risk constraint calculations as applied by actual operators, with a UK cyclotron as one example. Another ICRP *Publication 76* example concerned a Canadian irradiation installation where the operator had set a risk constraint. Since the Canadian regulator answering the questionnaire reported that risk constraints are not used formally, this seems to reflect that some large operators use risk constraints even if not required formally to do so.

5. Conclusion

Little quantitative information about the cost of implementing ICRP Recommendations is available. The qualitative information obtained indicates that in most countries, the costs were regarded as relatively modest (or at least tolerable), both by regulators and (after some initial concerns) by operators.

Important factors contributing to this relatively positive perception of the implementation costs include, e.g.:

- Considerable lead-in times permitting explanations and allowing licensees an orderly and timely re-organisation of their operations;
- Considerable efforts on information, discussions, training, and consultation with licensees and professionals before any binding decisions were taken;
- At least some stakeholders felt, after comprehensive consultations, that the recommendations ‘made sense’;
- Legislation and regulations were often updated in connection with scheduled revisions for other reasons, thus reducing the administrative costs;
- In some cases, costs were balanced in part by savings due to improved working conditions in areas with high radiation levels;
- Constructive discussions (e.g., on realistic modelling of shielding requirements) between regulators and operators evaded some costs that had initially worried operators.

The cost of implementing ICRP *Publication 103* is expected to be even less where ICRP *Publication 60* is already implemented, since the nominal risk and the dose limits remain essentially unchanged.

However, there may be cultural differences that were not revealed by the survey. The respondent countries have a tradition of participation in international work; some countries may not be as involved. Furthermore, the regulatory system in some of the countries surveyed fosters a mutual trust that may not be as evident in some other countries. As an example, some nuclear licensees interviewed in the survey claimed that they pride themselves of being 'ahead of the regulator'. Operators in some other countries may be more keen to question any new regulatory requirements, at least until a level of mutual trust can be achieved between regulators and operators.

6. Acknowledgements

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