CENTRE D'ETUDE SUR L'EVALUATION
DE LA PROTECTION DANS LE DOMAINE NUCLEAIRE

REPORT N° 266

THE MANAGEMENT OF PUBLIC EXPOSURES ASSOCIATED WITH THE RADIOACTIVE RELEASES OF NUCLEAR INSTALLATIONS

Decision makers seminar held in Cachan (France), the 28th of May, 1999

Editors: C. SCHIEBER, T. SCHNEIDER

September 2000

EC-DGXII Contract: FI4P-CT96-0056

SIEGE SOCIAL ET ADMINISTRATIF :

ROUTE DU PANORAMA BP 48 F-92263 FONTENAY AUX ROSES CEDEX
TEL : +33 1 46 54 74 67 FAX : +33 1 40 84 90 34
E-MAIL : sec@cepn.asso.fr WEB : http://www.cepn.asso.fr/

ASSOCIATION DECLAREE CONFORMEMENT A LA LOI DU 1 JUILLET 1901 SIRET : 310 071 477 00031 N° DE TVA : FR60310071477

FOREWORD

This report presents the transcription of the verbatim records of the presentations and discussions of the decision makers seminar held in Cachan (France) the 28th of May, 1999, within the framework of the European Commission DG XII contract on the optimisation of radiation protection in complex exposure situations. The aim of this seminar was to explore, based on presentation from French and UK Authorities and utilities, the various criteria entering into the decision making process related to the management of public exposure, and specifically to the radioactive releases from nuclear installations.

SUMMARY

This decision makers seminar was devoted to the presentation of current practices in the management of public exposure due to the radioactive releases of nuclear facilities. The points of view of UK and French regulators (the UK Environment Agency, the French Directorate for Safety of Nuclear Installations (DSIN) and the French Institute on Nuclear Protection and Safety (IPSN)) were presented as well as the practical experience of UK and French utilities (BNFL for the management of Sellafield releases, and EDF for the French Nuclear Power Plant releases). Some methodological developments concerning the monetary value of the man-sievert were also presented. Finally, a general discussion, including in particular, brief presentations from the SCK.CEN of Mol (Belgium) and from NNC (UK) allowed the participants to share their experience and to draw conclusions and perspectives for the management of public exposures in the future.

Summary of the presentations

The example presented by the UK Environment Agency, concerning some recent decisions on the releases of Technetium from Sellafield, reflects a willingness from the Authorities to find a balance between:

- reducing public exposure associated with the concentration of Technetium in lobsters because of international concern (i.e. reducing discharges),
- reducing potential exposures due to the storage of Medium Active Concentrate (MAC) in old tanks (i.e. need to treat the MAC which increases discharge of Technetium),
- allowing the utility to operate (i.e. find a limit of releases which is not so tight that it stops fuel reprocessing operations).

The new release authorisation of BNFL installations was accompanied by a proposal to manage discharges so as to preferably make the discharges during winter (inducing a lower concentration in lobsters than in summer time), to continue research and development studies on Technetium-99 abatement and make a full scale trial of one method to remove Technetium by floc precipitation, and, finally, to assess the cost of these new technologies and their impact on solid waste storage.

The analysis of the historical experience of BNFL concerning the management of radioactive discharges from Sellafield shows an evolution within the relative importance of decision making criteria. The three main criteria identified are: the collective dose, the critical group dose and a global criterion, which can be called "politics" or "international concern", including various other criteria. The following remarks emerge from this analysis:

- The rationality of decisions has been mainly based on the critical group dose. The collective dose was used only in a very few cases in cost-benefit analysis, while keeping the critical group dose as the main indicator.
- When examining the decisions made during the last 20 years, it is possible to estimate, *a posteriori*, an implicit "monetary value of the micro-sievert avoided", or what has been spent to obtain a certain level of individual risk. But as yet there is no coherent framework to evaluate if it was "reasonable" decisions from the economic point of view.
- The importance of the "politics" criterion seems to be growing in recent years. The issues in the near future will be to identify those other criteria, and more particularly the economic dimension and the risk trade-off aspects which are affected by the decisions taken.

In France, the requirement for optimisation in the radioactive discharges authorisation was introduced in 1995 by a decree which established new guidelines for regulating discharges and water intakes. Before, the utilities were required to reduce as low as possible the level of activity below the authorised limits. The new decree also introduced new specific radionuclides to be measured separately (including C^{14}, radioactive iodine's and alpha emitters). The Authorities are currently looking at a revision of the release limits for gaseous and liquid effluents for all nuclear power plants. This revision will reduce the limits, taking into account the technical progress made during the last 20 years which allowed the plant to considerably reduce their level of discharges. The documents presented by the utilities when applying for a new authorisation are analysed by the Authorities on two major elements: the source term, and the impact on the critical group dose. A recent working group led by the Ministry of Health with representatives from other ministries, industry and experts, has proposed guidance for the assessment and management of health impact from nuclear installations. The criteria to be looked at are the following: dose to the critical group, collective dose, number of people concerned, occupational doses associated with releases treatment, waste production, investment and operational costs. As the requirement for optimisation is rather new, it is difficult to clearly establish what are the most important criteria influencing the decision. At the moment, they are all examined. Furthermore, the question of studying alternatives is also often asked by the Authorities.

For the French utility (EDF), the substantial decreases of the activity level discharged were obtained without major investments, and essentially by a reduction of the production of effluents, a better segregation of effluents and a better adaptation of the already existing treatment systems. It is not the result of an optimisation study. However, in order to be in a position to discuss with Regulatory Authorities on the impact of possible further decreases of the level of discharges, EDF has started a study aiming at collecting the following elements:

- What are the technical possibilities (existing, or under development) to reduce discharges?
- What would be the costs (investment and operational) of improving the current treatment systems?
- What would be the impact in terms of trade-off between public and occupational exposure, between the releases of radioactive and/or chemical elements?

This study shall also be helpful to respond to the OSPAR requirement to reduce discharges 'close to zero' by 2020.

The methodological developments to evaluate the monetary value of the man-sievert for public exposure shown that, according to the non existence of a compensation system for the public in case of a radiation induced cancer, the willingness to pay for reducing the level of exposure for the public should be between 3 and 6 times higher than that of the workers, the latter having the possibility to benefit from a compensation if they develop a radiation induced cancer following their exposure at work.

These developments were considered to be interesting by the decision makers. As indicated during the other presentations, the main criterion in the decision making process related to public exposure is not the collective dose (and its monetary value). But such studies have the merit to clarify some aspects of the decision and to give some arguments to inform the debates and have a more coherent approach. The decisions made until now in the field of radioactive releases of nuclear installations might not be changed a lot by the selection of a monetary value of the man-sievert being 3 to 6 times higher than the one selected for occupational protection. But in other fields associated with public protection, such as the use of Natural Occurring Radioactive Materials, it could have an influence.

The final discussion of the seminar emphasised the fact that the implementation of ALARA related to protective options for public exposures needs to rely on a wider approach than the cost-benefit analysis. It appears to be much more a sort of "political" process, where many parameters (individual and collective doses, waste management, occupational exposure, views of the international community,…) are interacting in a decision which has quite often to be taken at the level of the society, i.e. the 'social' factors can dominate the 'economics' in the ALARA decision making. The main issue now is to define the way of involving the various stakeholders in the decision.

Conclusions and perspectives

This seminar clearly pointed out the fact that the decision making related to the management of public exposure is not a straightforward process. The various criteria interacting in the decision are not all quantifiable, nor related to the only radiation protection field. The implementation of optimisation of protection concerning public exposure is rather difficult to formalise into a define procedure. Consideration needs to be given to negotiation between the stakeholders around the level of releases which can be achieved and to pragmatism in the decision making process.

In the determination of the authorised level of radioactive discharges, the main criterion directly related to radiation protection is the individual exposure of the critical group. It seems however that the problem of its estimation is still under consideration. The recent EURATOM Basic Safety Standard Directive requires the radiological assessments to be "realistic". Both in France and UK, the meaning of "realistic" is being studied by the Authorities. It appears that there is a need for a harmonisation at the European level of the reference set of parameters to be used in such estimates.

The collective dose is seen as a risk indicator, but it is rarely used in cost-benefit analysis studies. The time cut-off proposed to evaluate the collective dose in UK is 500 years. In this country, the collective dose might be evaluated at the national, European and World levels. In France, as the requirement for optimisation is quite recent (until 1995, it was required to minimise the level of radioactive releases), the reflections on the use of collective dose are still under development. In both countries, utilities and the Authorities think that while being in some cases a useful indicator, the monetary value of the man-sievert should not be the only economic criteria used to evaluate what is "reasonable" to do.

One of the main problems which will have to be addressed in the next century is the implementation of the OSPAR convention which requires a «progressive and substantial reduction of discharges, emissions and losses of radioactive substances» into the marine environment in such a way that discharges are «reduced by the year 2020 to levels where the additional concentrations in the marine environment above historic levels, resulting from such discharges, emissions and losses, are close to zero». This implementation puts in front of the international stage the main issues associated with the management of radioactive releases, which are, among others:

- the identification of the available technologies to reduce discharges,
- the trade-off between releases and stored waste, public exposure, occupational exposure and potential exposure,
- the capability to store or dispose of the waste,
- the cost of new treatment systems,
- the capability to measure concentration of radionuclides in the environment.

The main conclusion is that, particularly in the field of public radiation protection, ALARA can be seen as a necessary dialogue between operators, regulators acting on behalf of the society and the society itself. The main challenge is to create the opportunity for dialogue and to find a mechanism where these issues can be debated properly and efficiently by the stakeholders from different fields: environment, economics, energy systems, waste management, public,… At the same time, it is important that the elements which will sustain the discussions and throw a light on the decisions be clearly identified and quantified, the economic dimensions being one element among others.

TABLE OF CONTENTS

INTRODUCTION OF THE SEMINAR

Bertrand MUNIER: Welcome to the *Ecole Normale Supérieure de Cachan.* Some of you have been already here, in the process of the research contract on the ALARA guidelines. GRID is the research centre associated in this contract with the CEPN and six other partners and this is the reason why we meet in this place. So I realise that this year's meeting is going to be slightly different from last year, to the extent that the focus will be more on practice and on practical questions than on the presentation of the methodological developments in economics.

Thierry SCHNEIDER: Thank you Bertrand Munier for your invitation to Cachan. Before starting the meeting and exploring the UK and the French experiences in ALARA for public exposure, I would like to remind you of a few elements concerning this seminar and the project in general.

The general title of the contract we have with the European Commission DG XII is called "Optimisation of radiological protection for complex exposure situations". It started in January 1997 and it will end in June 1999. It involves eight partners and is co-ordinated by CEPN. We have some researchers from the GRID (France), from the University of Toulouse, (Institut d'Economie Industrielle, France), from the University of Mons (Belgium), from the University of York (Centre for health economics, United Kingdom). We have some associated partners, and especially some economists from Universities of Berlin, Cologne and Geneva, and also Michael Thieme from BFS (Germany), who is working in the field of radiation protection. Since the beginning we decided that it was useful to have not only a team of economists to prepare some theoretical materials, but also to confront this reflection with practitioners. For this reason, we decided to have two seminars during the contract with a number of decision-makers.

During the first seminar, last year, we made some presentations on the characterisation of the exposure situations which could be called "complex exposure situations", and presented the elements on which we had focused our research (risk transfers between present and future generations, management of potential exposures and of public exposures). The main conclusions of the first seminar, which drove the organisation of this one, was that the economic tool is not the only element to be considered, although it provides some rationale in the decision-making process, and that the major concern for the decision-makers was the management of public exposure, and the evaluation of protection in an ALARA perspective.

For this second seminar, the presentations are focused on two national experiences on the management of public exposure. The first presentation is devoted to UK, with first a talk from Joe McHugh from the Environment Agency. And then, in combination with his presentation, Roger Coates will explain what is the management of BNFL with regard to the implementation of the protection option devoted to reduce the public exposure. Following that, we will have a presentation from Jean-Michel Deligne from DSIN and Philippe Hubert from IPSN, who will explain the French evaluation process and how the expertise Institute works with that. Finally, we will have a presentation from Alain Brissaud from EDF, on what does ALARA mean from the point of view of EDF in the design of installations.

What we would like to do during this seminar is to share the various experiences. It seems that we have identified some criteria which have to be considered. But may be between the countries, it’s not exactly the same experience. We would like to motivate some discussions on this topic, and to make some recommendations. What does it mean? Which kind of development do we need to do? What is the role of the economic tools in this field? What is the role of individual doses versus collective doses and what does it mean for public exposure? How is it used in different countries? And also, some questions concerning the public involvement and public acceptability. I know that some of you have also some questions concerning how to put that into perspective with other risks, and what could be useful and which kind of recommendations can we make on all these aspects, which could be interesting either for further development, or for further discussion between the different practitioners in the community of radiation protection.

1. THE REGULATORY FRAMEWORK AND ASSESSMENT FOR THE IMPLEMENTATION OF ALARA FOR THE MANAGEMENT OF PUBLIC EXPOSURE IN UK

1.1. Presentation by M. Joe McHUGH (UK Environment Agency)

I'm in the Head Office of the Environment Agency dealing with policy. I have a radiation protection and radioactive waste background. I'm not an economist, and so most of my presentation this morning won't be on economics, but instead from the perspective of a UK regulator on radioactive releases and regulating discharges from our nuclear sites, and particularly from Sellafield.

You'll notice on this slide there are two lobsters, I'm going to talk about those and the relevance of the lobsters to radioactive waste discharges later on.

The principal topics I'm going to talk about are the UK regulatory framework for regulating discharges into the environment, and I'm going to discuss the many factors which are relevant to radioactive releases and their regulation, both the radiological factors, and the non-radiological factors. For most of my talk, I'll be discussing Technetium 99, which is discharged from Sellafield and a radionuclide of international concern, so it's appropriate that we discuss it in an international audience. I'll summarise the conclusions from Technetium 99 issues and I'll raise just a few issues that I think we might usefully discuss later on.

The UK regulatory framework for radioactive waste discharges is based around a single act. That's the Radioactive Substances Act, which was updated in 1993. The regulatory authorities are my Agency for England and Wales and our counterparts in Scotland, the Scottish Environment Protection Agency (SEPA). We are empowered to issue authorisations allowing radioactive discharges and in those authorisations we place limits and conditions on releases and discharge management. In particular we place limits on the quantity of radioactivity which might be released into the environment, and we require the application of something called BPM, Best Practicable Means, to minimise releases below the limits. So we have limits and a requirement to optimise the discharges, BPM to minimise discharges below the limits. These limits reflect what I might call "operational business needs". So the operator needs to make a case to the regulator that he has a need to make a discharge. They are not set at dose constraint levels, they are not set on the basis of, let's say, 300 µSv, which is the dose constraint for a single source applied in the UK. We have separate authorisations currently for liquid waste discharges, gaseous releases, solid waste disposals. In the future we are looking towards integrating those authorisations, bringing together all the authorisations for a single site into one document. Now I know that that is happening in France as well and that there has been a change in the French law which allows that. I should say that my Agency is the regulator in the UK, we are independent of government, but our decisions, all major decisions for nuclear sites have to be sent to government ministers before they can be implemented. Government ministers can intervene in those decisions, they can indeed make their own decisions, decide that they are going to call in an application and determine it themselves, or they can direct my Agency to take certain action or not to take certain action. So they can impose their own requirements. As a regulator, we may make a decision, taking into account the factors we think are important, but ministers can then say “Ah, yes I hear what you say, but I think that this factor is much more important, so I am directing you to do something different”.

I mentioned this term we call “Best Practicable Means”. This is really the equivalent, in the European context, to requirement in the Integrated Pollution Prevention and Control Directive for Best Available Techniques (BAT) or BAT with a cost component built-in. One definition of BPM that we use is “the level of management and engineering control that minimises the release of activity, but taking account of cost-effectiveness, technology, technological status, operational safety and social and environmental factors”. One feature of it is that industry is not required to incur it in expenditure in what we term “money, time or trouble” which is disproportionate to the benefits derived. In taking decisions on what might be the best practicable means for a particular release of radioactivity, there are some factors which can be quantified, for example, the cost of abatement, the expected individual and collective doses. But some of the factors are only more qualitative and they require a degree of judgement, a degree of professional judgement (some would say a degree of political judgement), in coming to what might be a sensible decision on BPM.

In this overhead, I’ve listed some of the factors that influence decisions on discharges:

- Firstly, in dealing with radioactive waste, there is a preference for “concentrate and contain” over “dilute and disperse”. If any of you have read the IAEA’s Radioactive Waste Fundamentals, that document states that the preferred approach to radioactive waste management is concentration and containment rather than dilution and dispersion in the environment. The document goes on to stay that as part of radioactive waste management, radioactive substances may be released within authorised limits as a legitimate practice, into air, water and soil, and through the re-use of materials. So that in a sense constrains some of the options we might be considering as part of optimisation. We are really looking to concentrate and contain rather than dilute and disperse.

- We take into account of course, the radiation exposure of critical groups. And here I would note that the EURATOM Basic Safety Standards Directive requires, in assessing the exposure of critical groups, that radiological assessments are realistic. In the UK, we are considering what that means, and may be there needs to be an agreed methodology for calculating critical group doses.

- The costs of the various options are very important. The industry needs operational flexibility and to be able to run its commercial operations without undue constraints.

- Quite often, and I'll illustrate this with my talk on Technetium 99, there's a balance to be struck between occupational safety, public exposure and environmental protection.

- We must have regard to international commitments: protection beyond national borders, EURATOM treaty obligations and EURATOM directives, and the OSPAR Convention. Increasingly, the build-up of radioactivity in the environment is becoming of concern. If you can detect it, that's seems to be of concern. If it's discernible, that seems to be of interest, irrespective of the radiological implications.

- For some radionuclides it makes a difference to the radiological impact whether they are discharged to air or to sea, or disposed of in the future as solid waste. Particular examples are the long-lived radionuclides Iodine 129 and Technetium 99, which are mobile in the environment and if they were to be stored rather than discharged, they are likely to be released from a future deep repository and potentially cause exposure that way (potential exposure versus actual exposure). So the concept of BPEO, "best practicable environmental option", is something we have to look at. To an extent that also applies to some other radionuclides such as Carbon 14. In taking steps to prevent accidents, one has to tolerate, in some instances, a certain level of discharge, to avoid potential exposures.

- It's important that there's a consistency with regulation of non-nuclear industry, that there's what we call a level playing field. In the UK, and I know in other countries, the nuclear power generators are competing with fossil fuel generation. So we would say that at least the same principles should apply. In some cases you've got an historic legacy to be dealt with, in this particular case, at Sellafield, that there are past practices that have given rise to waste which need to be managed. And dealing with those wastes may involve a certain level of discharge.

This brings me on to Technetium 99. Before I get into the detail, I thought I'd put up some background information on Technetium 99 for those of you who might be unfamiliar with it. Technetium 99 is a fission product. Its half life is 210,000 years and it's a pure beta emitter. There's no gammas emitted by Technetium 99. Also, there aren't any stable Technetium isotopes. All the Technetium in the environment is Technetium 99. So when Technetium is discharged into the environment there's no isotopic dilution. It's a mobile radionuclide, it's multi-valent, it tends to move around quite a bit, and particularly, it concentrates in lobsters. For reasons for which are not absolutely clear, it seems to be specific to lobsters, rather than other crustacea, other shellfish, and to an extent it bio-accumulates in certain types of seaweed. But in the food chain, it seems to have an affinity for lobsters, and has a very high concentration factor in that species.

At Sellafield, the source of Technetium 99 is called MAC or Medium Active Concentrate, which arises from the reprocessing of Magnox gas-cooled reactor spent fuel. It doesn't arise from oxide fuel reprocessing, that is it doesn't arise from Thorp (the Thermal Oxide Reprocessing Plant). And so it isn't really an issue at La Hague. But from re-processing of Magnox fuel (gas-cooled reactor fuel), you get substantial amounts of Technetium 99 in MAC.

This overhead shows a brief history of MAC waste management. Before 1981, Medium Active Concentrate was discharged to sea, after storage or decay of short-lived radionuclides. I should explain that MAC doesn't only contain Technetium 99, it contains a wide range of radionuclides many of which are far more radiologically significant than Technetium. For example, it contains Caesium 137, Strontium 90, Ruthenium 106, and significant amounts of alpha emitters. Before 1981, MAC was discharged to sea, after storage for decay of Ruthenium 106. Between 1981 to 1994, it was stored in tanks until a new treatment plant, the Enhanced Actinide Removal Plant (EARP) became available to deal with MAC. In 1994, EARP started up and began to treat the backlog of MAC on the site. EARP is very efficient in removing most of the radioactivity in the MAC. It very efficiently removes Caesium 137, Strontium 90, Plutonium and Americium radionuclides, but it doesn't remove any Technetium. It was predicted that when EARP would start up there would be a large increase in Technetium 99 discharges.

And indeed, this is exactly what happened. Figure 1 shows the discharges of Technetium 99 in the late 1970s up to 1980, the long storage period when no Technetium 99 was discharged because the MAC was being stored, and then when EARP began operating in 1994, there was a rapid rise in Technetium 99 discharges from Sellafield. There have been some reduction in Technetium 99 discharges since then but the levels are still high, compared to the period when the MAC was in storage.

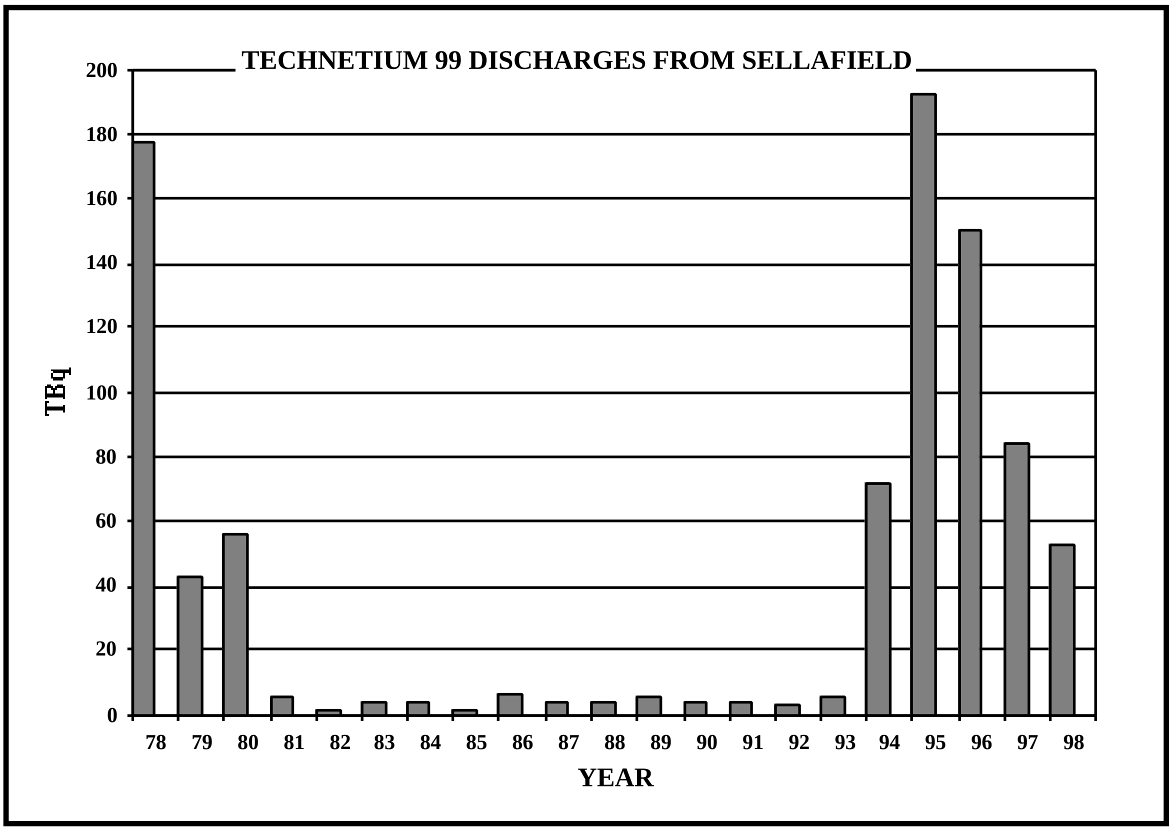

Figure 1. Technetium discharges from Sellafield

The effect on the concentration of Technetium in lobsters near Sellafield is presented on Figure 2. There's been a very considerable increase in Technetium 99 concentrations since EARP started up. It reached a high point of 16,000 Bq/kg in 1997. Technetium 99 is detectable away from Sellafield, even as far as Scandinavia. One of the issues which was raised about these high concentrations in lobsters was the relevance of European Community action levels following emergencies, so-called Community Food Intervention Levels (CFILs). CFILs are meant to apply immediately after a nuclear accident. There isn't a specific CFIL for Technetium 99, but it would fall in the category of "other radionuclides" and the CFIL would be around 1,200 Bq/kg. These values are not intended to apply to a routine discharge, but it has been pointed out to us that in effect, by allowing these discharges to occur, we are tolerating concentrations of Technetium 99 in lobsters which are many times those which would be tolerated immediately after a nuclear accident. Now there are good reasons for that, in that immediately following a nuclear accident you haven't got the chance to do full radiological assessments and you need figures and values to come into force which would allow trade in foodstuffs. Here there has been an *a priori* radiological assessment of the consequences of the discharges.

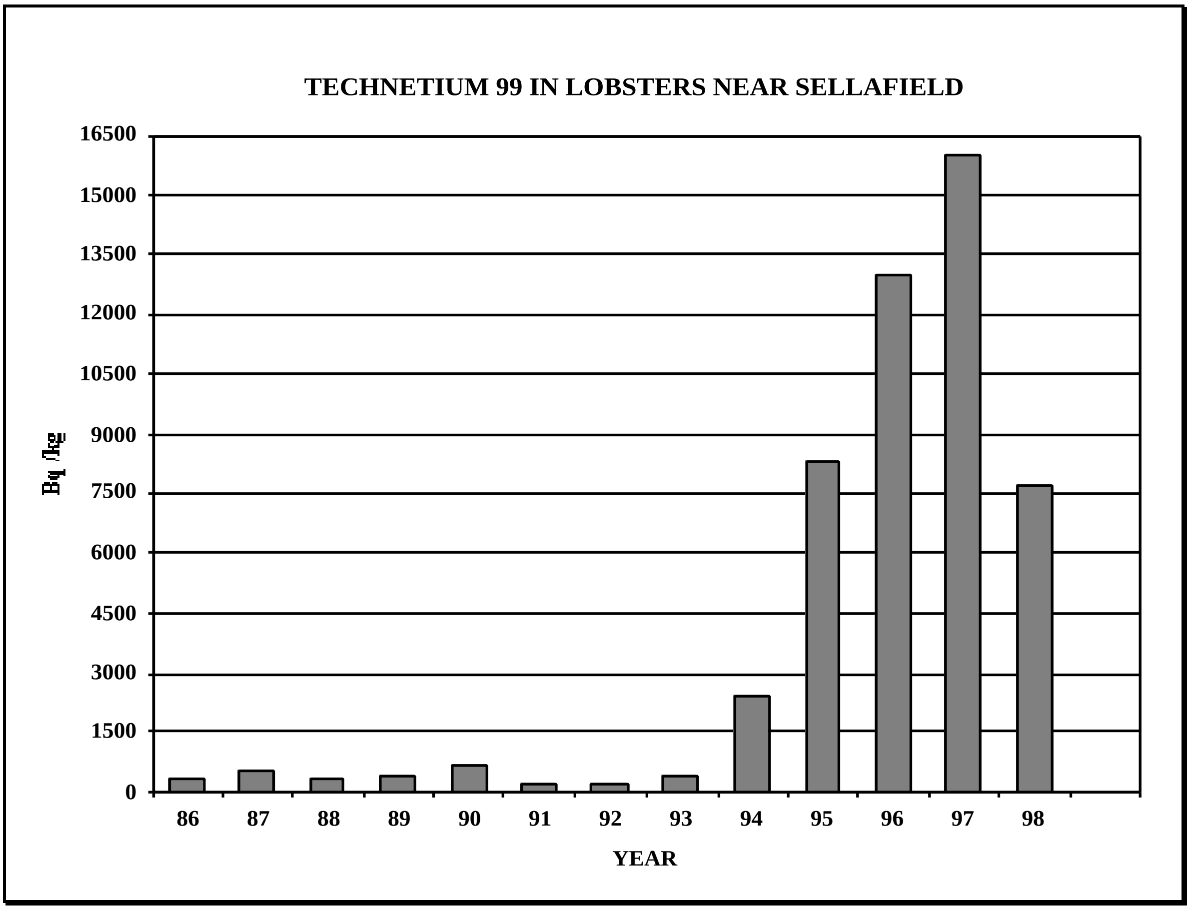

Figure 2. Technetium 99 in lobsters near Sellafield

The Agency is determining an application from BNFL for a change in the authorised limit for Technetium 99. And for reasons which I'll set out, we propose a future limit of 90 TBq/year. At that limit these are the consequential individual and collective doses. The individual doses to the critical group, the coastal group near Sellafield, is about 25 µSv/year. To put that in context, for all radionuclides discharged from Sellafield, the critical group dose would be 155 µSv/year. The collective doses for Technetium 99, truncated at 500 years for UK, is equal to 0.095 person-Sv, for Europe 0.216 person-Sv and the World population, 0.240 person-Sv. Again, in context, the collective doses from other radionuclides discharged from Sellafield are 7.61 person-Sv for UK, 33.2 person-Sv for Europe and 228 person-Sv for the world. So, I hope you would agree, these are not terribly high, for Technetium 99, certainly. The radiological significance of Technetium 99, even near Sellafield, where you've got the highest concentrations, is quite low. In view of those low doses, why do we need to do anything? Why do we need to address the problem? From a pure radiological protection point of view that might be a reasonable position to take. As I mentioned earlier, there's a lot of international concern about Technetium 99, and here are some of the statements which ministers of European Union countries have made about the increasing concentrations. The Nordic ministers have said there's an increasing trend of Technetium 99 in water and seaweed, it's going to stay in the environment for many hundred thousands of years and pollution from Sellafield will taint public perception of Nordic seafood products. Ireland has said that discharges are objectionable. I think it's important to recognise that particularly in this context, it's the public perception of the Nordic seafood products which is one of the issues. That is really a trade issue in that customers wishing to buy seafood can choose where they buy it. They can buy it from outside the EU or some part of the EU which is unaffected by discharges, and the Scandinavians feel that it's the taint which is attached to the seafood product which is affecting their business, their seafood. UK ministers have recognised that activities in one state shouldn't have adverse radiological effects on the common marine environment, and we are all neighbours, we have the marine environment around us, and we should avoid adverse radiological effects on the environment we all share.

In the OSPAR Convention, European countries have produced a radioactive discharge strategy, the ultimate aim of which is to achieve environmental concentrations close to zero for artificial radioactivity by 2020, taking into account legitimate uses of the sea, technological feasibility and radiological impacts to man and to biota. This strategy was agreed last year. I think it's fair to say we're still in the process of considering what the strategy all means, particularly some of these terms like "close to zero". But we need to have the long term objective in the back of our minds when we are considering these issues which are relevant to regulating discharges.

To move on from the international policy to some of the practical issues: what realistically can be done about the discharges? There are a number of the issues we need to understand. Currently there's about 4,500 m^3 of MAC in storage at Sellafield, there is storage capacity for 6,000 m^3 and it arises at the rate of 355 m^3/year and is that, 60-65 TBq/year are Technetium 99. The MAC is stored in old tanks and which were built 40 – 50 years ago. Their structural condition is fairly uncertain because it's difficult to inspect the tanks – there's some very high dose rates near them and the nuclear safety regulator, the Health and Safety Executive is understandably concerned about the uncertain structural integrity. In case of failure of one of the tanks, it would be useful, in fact very desirable, to have a spare tank available to store the contents of a tank which might suffer a failure. So there's a strong imperative to empty one of these tanks and to process the Medium Active Concentrate in EARP. You might say: "why can't you build new tanks?". New tanks are going to cost about £70 million or so, to build the necessary capacity, and in any case, that doesn't really solve the problem, does it? It only stores the MAC again for a future generation. There are some real practical problems anyway about where you'd put these tanks. The current building B211 which stores the MAC is close to other facilities on the Sellafield site. It's not easy to find where we could put another tank, or several tanks. Some significant engineering work with pipe bridges etc. would be necessary to create another facility for tank storage. So if storage is really not an option we really want to contemplate, what about treatment? Can MAC be treated to remove the Technetium? At present there isn't any technology which you can simply fit to EARP to remove it, which would be compatible with EARP. You can adjust the processes in EARP to remove more Technetium, but at the expense of increasing discharges of some other radionuclides, for example Strontium 90. Strontium 90 is considerably more radiologically significant than Technetium 99, so we don't really want to do that, it doesn't make a lot of sense radiologically to increase strontium 90 discharges and discharge less Technetium. There's a major research and development programme underway, looking at options such as precipitation, ion exchange, chemical reductions, electrolytic removal and modifications to processes. Some forms of Technetium residues which might be produced from these processes would be very difficult to dispose of in a deep repository. And the UK organisation which deals with the planning for a deep repository (NIREX) would comment on the acceptability of some of these residues for a repository. From the safety point of view, NIREX has said that they wouldn't accept some of these residues for deep disposal. So, although it might be nice just to precipitate out the Technetium, could you eventually dispose of it? Or if you do treat it, would it be necessary to store it indefinitely? The costs of abatement are going to be quite significant. Electrolytic reduction, which was looking very promising at one stage, would cost about £100,000,000 excluding the disposal costs, and the costs of the other options are rather uncertain, because some of them are still at the R&D stage. So what do we do? The proposals that we have put forward to ministers, in October last year, were that the future discharge limit should be 90 TBq/year. That allows for the arisings of Technetium 99 from re-processing and it allows some headroom for the backlog of MAC which has been in store to be treated. The long-term objective is to get to a limit of 10 TBq/year, which was the limit before 1994, when the MAC was in store. There are some things which can be done, some practical things to reduce doses. It appears that the concentration of Technetium in lobsters seems to be lower in the winter-time than in the summer. So by managing the liquors in the tanks in such a way that discharges are made in the winter months rather than the summer months, you can actually reduce the doses, and reduce the concentration in lobsters. So we've made that a requirement in our proposals. We're saying that there should full-scale trials of one of the more attractive methods for removing Technetium flock precipitation. We believe that other technologies and plant modifications should be assessed, as well as their costs and implications for storage and disposal. The management strategy for liquid waste storage really need to be optimised as well. Both decisions are being considered by UK ministers. And I should say that this is not the end of the story, because they may consider that some of these other concerns override the factors that we felt were important.

So in conclusion, I think the Technetium 99 story shows that whilst there are small, individual and collective doses, there's still a lot of concern. Some of the UK's neighbours amongst the EU regard any discernible Technetium in the environment as being unacceptable. There are high costs of abatement and tank storage. My Agency's proposals would balance the need to prevent accidents, to deal with the historic legacy and take account of operational needs and public exposure. There's a big question mark whether they are acceptable to UK ministers and internationally. Since this is an international audience, you might like to consider what you think is ALARA for Technetium 99 discharges. I hope I've given you an illustration of some of the social issues we've had to deal with.

Finally, some important factors, some issues for discussion. Which are the most important factors in decisions, over optimisation of discharges and public exposure, which actually drive the decision? How important are radiological and non-radiological considerations? And this issue of "Well, if it's measurable it must be bad". And the issue I think we're going to consider, this afternoon, the issue of costs, what it is reasonable to pay to reduce discharges and exposure?

1.2. Discussion

Thierry SCHNEIDER: Thank you for this interesting presentation, which in fact combines the principle of the management and the regulation as well as the practical experience which is quite important. One element we never put really in all this management framework, is the international concern, as you mentioned, and it's one of the factors which in fact is quite difficult to handle with optimisation principles as we applied with economic tools and so on. So it's one element that we will have to discuss later.

Mark DUTTON: You must have answered some of your questions when you decided on the future limit of 90 TBq/y? What was the basis of your future limit of 90?

Joe McHUGH: Well, to allow Magnox re-processing to continue, the limit has to be at least 60 – 65 TBq/y. BNFL have indicated that it's possible to manage the tanks within a limit of about 90 TBq/y which will in a few years time create this spare tank capacity. So it allows you to deal with the arising from Magnox re-processing, to work off some of the backlog, so you create this spare tank, which you need in case of failure. There are some other factors in this tank management strategy which I haven't alluded to. There is a need to create a kind of a window in time to deal with some other waste streams which are also on the site, some flocks which contain alpha activity, and by working off some of the backlog now, within a limit of about 90 TBq/y, you can create that window of opportunity. There are several factors which need to be taken into account, but we think that 90 TBq/y is a reasonable balance between the various factors involved, allowing Magnox re-processing to continue, reducing Technetium 99 concentrations, and working off some of the backlog.

Pascal DEBOODT: Only for clarification may be. When you told us about the important factors which have to be taken into account you wrote their consistency with regulations of non-nuclear industry, can you give more explanation? How do you think it is possible to reach consistency?

Joe McHUGH: I think there is consistency at the level of principle, that we would say the same principles apply to regulation of non-nuclear industry, in the UK in the sense that control should be based on technology, what the plant is capable of achieving, with the introduction of new technology, there should be a kind of racketing downwards of discharges. It's very difficult to get a common currency of comparing risks from non-nuclear industry with nuclear industry, although I think some work is underway in that regard.

Thierry SCHNEIDER: In the same kind of consideration you mentioned the principle of best practicable means for environmental protection. When you compare with best available technology which is put on the way by the European directive, the directive on pollution, you have consideration of local environment, it’s based on the best available technology, but taking into considering the economic, social and environmental local conditions. So what is the situation with regard to your principle, what is the dimension of local environment that you take into account?

Joe McHUGH: For radioactive discharges? Well, primarily the local critical group dose, of course. The local environmental effects would be taken into account by way of the individual doses to the local critical group.

Roger COATES: Clearly, the local critical group is one of the factors on which all of this is judged. What I can say is that I wouldn’t like to give the impression that there is an enormous amount of lobsters off the Cumbrian coast. The Cumbrian lobster fishery is very small, and in fact we believe that the sampling that we do actually effectively consumes all of the local lobsters. So this critical group is somewhat mythical, but nonetheless, that’s what goes on the record books.

Augustin JANSSENS: In your sheet on the OSPAR declaration, you mentioned whether we should not be concerned with men but also with biota. Is this being given consideration in the UK?

Joe McHUGH: Again, it is being considered. My agency is sponsoring research in the area of effects on biota, but that’s at a very early stage. You may be aware of papers by one of the members of our staff, Jan Pentreath, on the subject of radioactivity in biota. That’s a major subject, but increasingly the ICRP statement that if one protects individual humans, one protects biota, at the species level, is beginning to be questioned. And so we feel there’s a need for research in the area, but I’m afraid we don’t have answers to questions. But there is no suggestion, for example, that (if that’s what’s behind this question), the lobster population which is small, is actually at risk from the Technetium 99 discharges. There is no indication that they are suffering, at a genetic level.

2. PRACTICAL EXPERIENCE OF THE IMPLEMENTATION OF ALARA FOR THE MANAGEMENT OF PUBLIC EXPOSURE IN UK

2.1. Presentation by M. Roger COATES (BNFL)

I'd like to preface this statement, or this presentation, by saying that the comments that I'm making are based on the experience of discharges from Sellafield, and their regulation. The comments may not be relevant to other forms of public exposure from radiation, but this is what I was asked to talk about.

The theme, which is going to be developed as we go through this presentation, is that recent experience indicates that collective dose cost-benefit analysis, which certainly was a significant feature of the previous seminar, in my view, has only made a small contribution to decision-making. The idea of this presentation is to try and explore what else can economics and economic theory bring to the decision maker, perhaps in addition to collective dose cost-benefit analysis. So, that's the focus of this particular presentation. I'll try and do that by using the pattern of discharges from Sellafield over the years to being out the examples. That's the pattern of discharges for basically total Alpha, Plutonium plus Americium, primarily. The early days Sellafield started off as a military operation, as you'll be aware. There are now two re-processing plants there. The Magnox plant, which has the Technetium issue, and a more modern oxide reprocessing plant called Thorp. There has been a significant decreases in discharges over that period of time, a peak in the seventies, and what I'm going to do is explore what were the reasons for these decreases, and how were those decisions made. We have a similar pattern in betas, with a slight increase at the end there that basically is the Technetium story. So, that's the overall picture. What I'd like to do is really, first of all, go to 1977. The discharges were relatively high at that time. We had the design and the intent to build a new thermal oxide reprocessing plant, Thorp. Critical group individual annual doses at the time were perhaps about 1 mSv or a little bit higher than that, and in the public enquiry, BNFL made a statement of intent that, upon completion of the new plants (Thorp plant plus several other plants that were coming along, a vitrification plant, and specific effluent treatment plants), we will reduce the critical group doses to less than 500 µSv. Note, twenty years later, we've now got a situation where 500 µSv is the top tier constraint, so that was twenty years in advance of that particular derivation, and against a background where the public individual annual dose limit at the time was 5 mSv. The decision-making process was centred around critical group dose. There were some considerations of ALARA, and at that time it was collective dose cost-benefit analysis type ALARA. They were the decision parameters. As far as I'm concerned, it was the critical group dose that was the key decision parameter. We saw some reasonably high beta discharges in the seventies, and that arose principally because of the corrosion of Magnox fuel cladding in the ponds due to some longer storage than was anticipated. The first example that I'm aware of, where cost-benefit analysis actually played a role in the decision process, was the examination of some interim measures putting Caesium absorba material into skips, into the pond, in order to reduce the Caesium content, and that was shown to be cost-effective as an interim solution. The permanent solution was the Sized Ion Exchange Plant, SIXEP, that came along later. The investment costs involved: £ 180 M for capital cost, and £ 360 M for total lifetime cost. Radiation detriment, evaluated through the collective dose calculation and the recommended valuations that were coming out of NRPB, is approximately equal to £ 69 M, that is third of the capital costs, a sixth of the total cost. The critical group dose saved is in the order of several hundred µSv (570 to 800 µSv). Well, you can see that the £ 300 M was not covered by cost-benefit analysis in terms of collective dose. Therefore, did we spend about the £ 300 M to reduce about 600 µSv, in terms of critical group dose? Is there an implied economic parameter there of about half a million pounds per µSv? Is that part of the overall picture?

Let's look at the Enhanced Actinide Removal Plant (EARP). That plant was there to deal primarily with Plutonium and Americium and also pick up things like Strontium and Caesium. Clearly, it did not address Technetium. But at the time that this debate was going on, Technetium was agreed by everybody, including regulators and government, not to be an issue. It was more important to address the key aspects that were radiologically significant. And that was the whole basis of the decision: Capital cost: £ 180 M; Total cost: £ 500 M; Radiation detriment: £ 5M - £ 30M. You can see clearly not cost-effective based at the time, we were two orders of magnitude adrift from being cost-effective on cost-benefit analysis. Cost-benefit analysis did not enter this particular decision. Again, if you look at the critical group dose saved: between 520 and 730 µSv, it was effective in dealing with it, that was quite high at this time, there was a change in gut transfer factor for Americium that was recommended by ICRP which overnight significantly increased the critical group dose, and that was part of the decision process. Right, we've had this change, those that are now going up to two millisieverts a year. A large part of it from alpha, and therefore the driver, critical group dose, let's reduce those discharges. And you can perhaps see what £500 million, 500 µSv, is that £1 million per µSv? That sort of order. If it's £1million a µSv, a quick calculation that I just thought of in the previous presentation that comes out at about £20 million for a 10^{-6}

reduction in individual risk. £20 million per 10^{-6} reduction. How does that stack-up with risk reduction in other fields? Is there some sort of economic theory, economic linkage that we can start to there? Is that a good way of spending money? But perhaps that's an implied valuation of those decisions.

Let's then look at the Thorp plant. We've made our site declaration of 500 µSv maximum. There's a lot of history there. So that meant that within that 500 µSv, having a whole range of new plants, a vitrification plant, other encapsulation plants, Thorp reprocessing, we had to set the designers some targets. And the target that we agreed on within the company for Thorp, was that it would have one tenth of that 500. So it had a design target of 50 µSv for the critical group. The key decision-making process, the key challenge set to the designers was in critical group. As far as I'm concerned, that is the key parameter. We also had to demonstrate ALARA. As far as ALARA is concerned, collective dose cost-benefit analysis is one part of the picture, you've got to look at it, but common sense, critical group dose reductions, if you can get below the 50 µSv reasonably, however we judge reasonably, then that is a clear part of the decision process.

If you look at the collective doses coming out of that plant, then there are only three nuclides that you could even afford to do the assessments, afford to even think about it. Because if you look at the collective dose, from what could have been Plutonium limited to that critical group dose, or Caesium right, then you would have got one pound collective dose. And you couldn't even do the assessment for that value. So those nuclides were the only ones that really involve any consideration of collective dose: Carbon 14, Krypton 85 and Iodine 129. For Thorp, we decided that we would put in Carbon 14 removal. And it is actually the only re-processing plant in the world which has Carbon 14 removal, and through the sort of common sense, pragmatic approach to critical group doses, the designers came in well within the target that they were set, at about 25 µSv /year for the flow sheeted through-put.

Let's just take a look at some of those collective dose issues. Start first of all on Carbon 14. The guidance at the time, and this is primarily what was coming out of NRPB, was that perhaps the principle decision timescale or collective dose integration should be 10^4 years. The current flavour and advice is that no, that's too long for the purposes of decision-making and the emphasis in the UK anyway is more on 500 years. Detriments were coming through, calculated for the lifetime of the plant, or perhaps of a few tens of millions of pounds, and the designers came to the view that for that sort of money, without being exact, we could put in a process that would remove Carbon 14 or 95%-99% of it and put it in solid intermediate level waste. So that was the decision-making process that led to Carbon 14 removal on Thorp.

Krypton was rather different. You can go through, you can do the cost-benefit analysis, the dispersion modelling, and for the lifetime of Thorp, you can come up with detriment valuations of a few tens of millions of pounds. If we could have got viable Krypton removal and storage technology, then on the information that was available, it was clearly going to cost a few hundreds of millions of pounds. That makes it not viable, economically. The critical group doses are about 2 or 3 µSv, absolute peanuts, so on that basis, it was easy to make the decision, but it was even easier to make the decision, because there's no viable technology. People have wrung troublesome pilot plants on small scales, on an intermittent basis, some of them using CFCs. If we had have installed it, the most promising technology would have been major discharge of CFC greenhouse gases. So that was a reasonably simple decision to make no Krypton removal.

Iodine is the third of the nuclides. How do you do a cost-benefit analysis on iodine? Almost all of the dose is delivered on a time scale of between 10^6 and 10^8 years. How do you do the differential cost-benefit analysis of how much dose you are going to save by putting it in a hole in the ground? Are you going to be able to guarantee to maintain that out of the biosphere for time scales of 10^8 years? And I don't think you can. And on that basis, plus the fact that it was not attractive in any case on collective dose grounds, we made the decision that we would manage iodine by, as far as practicable, routing it to sea, which gave lower critical group doses than routing it to atmosphere. It was a pragmatic decision. But collective dose, perhaps of no value over those sorts of time scales.

Concerning Technetium, from my perspective, the design basis of the treatment plant EARP was primarily decided by radiological effectiveness and it was agreed by the company and the regulators and the government, at the time of the design, and at the time of the introduction of that plant that that was the right decision. The critical group dose is approximately equal to 20 µSv/year with a release of 90 TBq/year of Technetium 99. If we take an approximate collective dose valuation for the lifetime remaining Technetium discharges without abatement, then it generates about a tenth of a million pounds of the detriment. There is an international dimension. The 20 µSv critical group is to this mythical person who finds that the BNFL boat has just got to the lobster before he did. As far as Ireland is concerned, their critical group gets about 0.3 µSv from Technetium. The critical group eater, from exactly the same lobster gets six hundred times as much radiation dose from the polonium naturally in the lobster as he does from the Technetium, six hundred times as much dose. In Norway, the doses to the critical group will be much less than 0.3, but in that case he’ll be getting more than a thousand times as much dose from Polonium naturally in the lobster. So that’s the overall context that we’re dealing with here.

So how are we going to make decisions on discharges? There’s various sorts of parameters. There is becquerels discharge, there is critical group dose and there is collective dose (Table 1).

Table 1. Potential Decision Parameters: 1977 Sellafield Discharges

	Nuclide	GBq in 1977	Critical Group (μSv/y)	Collective Dose (man.Sv)
Sea	H^3	2,600,000	0.01	0.1
	Tc^{99}	84,000	~18	0.2
	Ru^{106}	9,800	3	0.1
Air	H^3	163,000	3	0.3
	Kr^{85}	95,000,000	1.3	40
	I^{129}	25	12	2.5

My contention is that as far as it stands today, most of the decisions in the UK have been made on the critical group dose basis, some decisions, a very small number, have been made on the collective dose basis. No decisions have been made purely on the basis of becquerels. But if decisions did come to be made purely on the basis of becquerels, then the key ones that you would start to look at would be Tritium and Krypton. And you would be making decisions based on extremely small critical group doses and either extremely small or relatively small collective doses. And that’s the dilemma, if you focus on becquerels. But as we are aware, becquerels are currently on the agenda. OSPAR clearly mentions becquerels, discharges close to zero. Now do we mean discharges in terms of becquerels, do we mean discharges in terms of dose, do we mean discharges measured in terms of the environmental concentrations? Becquerels/kilogram in lobsters or whatever? If we are talking purely becquerels, you saw in Table 1, the numbers are dominated by Tritium and Krypton. That will have a major impact on re-processing, and would have potential knock-on effects on nuclear power. If it had knock-on effects on nuclear power, then it starts to bring into play… What are the other environmental issues around? If we’re going to eliminate one option of deriving energy on the basis of large numbers of becquerels, how does that translate into other effects? If you want the same amount of electricity, you're going to have to generate it through large increases in CO_2 emissions, and other things. A whole field of environmental economics in valuing different sorts of detriments is the level playing field. That to me is another key area for economic theory to come into play. A very, very difficult, complex area. But if we are really going to involve people in making decisions, then that's part of the picture. If measurability is really going to be one of our decision parameters, then clearly if someone introduces a new measurement technique with a lower limit of detection for a particular nuclide, suddenly we're going to have to say "Ah, now we can measure this nuclide down to lower levels, you are going to have to introduce a few more tens of millions of pounds worth of abatement", just because we've introduced this measuring instrument. I mean how are we going to make decisions in this environment?

One way, and the way that it's done at the moment, is using dose or risk as the key parameter, and as you've seen in the thesis that I've been developing, that has been the principle way that decisions have been based to date. Our other regulator in the UK, the Health and Safety Executive, have worked up a risk-based decision-making hierarchy. They call it the "tolerability of risk" and basically, I think many of you will have seen a diagram that looks something like Figure 1.

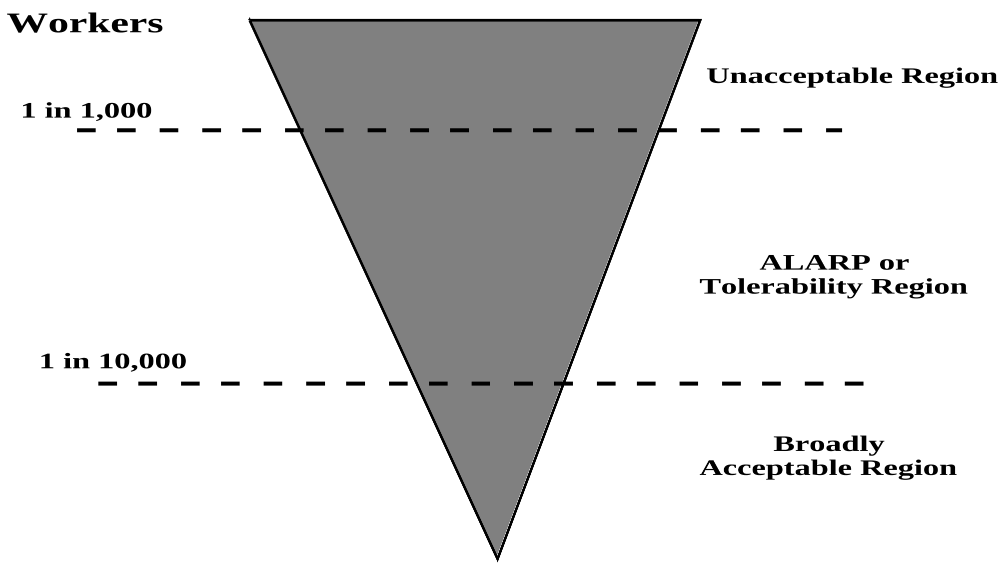

Figure 1. Tolerability of Risk

That actually expresses it in terms of the worker risk, but for public, they said one in ten thousand as the border of unacceptability and about one in a million as the border of acceptable region. Now that is a coherent framework. It doesn't address all of the factors.

Certainly a lot of the politics. But when I look back at the decision-making processes that have gone on today, that encapsulates both critical group dose and collective dose. And it's what one of our regulators is requiring us to do.

So what does the decision-making framework that we're in actually look like now? That's how it seems to look to me, be it Technetium or Carbon 14 or whatever (see Figure 2).

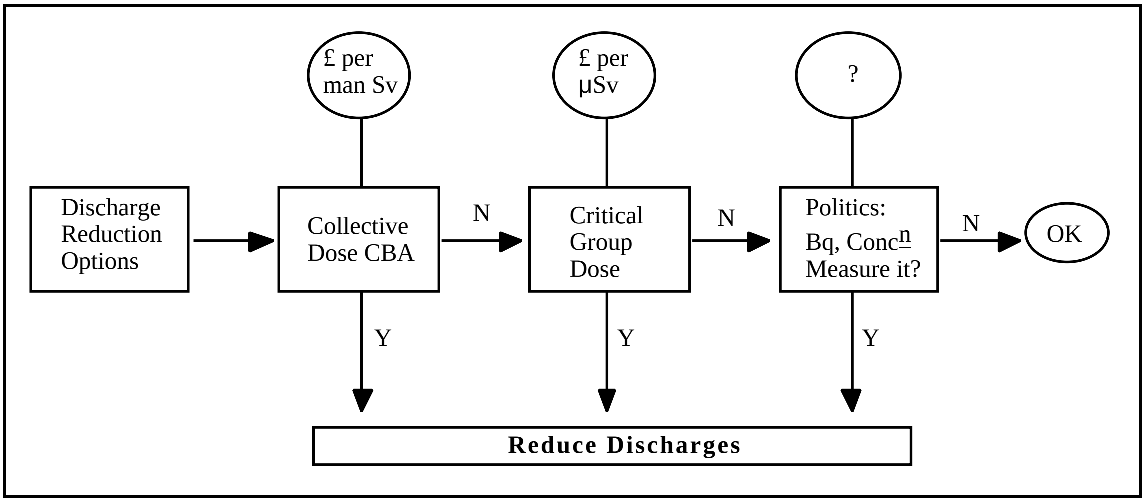

Figure 2. Decision Framework

There are a set of discharge reduction options, we can go into brainstorming sessions, we can review the technology, we've got various options. It seems to me that the first gate is collective dose cost-benefit analysis. If it comes out as being cost-effective, then we can reduce discharges.

It is more complicated when dealing with the critical group criteria. In this case, the economic theory exists. Critical group dose said "Well, implied in our decisions has been a pounds per μSv ". It may say we've come out at about twenty million pounds for a one millionth per year risk. How does that align with other factors? That valuation seems to be increasing with time. But there is some logical framework there. What economic theory is able to tell us about how that value for money aligns with saving individual risks in other walks of life? I would be interested to hear. But there is a theory there. Then, we seem to be moving into an environment of, well we're now in politics, becquerels, concentrations, "can you measure it?". What is the decision-making parameter there? As far as I'm concerned, I don't know. I haven't a clue. But that seems to encapsulate the decision-making framework that we're in at the moment. If you concentrate on these three boxes: collective dose, critical group dose and other criteria (politics or whatever). I use my judgement on how much each of those has contributed to the decision-making programme. If we go back to about 1977, two thirds, 70% roughly, in my own personal judgement, of the decisions were made on critical group dose. 15% on collective dose, perhaps 15% recognising that politics is part of the picture. Mid-eighties when we were making the decisions for the enhanced actinide removal plant, politics was starting to play an increasing role, collective dose decreasing, critical group still a key decision parameter. By the time we got to 1993 introducing Thorp, introducing the politics surrounding that, critical groups seem to me to be decreasing in importance, politics was definitely increasing. Collective dose falling off the decision-making horizon. What about next year? What about OSPAR? It seems to me that if we continue the way that some trends are indicating, certainly collective dose doesn't seem to be there. I'm not certain, unless we manage to pull things into what I consider to be a more sensible regime, the critical group dose will have a role, and my overriding fear is that we will be in that particular regime (see Table 2).

Table 2. Historical Experience - Importance of criteria in the decision (%)

	Collective Dose	**Critical group Dose**	**Politics (Bq, etc..)**
1977	15	70	15
1985	10	60	30
1993	<2	50	50
2000?	0	5	95

So, whatever the decision-making regime, which of those boxes are we in? How do we measure value for money? If economics and that type of theories going to sit the decision table, surely its got to bring something more than collective dose cost-benefit analysis, it's got to bring other aspects. In my view, it's absolutely important as we move forward and make these decisions, that the decision is not left purely to the environment agencies and the environment ministries. The decisions are huge, they involve significant sums of money, the way society allocates its resources and we must involve industry ministries, energy ministries, economy ministries as well as environment ministries. If economy ministries are going to have a seat at the decision table, what are they going to bring? If you just bring pounds per man/sievert, then I don't think you'll have a very big seat.

So what could be brought? I was saying collective dose, minor contributions. Collective or cost of individual risk reductions, perhaps at BFNL, if we analyse our data, an implied value of twenty million pounds for a 10^{-6} risk reduction. How does that stack up with other things? Can economic theory tell us anything about that? We mention the level plain field, nuclear radiation discharges versus carbon dioxide, global warming, versus CFCs, versus a whole range of parameters. One of the interesting debates in the Technetium was the simplest, the most viable technology for reducing Technetium involves a chemical called TPP which contains phosphorus, it's a phosphate or organophosphate and which is the best? Do we discharge organophosphate or do we discharge Technetium? The pragmatic plea from the agency was to discharge phosphate, because it dealt with a particular political issue, but how do we get the level plain field?

Perhaps another way of looking at it is the opportunity cost. Surely economic theory can tell us something about opportunity cost. If we spend 400, 500 million pounds reducing nuclear discharges, that is society's money. It's not BNFL's money, it's Britain's money, as far as I'm concerned. And if Britain wants to spend that money, it can spend it to reduce nuclear discharges or improve health care. BNFL profits were used, because we are a state-owned company, the profits were specifically used a couple of years ago to release funding for hospital beds, or you can reduce taxation. Or what? Surely economic theory can start to bring into play some of these opportunity cost issues. If it does that, then perhaps that decision graph looks like Figure 3.

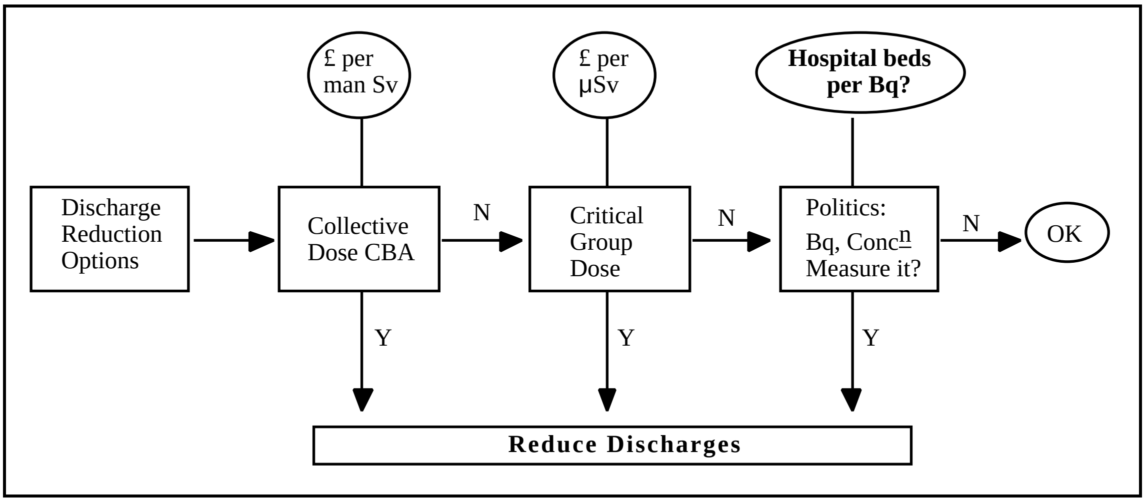

Figure 3. Decision Framework

I think that we need some principles, we need some ground rules that are agreed across the Government, the Environment Ministries, the Environment Agencies, the Industry, the Treasury, the Economy, all come together. We need some ground rules where we've got open and transparent regulatory control, as far as possible founded on sound science. I would like to see a link to tolerable day to day risks. It should be consistent rather than totally arbitrary based on clear declaration of policy, which in the UK I have to say, we feel as though we’re just living hand to mouth, and should acknowledge widely agreed standards for public protection. That’s what I feel we’re looking for.

And finally, what we’ve got, decision-making is clearly complex. But the decision-making should not be left solely to Environment ministries. These decisions are too big to be left entirely to Environment ministries. If economics is going to bring something to the decision table, then it must bring something more than collective dose cost-benefit analysis. And in particular, if it is going to bring anything to the decision table, it must do it soon. If you look at the OSPAR timetable, decisions, strategies, etc., to be laid out in the year 2000, you ain’t got long to bring some true economic power to bear on these issues.

2.2. Discussion

Wolfgang GOLDAMMER: I have two comments. First I think one should widen the perspective a little bit, you have been talking about releases and I can understand where you are coming into this area, but there are other areas, like what I am working in, the rehabilitation of contaminated areas or the NORM (Naturally Occurring Radioactive Material) business where there are substantial radiation exposures of many people and I think the picture is different there. The whole assessment of the role of collective doses is different there. That’s the first comment. And the second comment is maybe a little bit provocative. Couldn’t it be that the reason why you say cost-benefit analysis is not important for you, could not the reason be that you waste money? Could it just be that you should not do all these things that you are doing, that you just should follow the CBA results, just as a theory? Maybe the right decision would be to follow the results of the cost-benefit analysis?

Roger COATES: I just hope my friendly regulator was listening to that comment. It would be one way out. I don’t actually believe that. I’m quite happy to consider individual risk as a very valid and indeed a dominant contribution to the decision process. I think cost-benefit analysis is fine as the first box in that decision flow chart, but I’m quite happy to operate on the basis of individual dose and individual risk, and have that as a key decision parameter. I just get more and more uncomfortable as we move further along that decision process where we are moving into uncharted arbitrary waters where we don’t have a decision framework on which we can make decisions that will be valid for ten, twenty, thirty years. That's the time-scale for investments in the industry in which we work, but that’s my view.

Mark DUTTON: I like the table which ends up at 95 % of the decision on Politics in 2000, I think it's right. But, it skates over some issues, because it's black and white like the choice of 50 µSv a year which was the tenth of the original 500 µSv a year, and this significantly below the current 300. And now the question is what was the basis of the 50? I suspect that there is a lot of politics when an organisation chooses its design criterion which is one tenth of the limit of the time. And I would therefore suggest that it's been a mixture of politics and dose to the critical group which has actually driven the designs of the plants, and not just a critical group dose on its own.

Roger COATES: Clearly the judgement about the level of exposure to the critical group which we were going to aim at, which was 500 µSv for the site, which was the vision set in 1977, was taken in a framework, that took account of all of the political environment at the time. But at least, having made that as a strategic decision, right, and saying 500 was a logical upper limit for the site, we then had a logical and scientifically sound framework for taking the decisions from there on it. We made fifty as the target for Thorp, which allows 450 for the rest of the site. Remember at that time, the rest of the site was giving perhaps about 1,500, so setting 450 for the rest of the site was perhaps not too unrealistic. So that was a target. It wasn't cast in tablets of stone. If the designer had come along, came back and said well we think we can get to 100 µSv for Thorp quite easily, but it would cost us another 500 million pounds to get down to fifty, then internally within the company we could have looked, and in theory this was stated as part of our formal regime. We could look at how to rebalance the targets. It might have been more cost-effective within the company, within the site to set another part of the site, a tighter target and relax the contribution for Thorp. As it happened it came in the other way. The designers were able to say, OK we acknowledge fifty, that's what we'll start looking at, but using reasonably pragmatic approach, they came in at 25. If they had gone to 75, we'd have had to look at reallocating around the rest of the site.

Thierry SCHNEIDER: When we prepared the presentation, you showed us some detail elements concerning the critical group assessment of the dose, and it seems that in UK it's really based on some realistic data and you update quite frequently this element. Could you give some few elements, because I think it seems quite different from the past experience in other countries, even if there is some evolution?

Roger COATES: As part of the Environment Agency's decision document on the Sellafield discharge application, of which Technetium is but one component, contained in here are two sets of environmental assessments. There is one that BNFL does, which we believe is reasonably and prudently conservative but takes account of real people, real consumption rates, but has enough conservatism in there for it to be prudent and there is also an assessment done by the Ministry of Agriculture, Fisheries and Food who, from our company's perspective, take a much more theoretical, more rigid, hypothetical approach. If I use an operator's prerogative says that we have a six month old infant who eats three kilograms of lobster a year. That's the type of assessment. So one key aspect of this is how realistic do you make these assessments. But they don't make anymore difference than factors of 1.5 or 2, taken across the board. OK, it's embarrassing, it's difficult to stand up in public and say, we say this, MAFF says something else. But I don't think it affects the principle I'm trying to get to here.

Joe Mc HUGH: Could I comment again, to follow that comment by Roger. As I alluded to in my presentation, the EURATOM Basic Safety Standards Directive has a requirement that radiological assessments are "realistic" and we are considering what that means. And certainly there's a need in the UK, may be there's a need elsewhere in Europe, for an agreed methodology for some of these assessments, agreed set of reference parameters one should use. As Roger COATES has pointed out, it's been done on an ad hoc and iterative basis. The MAFF have studied the habits of people around Sellafield in very considerable detail, and that has caused the assessments to vary year on year, depending on whether people are eating 25 kilograms of shellfish a year, or 40, or whatever. So it would be useful to have a reference set of parameters on which to base your assessments, and we are thinking about that in the UK and may be the Commission might like to consider if there's a need for that in Europe too.

Augustin JANSSENS: About the methodology for assessing critical group doses, there is indeed work being conducted at the level of the European Union trying to harmonise this, but progress is very slow. There is a working party of the Article 31 group of experts, chaired by Annie Sugier. There is a lot of tradition in approaches to setting critical group doses and it is difficult to move away from this tradition. The approach is very different from one Member State to another. The overall belief is that the UK is rather more realistic in their assessment than other Member States.

If I may use the opportunity for a further comment, you have discussed the collective dose on the one hand and the individual dose on the other hand as a possible parameter for assessing the benefit of spending money for reducing exposures. Even if individual dose may seem to be more striking, the number of people affected by this individual dose is important as well. So maybe we should look for a kind of parameter in between collective and individual dose that would account for the number of people – a kind of restricted collective dose. Have you any views on that?

Roger COATES: I can see where you're coming from. I have an inclination as far as possible to favour the simplest system that we can get, and to add in a third, sort of hybrid, collective critical group, I'm not certain how helpful that is. One advantage of the Health and Safety Executive's tolerability of risk approach, is that it is simple. It is accepted, certainly in the field of occupational risk, of risk from radiation, and other types of potential hazards. And it seems to me that there is an obligation to not expose individuals, as individuals, to levels higher than, whatever the level society may judge. But I'm quite comfortable with having the concept of individual risk and then, on the other hand, having the total collective dose as well.

Philippe HUBERT: We have encountered cases where the realistic doses were higher than the conservative ones. Because, actually, when people make computations, when they compute something, they take safety margins. But quite often, also, the modelling is incomplete, and in a way there is a balance. And very often, we went to look more closely at assessment, and we have seen that actually people did not eat three kilograms of lobster, but more crabs and things like that. But at the same time, we have seen that the people making the assessment have forgotten such and such pathways, direct irradiation and things like that. So we are starting from a point whenever there was a computation, people were taking safety margins, but they didn't ask themselves the question of completeness. And I have a couple of examples, where being realistic raises higher doses. So, is it the case for you now?

Roger COATES: That's always a possibility. I am certainly aware of many, many situations where the theoretical doses are very significantly higher than those that I believe are received. But I accept in principle it can go either way.

3. THE REGULATION FRAMEWORK AND ASSESSMENT FOR THE IMPLEMENTATION OF ALARA FOR THE MANAGEMENT OF PUBLIC EXPOSURE IN FRANCE

3.1. Presentation by M. Jean-Michel DELIGNE (DSIN)

I'm going to present our new regulation framework, concerning discharges and water intakes through a new decree of 1995. Before this decree, licences for water intakes and non-radioactive liquid and gaseous effluent, were granted through directives from the Prefecture, and the radioactive liquid and gaseous effluent were granted through and ministerial order. This new decree simplifies this licensing procedure. Indeed this decree establishes new guidelines for regulating all sorts of discharges and water intakes at major nuclear installations. A number of circumstances may lead the operator of major nuclear installations to apply for discharge or water intake licence. The first one is the renewal of the discharge or water intake guidance. The second, a creation of major nuclear installations and the last one, substantial modifications to an existing nuclear installation. The first one, licences for water intakes and non radioactive liquid and gaseous effluents, were granted before 1995 for a limited period of time, through directives from a Prefecture. And these licences will have to be renewed on expiry in accordance with the new regulation, as stipulated by the decree of 1995. The discharge and intake licences, whether new or renewed, may henceforth be granted for an unlimited period of time. A licence, granted under the previous regulation for a limited period of time, shall henceforth be renewed in accordance with the complete procedure including a public inquiry, even if the operator does not intend to change the discharge or water intake conditions. The second point is the question of major nuclear installations. The decree of 1995 does not establish a link between the discharge or intake licence procedure and the creation of a major nuclear installation, but simply requests that the enquiry to obtain the licence be opened at the same time as the public enquiry necessary for the creation of the nuclear installation. The last point, substantial modifications. The decree of 1995 stipulates that any modification to facilities, structures etc. likely to affect effluent discharge or water intakes shall be made known to the Ministers of Industry and of the Environment, before being carried out. After these two ministers have consulted the Ministry of Health, if it emerges that these modifications may be dangerous or damaging to the environment, a further licence application shall be required. The licensing procedure is presented on Figure 1.

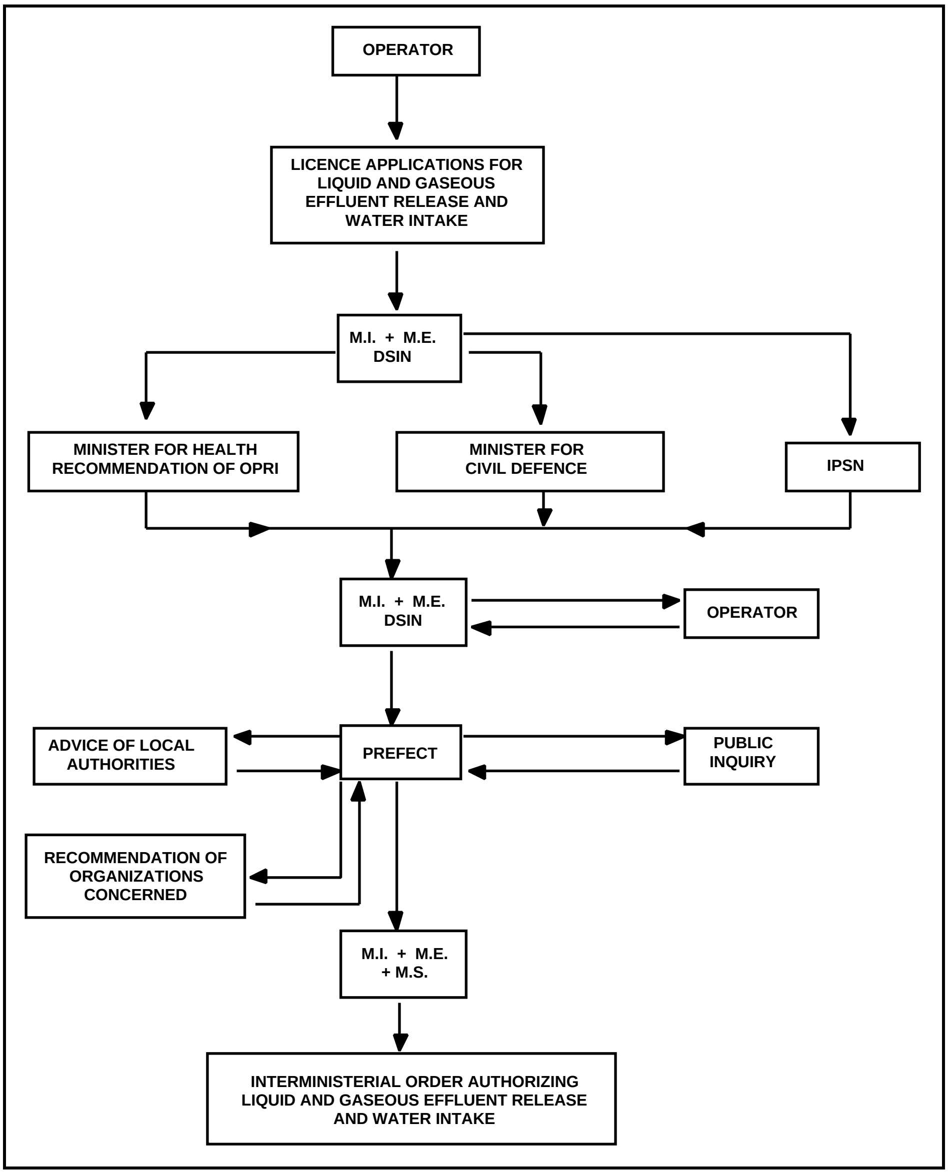

Figure 1. Licensing procedure for liquid and gaseous effluent release and water intake

The operator sends a licence application for liquid and gaseous effluent discharges and water intake to the Ministry of Industry, and the Ministry of Environment and most specifically to the DSIN which is the instructor body. As soon as the file is accepted by these ministries, the request will be sent to the Minister of Health and Minister of the Interior for advice, and to the IPSN for analysis. After these consultations and a meeting with the operator about the acceptability of the file, the request with all the advice, will be sent to the Prefect who will organise all the consultation of local authorities and the public enquiry. At the end, the Prefect transmits the results of the whole consultations with his advice, to the Ministry of Industry and the Ministry of Environment. Then the licence is granted through a ministerial order. This one, signed by the Ministry of Industry, the

Ministry of Environment and the Ministry of Health, will be published in the Official Journal of France.

Now, I would like to present some technical requirements which have to appear in the file. All the installations are to be designed and operated in such a way as to limit releases of effluents to levels that are as low as reasonably achievable. The licence sets the limit for discharges on the basis of use of the best available technology at an economically acceptable cost, and on the particularities of the site environment. And the last one, the willingness to reduce the limits of the radioactivity discharges in order to bring them into line with the actual discharges, which are dropping as a result of improvements in operation and experience feedback from 57 nuclear units in service. In regard to the third point, it seems important to note that around 1995, the Ministry for Health required that discharge analysis point out certain radioactive elements such as radioactive iodines, alpha emitters, Carbon 14. As you can notice, before, all these radioactive elements were included in a single item for liquid effluents: radioactive emitters, except Tritium, Radium and Potassium. For the gaseous effluents: radioactive halogens and aerosols. The aim of these refinements is to assess with more efficiency the effect on the environment (see Table 1).

Table 1. Radioactive elements to be analysed by the operator

	Previous parameters (before 1995)	**Present parameters (since 1995)**
GASEOUS EFFLUENTS	Gas	. Tritium . Radioactive noble gases . C^{14}
	Radioactive halogens and aerosols	. Radioactive iodine's . Other beta and gamma emitters . Alpha emitters
LIQUID EFFLUENTS	Tritium	Tritium
	Radioactive emitters except tritium, radium and potassium 40	. Radioactive iodines . Other beta and gamma emitters . Alpha emitters . C^{14}

If no limit is set for a particular category, absence of the category is verified as per authorisation order.

Now I would like to show you three examples of average release and the determined limits for the discharges. I'm going to start with the liquid discharges of Tritium from French nuclear power plants. Between 1992 and 1997, the average release was about 20 TBq for two units. The current limit is set at 55 TBq/year. The proposed new limit is at 50 TBq/year. For technical reasons, we can't reduce the limit of Tritium.

The second example is for radioactive iodine. The average annual release for 2 units is around 0.070 GBq/year. The proposed limits is planned to be at 0.3 GBq/year. There is no previous limits, because, as I said before, this emitter was included in only one item, radioactive halogen and aerosols.

The last example concerns the liquid discharges of other emitters. The average value for 2 units was around 5.32 GBq/year between 1992 and 1997. The current limit is 750 GBq/year, and the proposed one is 30 GBq/year. This limit has been reduced by a factor approximately of 25. And we keep a margin between the average release and proposed limit to allow an easier operation of the plants.

3.2. Presentation by M. Philippe HUBERT (IPSN)

I am working at IPSN and our job is to make the critical analysis of the documents that are presented to the authority for requesting discharge authorisations. So I will tell you what is our day to day work and then present the results of the working party with the Ministry of Health about the possible evolution of the analysis of those cases. When we analyse the documents we receive for discharge authorisation, we are looking at two things : We check the basic data and the dose assessment and at the same time we try to elaborate a judgement about the way things are managed and in particular to answer the question: is it optimised or not? Which is a very qualitative judgement. We have to check if there is a compliance with the prescriptions and to discuss questions of acceptability in line with the new goals of the new decree. In our work there are really two levels, direct comparison with limits and, without having quantitative reference criteria, discussion of the question “is it low enough or not?”

In the present system, we are now working on this single document which is provided in extenso to public enquiries. This creates some difficulties, because of course if all data are available, it’s a bit difficult for the public, and if it is simple enough for the public, it’s not useful for us. Then there is some balance to be found. When it is presented to the public, this document is complemented by a non-technical summary. It is not established yet if we have to criticise and analyse this non technical summary or not. Recently we didn’t do it and some of those technical summaries were not acceptable and raised major controversy in the public because it has been written in such documents that the medical doctors of the ICRP said that there where no problems with radiation at low doses and things like that. What is new, as was said by Mr. Deligne, is that now we have to look not only at the radioactive discharges, but also at chemical ones. We have to look at water

water intake. Ideally we are supposed to look at other impacts like smell, landscape, maybe noise, which for the moment, we have never done. And I don't know if anyone does. What we do in practice is to look at the whole process for treatment of effluents and the plausibility of the source term that is requested. So, our expertise is actually divided into two areas: source term (technical evaluations) and impact assessment. The technical analysis of requested discharges starts with an evaluation of the consistency of the report with the operational parameters (amounts of nuclide, chemicals,...). You may have a plant which is supposed to deal with such and such nuclides, and declares a source term that does not match exactly its activity. So we work to check that. Of course we look if the computation and forecast of the source term is correct. That's also a technical investigation. Specialists of the process try, and may be sometimes they do not succeed, to know if the source term is only linked to the normal operations, if it takes into account some margins for fluctuations around normal operations, or even some margins for some incidents. And that's an issue that was quite controversial until one year ago, and I understood that the authority has taken a clear position that the operators are not allowed to include small incidents in their requests for discharge authorisation. But it took ten years to solve that question. Then, of course, nominal releases are compared with actual releases, and finally we look, more and more, but still not a lot, to the efficiency of the processes for treatment that are proposed by the operators. And so the goal of the experts in this process is to check if the demand is reasonable from a technical point of view.

The other point to look at is the impact assessment. All the steps of impact are analysed. We look at the adequacy of the reference group (or critical group). We make a critical analysis of the hypotheses on lifestyle and the reassessment of transfer. We make our own computation with our own tools of the transfers to airborne, water, food chain, and all pathways. And we end up with a dose assessment which we compare with the operator's estimate. Sometimes we demand a reassessment. At the same time we have a judgement on the dose level. Most often the levels are between one and ten micro-sievert.

We have still open questions and we are working on some improvements. On the source term, the point is that we don't have a lot of references. I told you that we try to see if the demand is reasonable. We lack technical references of the processes that are used and such element that allows an engineer to have an engineer's judgement. There is not a lot of documentation on the cases, and there is not yet a lot of acquired experience on our side. May be there is more on EDF side (see the presentation from Mr. A. Brissaud). We are also improving our ability to look at chemical impacts. We are doing that quite easily when it is just a question to compare the release and concentration with an authorised limit of concentration in water. But if we have to look at, for example, what would be the hazards of amoeba around the plants, we are not specialist in that. We don’t investigate deeply the water needs. For the collective dose we are also looking for references. We can compute it, but we don’t know exactly what to do with it. I mean how to judge it, or even what should be the exact quantity to compute. Do we stop at a certain distance or not?

A point on which we are working a lot is improving this concept of realistic assessment, and we make some research on methods that allow an assessment to be as realistic as possible, and how does that compare with other assessments. I will show you an example of this after. We have developed some guidances, and these guides aim to improve the documents we receive, by a better way to track the computation steps so that the critical analysis is easier, i.e. with intermediate results on the source term, the concentration in air, the concentration in the environment at that level of compartment of the environment, the concentration in the food. On one side it would be easier to check the computation of the operator, and on the other side, something which is not really done now in the documents we receive, establish the link between what is computed and what could be measured. At the moment, planning for measurements is not really connected with the theoretical computation of the impact, and we think that it would be a great improvement to do that. Among other things on which we are working on is the link between the technical optimisation, and the dosimetric impact.

Figure 2 presents the kind of modelling we look at, we apply and we check at the same time, and on this picture I insisted on an aspect that we feel important, that is the definition of the group of reference. So we look at the demography. We look at the time and motion in different places. We look at the intakes. And of course, we use theoretical models to look at the transfer. Many of you are familiar with a scheme which starts from the plant and goes to the people. And I put it deliberately on the other way, because it is on that way we are working. We start from the people, the target, and go upstream to the power plant, or any other plant.

Figure 2. Dose transfer model

So, the figures we have in France in requests for discharges start from 1 µSv. Usually for power plants they are around one to ten. For factories, for re-processing plants, they are higher, and they can go up to, but that's an old figure, 500 µSv for the critical group of the population, with the traditional computation which has some conservatism, and with the maximum authorised limit, of course.

I want to show you, to illustrate some of the more theoretical work we are doing, a study we made trying to see what were the actual doses to the reference group. We started by the computation that was made in a traditional way, on the discharge authorisation at the maximum level, and this is for a case which is the re-processing factory in Marcoule which is now under dismantling. But there is still a lot of industry on the site. And the figure was around 300 µSv. Then we applied this traditional way of computing, with all its degrees of conservatism, to the actual releases (just disclosed from defense confidentiality). And we found that it was only 90 µSv. Then we tried to look more closely at the lifestyles and we came down to fifty. What is interesting is that you cannot have a generic scheme *a priori*. If you look at ingestion, you see that for some kinds of food like the vegetable roots (potatoes …), we have dramatically decreased the doses, because actually there are no potatoes and carrots in the area. But when we looked at the fruit, we didn't decrease a lot the doses, because actually people do eat many fruits from their gardens, and when we looked at the meat, it is very traditional to suppose that people eat milk and meat from their cows. But, actually in this area there are no cows. So it comes down to zero. But at the same time we suppressed the cow, we checked that there were no people breeding chickens and rabbits. But it is a typical thing when I say you have to be cautious when you want to be more realistic. And then we came to another approach: in the same framework we tried to use the actual measurements in the environment and in the foodstuffs. And we came down to a much lower figure which is 6 µSv instead of 45 µSv. And still you must not have a global judgement, because for some nuclides or pathways the ratio is very different. If some pathway is neglected in the models, so measurements yield higher doses. The dose from drinking water was smaller than in the computation. But that was because we had measurements for a year where residents used the very deep ground water. After that year they stopped to use the very deep ground water because it was not tasty, and they came back to use the surface nap, and doses came up from 0.2 µSv to 20 µSv. People were advised not to use that water which is Strontium polluted, but fossil water was really untasty.

So this study was very useful in discussing detection levels. Computation allowed to predict what is likely to be detected and what cannot be measured. We have found it very interesting to conduct those two parallel assessments, one based on modelling, the other based on environmental measures. Of course, the comparison is difficult. If doses derived from measurements are smaller here, it may be because the actual contamination of the environment is lower, but it may also be due to bad detection levels. It led us to try to make better relationship between the models and where you can measure. It also led us to define a policy to improve measurement strategies. When the models predict for some nuclides a concentration that is one hundred or a thousand times below the detection level, there is nothing to do. But for some nuclides (among others, for one nuclide which is important, Iodine 129), we have found that the computed value was just two and a half times below than the detection level of what we are able to achieve. So we pushed for technical improvement and now we start to detect Iodine.

I will now present some results of a working group that was led by the Ministry of Health, with representation from other ministers, industry and experts, in order to set up general guidelines for the improvement of all the regulatory work that was starting, because we are, in France, as in any other European country, reworking all our regulatory documents because of the application of the EC directive. The aim of this group was to give some general directions for the ongoing regulation work on the assessment and management of health impact from nuclear installations. We were faced with an uncomfortable issue when we addressed the "impact" of installations, because nobody knows what it means. It can be the becquerel in the environment, it can be the cancers, it can be the doses, or whatever. Operator, authorities and the public call for a "health impact assessment", but there was a need to state what we put behind the word "health impact". Also, the question was to look how to implement this concept, how to apply constraints. Optimisation, in a way was also a new issue, because in the present set of regulations the word "minimisation" was in use. The third point was to see how to answer the demand for openness from the public. So, there was a long discussion to say what is the correct quoting for health impact. And we arrived at something which is may be not a surprise to you, but it was a surprise to me because it has been so difficult to obtain, the effective dose is the index which represents the risk and the health impact. So when you make a document for discharge authorisation, you compute now the effective dose. It may look odd, but it was very new in France, that's a kind of revolution. The group stated that the effective dose can be assumed to be a surrogate for a risk index, and the group said that it is not necessary to compute the risk itself. You may, in the impact assessment for the discharge of a plant, look at the number of cancers, but these are not "recommendations". It has been agreed that the effective dose should be estimated, even though it is not directly measurable. And that was a change in the philosophy of the regulation because measurable quantities were favoured by regulations. There was a lot of discussions about epidemiology. Some people were saying, "why do you make all this computation, why don't you make epidemiological studies around the sites?", and there has been some tutorial work to explain that if you have epidemiology you cannot detect excess at this level, nor in due times. So, it is mostly traditional radiation protection approach, but for France it was a step forward. A series of recommendations have been made. When looking at the dose to the reference group, one should take into account the doses from all practices around (but it's not yet done, and I don't know when it will be done). It has to be compared to one millisievert per year. The philosophy of the dose assessment is not to demonstrate that the impact is negligible. Yet this was a matter of debate. Some people said "I want you to tell us what is the dose level you consider as negligible so that I can stop working below that". This working group, which represented all the ministries gave a negative answer to this claim. It was recommended that the estimation of the dosimetric impact be used to discuss the options. But, it's not yet the general case (it has indeed never been done). So there was also some recommendations about the different impact assessments which can be done. There are several occasions that request an impact assessment - Mr Deligne has shown you that there were three circumstances under which you make the impact. Actually there are much more. And the group recommended to make the same impact assessment in the safety case, in the demand for discharges, in the reassessment etc... This is not yet fully implemented, even though there are some difficulties because if you make a health impact assessment for a discharge authorisation request, you will do it, this is normal, for the maximum authorised level, and if you do it in the framework of an impact assessment of an operating plant, you will do it on the actual releases. But one may use the same models and just change the parameters. What was strongly recommended and what is more and more done, is to perform an *a posteriori* assessment. Two years ago in France, the impact was never reassessed as an effective dose for an operating plant. It was only done when the plant requested the discharge authorisation. So now the legal framework for such requirement is not fully tuned, but such a reassessment is becoming a current practice.

The working group looked also at the *a priori* and *a posteriori* impact assessments. The *a priori* should be based on forecasted releases and not arbitrary figures. The reference group is used to verify that the doses are below the limits. The *a priori* impact assessment must also be used to show that releases were optimised, which is not yet implemented. The *a posteriori* impact must be realistic and this is more and more the case. It should provide references for good practices, the idea is that the more *a posteriori* impact assessment we have, the more we will be able to judge the *a priori* and discharge requests on the basis of what is going on. It will help to build up the references which are presently lacking.

The working group also provided guidance for the impact assessment itself, asking for more realistic assessment and for more explicit margins. Such demands are not fully satisfied but great improvements were made. All the pathways should be considered, which is not yet the case. Direct radiation from the site is not always considered, and releases other than the authorised discharges (the releases that are not going through procedural pathways), may not be taken into account in the impact assessment of a plant. And of course, what was requested and is now accepted is that the source terms should be very precisely defined. Mr Deligne showed you that the “regulatory source term”, that was described in four categories, is now described with six or seven categories. In addition even if there are not many categories in which the regulatory real-time monitoring is performed, the operator should keep records of all the nuclides in a detailed way so that it can be checked what has been released.

There was also guidance for optimisation. It was said that optimisation must appear explicitly in the document asking for releases. It was said that the choices must be justified and then I noticed a clear improvement in the documents we received on this aspect, although there is a room for further improvements. Some criteria were discussed and proposed: the dose to the reference group - (this is done) - the collective dose - (I have seen no documents in which it is computed). The dose to the workers was also pointed out as a factor that should be taken into account in the optimisation process. The waste production (I mean the amount of waste that you produce out of the treatment facility in the plant) was quoted as something you must look at in the optimisation process - but yet I have never seen that in a request for discharge. Waste is an important factor that influences the cost, because the less waste you produce, the less costly is the process. At last, investment and operation costs were pointed out as factors that are important to estimate. Investment costs appear sometime in the safety documents, but I have never seen operation costs.

Which criteria are the most important when discussing a discharge authorization? Part of the above discussion looks very new from a theoretical point of view, but you have to remember that it was not requested to optimise in the previous decrees. It was said that the operator had to minimise (and the word was “minimising”) its releases. So in the discussion between operators and authorities, this issue is a new one. With respect to the subject of this meeting, I think it is quite important to discuss the criteria to be considered. For me, it’s difficult to discuss optimisation with only the dose to the reference group, without looking at the investment cost, the collective dose… I don’t mean that all those criteria are pertinent, but they must all be considered. The points made on collective dose were not exactly that the overall collective dose should be computed, but at least that the number of people that are under consideration should be considered. I think it’s a common sense to see that two people exposed to ten microsieverts is not exactly the same problem as two million people.

3.3. Discussion

Roger COATES: Did I understand correctly that the working group in 1995, clearly concluded that the key parameter for decision making is the critical group dose?

Philippe HUBERT: No, you can conclude that the only one that has been implemented is the critical group dose.

Roger COATES: Right. I thought that it was agreed that this was the measure of health impact, and that it would be the parameter in which assessments were displayed in the future.

Philippe HUBERT: It's the key parameter for assessment. I don't know to which extent it's a will or a tradition. What I wanted to show, is that regarding optimisation, at the same time you can say that nothing has been done, and nothing is being done, but you can also say that things are moving. I think that we never had any formal computation for optimisation, but the minds of people have changed, and the question, "Have you studied any alternatives?" is more often raised. I think it's the beginning of the process now, but as I said, the doses are not really a parameter that is looked upon when we looked at the so-called optimisation. People look at the technical part. We check on the health part that there is nothing absurd or unreasonable, but we don't make the connection between the two.

Joe McHUGH: I explained how special equity is an issue for Technetium 99 discharges, and especially the effects in other countries. I know that some French nuclear installations are located close to your borders. Is that an issue in setting limits from discharges in France?

Philippe HUBERT: No, I've never seen this issue discussed. In line with what you have said, there is just a little thing that we have started to look at: to define a reference group which is not a geographically defined one. At the time, it was out of the question to look at a specific village. Now, we start to have social groups instead of geographical groups, but looking at equity, in a way, Mr. Deligne has answered you. He has showed you that the discharge limits do not depend on the place where the plant is, so it means you can monitor discharges with two principles. Achieving the same doses around the plant, or allowing all the plants of the same type to have the same discharges. On one side, you have equity on the people, and on the other side, you have equity on the plants. And the French approach is equity on the plants, and we admit and we never make any problem with the fact that with the same release we can have doses ten times higher in one place than in the other one. And maybe if we would take into account the collective dose, that would be a hundred times, because we have some plants around which there are a lot of people, and others where there is nobody. It's a partial answer, I'm sorry.

4. PRACTICAL EXPERIENCE OF THE IMPLEMENTATION OF ALARA FOR THE MANAGEMENT OF PUBLIC EXPOSURE IN FRANCE

4.1. Presentation by M. Alain BRISSAUD (EDF/SEPTEN)

I will talk to you about optimisation or not optimisation concerning radioactive discharges of nuclear power plants. First, a recall of what was the French legislation. In this period, from 1974 to 1976, a set of dispositions was published for the authorisation of liquid and gaseous radioactive effluents discharge. They also specified which measurements we should carry on and how they should be controlled by safety authorities. A special decree was issued for any nuclear power plant site, with limits that were below those in the general decree. The annual limits were set in Becquerels and in terms of specified added concentration, I can say they were rather comfortable, large. So it was not very difficult to have lower releases than the limits. It was also specified that the activity should be kept as low as possible, under the limits. The corresponding doses to the public, critical group if you like, were not the object of very specific calculations, but in a way safety authorities demonstrated that the corresponding doses were less than one or two hundredth of the limit for the public.

As you have heard, many things are changing and practically in 1995, it was said that consequences of radioactive releases on public health, if any, should be indicated, and on two other occasions (1996 and 1998), it was confirmed that health effects should be assessed in terms of doses. Present and future legislation: limits are lowered by a factor of five to thirty-five, except for Tritium. This is based on observed releases, feedback experience. There are specific limits for Carbon 14, and the legislation is moving towards an integrated law, with noise, odours, intake of water, water need, temperature and etc..., and also the use of BAT (Best Available Technology). There is also a reference, of course, to the OSPAR Convention. As a matter of fact, as an operator, I find that the past legislation was not a strong driving force for low releases. Either legislation was putting emphasis on the limited number of isotopes, clearly seven or eight identified radionuclides. Carbon 14, for example, was not cited. However, considerable reduction of releases over the years were observed. This reduction was not the result of an optimisation process, which means that no cost-benefit analysis was carried out. It was obtained by some modifications of the units, not large ones, and also mainly operation practices and operator awareness concerning the releases.

Figures 1 and 2 present examples of the released activity in liquids effluents from 1986 to 1998 (average annual value per unit). You can see that a considerable decrease has been observed for the 900 MWe units, as well as for 1300 MWe units. So now we reach approximately 1 Gbq/year on an average, and the best units reach only half of this value.

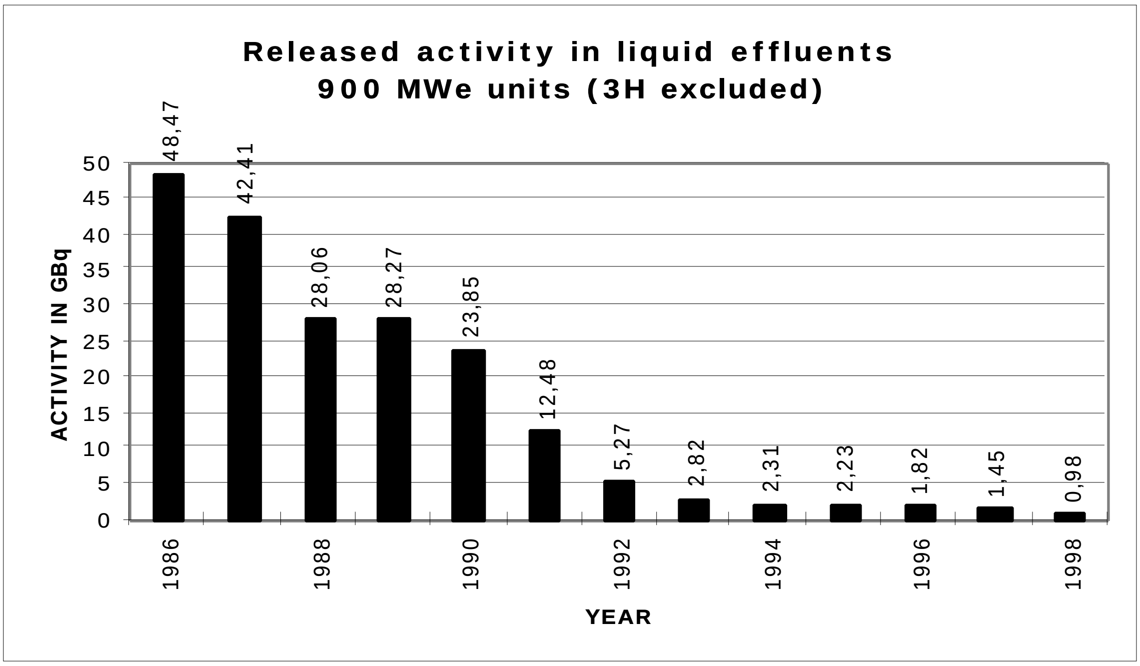

Figure 1. **Released activity in liquid effluents. 900 MWe units [^{3}H excluded]**

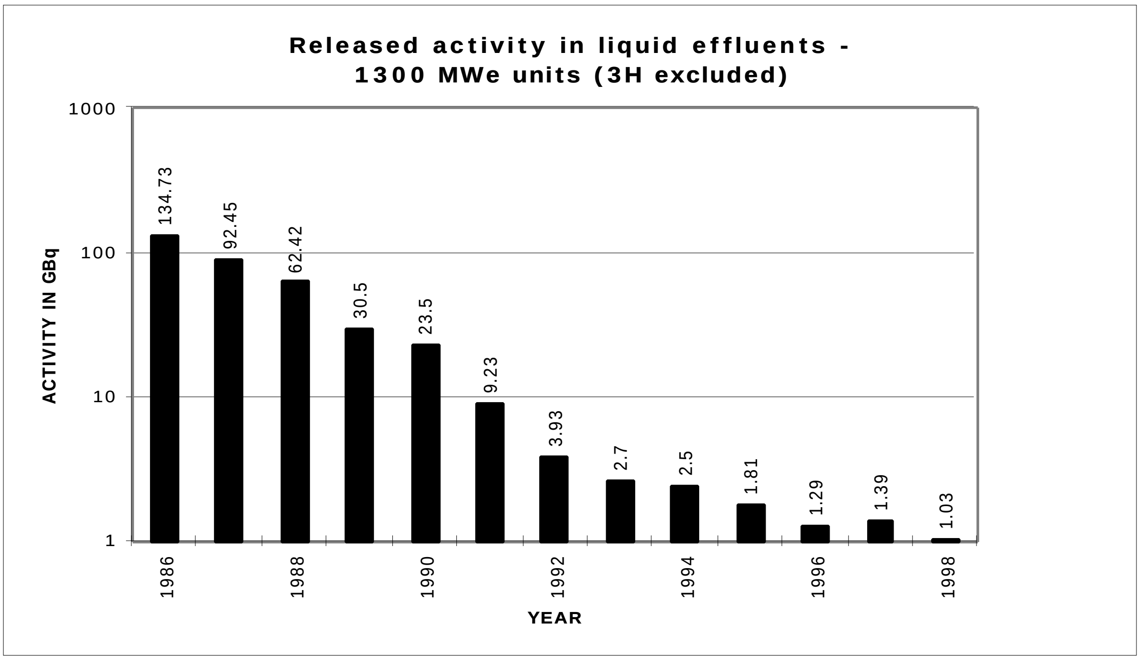

Figure 2. **Released activity in liquid effluents. 1300 MWe units [^{3}H excluded]**

Concerning the impact in terms of doses, I took a document readily available, which was the discharge authorisation request of CRUAS (see Table 1). The calculated doses are very low. The final value of 1.3 µSv per year to the individual of the critical group corresponds to a release of what is asked for in the authorisation, not actual releases. The calculation for actual releases in 1996, presented in the CRUAS document was not including Carbon 14, which was not monitored. So I added a theoretical value and we obtain, for the actual releases, a total individual dose to the critical group of 0.03 µSv/year. Anyway, you see it's, as someone said, absolute peanuts.

Table 1. Assessment of the individual dose to critical group corresponding to the authorised release limits of Cruas (4 units - 900 MWe) (in Sievert)

Isotopes	Gases	Liquids	Total
Tritium	1.0 E-07	2.5 E-08	1.25 E-07
C14	1.7 E-07	2.9 E-07	4.0 E-07
Rare gases	5.3 E-07	//	5.30 E-07
Iodines	3.5 E-09	1.4 E-09	4.90 E-09
Others	2.4 E-08	1.4 E-07	1.64 E-07
	8.3 E-07	4.6 E-07	1.3 E-06

Concerning optimisation, one question is: "is it worthwhile doing it?" Many people's current answer to that question is: "Well, it's peanuts, and we are not going to optimise peanuts. It's not useful. It's a loss of time, and spending money on studies and so on." However, in our opinion, it's better to carry out optimisation studies, with expected following benefits. The first one is the respect of the legislation. We have to carry out studies in order to demonstrate the optimisation degree. In the process, we can find out some efficient reduction means. Maybe, it's possible. Why not? I mean efficient on a cost-benefit analysis basis. We could also, probably, point out possible pollution, I mean, trade-off, between present time and, later, between doses to the public and doses to the workers, trade-off between releases of radioactive and/or chemical elements. But anyway, I think a major benefit is to clarify the situation, which is clearly asked to the operator, EDF, from the safety bodies now, and it will give a clear basis for discussion with the safety authorities and, why not, with the public. Such an optimisation study is currently being carried out. I would like to address some technical points

Tritium: there is probably no available industrial solution for low quantities. You have to keep in mind that even for a discharge of 10 to 15 TBq/year, for one unit, the corresponding mass of tritiated water is 30 mg, and if you want to sort the Tritium out, you have to sort this out of 4000 to 8000 tons of water. Anyway, we will verify.

Carbon 14: we could probably transpose what is performed in Sellafield, wash out gases with soda, something like this, and, in this case, we would have to address the cost, the storage problem, the possible discharge of chemicals, and clearly, it's the choice between concentration versus dispersion.

When you look at the release of rare gases, at least in a number of units, you find Argon 41, which is coming out from the reactor building. Sometimes the pressure in the reactor building is increasing (slightly) because the pneumatic devices of valve actuators are somewhat leaking. So sometimes we release the pressure of the reactor building that should be below the natural pressure and, in this case, we get out some Argon 41, that comes from the activation of the air around the vessel. We could think of adsorption techniques, charcoal filters, any kind of delay line, because the radioactive period of Argon is not so long, it's less than two hours. For others, we could probably add ion exchanger, down stream evaporators, it has to be studied anyway. And we also could look at the performance of monitoring systems, and also have a look at what I call the "fake releases". I think it is - or has been - the case for gases when the release is evaluated multiplying the measurement threshold (detection limit) by the flow rate, at which the gases are released. So, that means possibly, on this occasion, the actual release is somewhere between zero and one hundred percent of what we indicate.

This study is being performed by CEPN and EDF, and it should end next year. Technical aspects: the bibliographical study for Tritium removal is currently being performed. Carbon 14, we will try our best to make a transposition of the Sellafield process, see if it could be adapted to less quantities than in a reprocessing plant. Unfortunately, I think that the Sellafield process is proprietary, so we will have to make some thinking about it, and also study all possible options to further decrease the releases. Then, we will carry out an evaluation of options, including the operation costs of the system. This is because we have seen in the past that these costs are not negligible. We will also point out the possible trade-off problems, which are costs, wastes, doses, short/long term. We will use, if necessary, an implicit monetary value of the saved person-Sv for the public, which should be derived from past actions, or international values, and we will evaluate the dose savings and perform a cost-benefit analysis.

Conclusion: the first difficulty was to convince decision makers to spend the money on the optimisation study. There is also a cultural problem, because a lot of people say, "Why even think to reduce such extremely low doses?" An estimate of the risk, by the same people, is that: should we discover options allowing further release reduction? Even if they are not ALARA, they will be imposed, only because it's possible. The benefits of the study: clarify the situation for the operators, the safety authorities and the public. For the public, I would say, if possible, I doubt it's possible. And finally, of course, this study will help to reduce radioactive releases.

4.2. Discussion

Mark DUTTON: My question is: "What do you mean by optimisation?" You see, if I look at the achievements of EDF, the liquid discharges have come down from two hundred to one. Now, I can't believe that's justified by any sort of cost-benefit analysis. My own judgement is that it must be based on using all the equipment in the plant, so that it moves as much activity as it possibly can. Is that what you mean by optimisation?

Alain BRISSAUD: This reduction, which is noticeable, is not the result of an optimisation process. Not at all. It is rather the result of, or the idea of, reducing and some increase in awareness. It was probably possible, so why not do it? So, we did it, and it was, in fact, obtained without major modifications in the treatment systems. The main points were: have a better sorting out of effluents by categories, use the adapted treatment system and so on. But no major modifications. And, it's not an optimisation process, because we never balanced the cost, if any, against the benefits, if any.

Mark DUTTON: The supplementary question is: "It must have cost money, so why did you spend the money?"

Alain BRISSAUD: Well, maybe an answer to this question is, you know, many people and decision makers always say, "Radiation protection costs and costs and costs, too much costs" and, in fact, today we want to know the cost. For this purpose, a study is just being performed, with the help of CEPN. That means, that up to now, we do not know the cost! And, well, I can't give the results, because it's too soon, but some points are very surprising. It's not what people could think. Maybe it's not so expensive. Maybe.

Philippe HUBERT: About the reduction of releases, you mentioned the treatment systems, but did you investigate what you can do before? I'm thinking of the source term.

Alain BRISSAUD: Yes, of course. But this has been done because the main problem with the source term is not the releases to the public, but the doses to the workers, and so for this reason, we have checked a number of possibilities to reduce the source term. One thing I would like to add is that this reduction has not been accompanied by a large increase in the solid waste volume. On the contrary, both have been decreased.

Roger COATES: One observation and one question. The observation relates to your comment on your earlier regulatory regime, which you agreed did not give you any strong driving force to use your imagination to reduce doses. I would like to point out one aspect of your current regulatory regime, which is part of our current regulatory regime, which, likewise, gives you no incentive to reduce discharges, and that is this expectation of continually reducing limits to match discharges. The theory goes, that if you work really hard, to reduce your discharges, we will reward you with even tighter limits to make your life even more difficult. So, that's one observation. The question is: "We now have the OSPAR requirements placed upon us, which were agreed across Europe last year. Do you, in France, feel any particular pressures directly relating to OSPAR, and the response that your national authorities will have to be making, within the international community, over the coming few months?"

Alain BRISSAUD: You have heard from the preceding presentation that our safety bodies, or it's technical support, were citing the OSPAR Convention, and inside EDF anyway, some people claim that the result required by the OSPAR Convention are yet reached, with very low releases, and others say, "Well, okay, these releases are peanuts, but have a look, see if something is possible, and particularly without trade-offs, and particularly no trade-off between very low individual doses to the public and doses to workers". I think this is important. And, also, have some thinking on the trade-off between short and long term. Clearly, what is the benefit of stripping out Carbon 14 from gases? Is it a good operation? And I must precise in this case that the authority that manages the storage site in France does not want any Carbon 14. This is because in three hundred years, this storage site should be supposed to go to the dogs, without any radiological consequences. With a lot of Carbon 14, it probably wouldn't be the case.

Florentin LANGE: I only have a question for my understanding. If I understood you correctly, we have seen that you have major reductions in the liquid discharges, and you said that you are not aware of how much cost you had, to have these reductions. So, my questions is: "Maybe you got it without very many costs, maybe just by improving the radionuclide concentration in your primary coolant, by changing maybe the chemistry and by improving the fuel cladding and so on".

Alain BRISSAUD: No, the primary coolant chemistry known as "co-ordinated Boron Lithium chemistry" has been applied since 1981, in the first units, and the recommendation, or the prescription, was to respect a pH higher than 7.0 at three hundred degrees. And, then, we are still discussing whether it would be better to have 7.4, 7.2, or whatever. But, definitely, the international community is agreeing that 7.0 at three hundred degrees is not so bad. And, also we had some difficulties to lower the source term of corrosion products, because, as you might know, all these units have been built very quickly, so that it was difficult to impact the design. This reduction has been achieved by improvement of practices, awareness of the people that operate the plant, and also some modifications, that we would apply to the new reactor EPR. The idea is that if you want to have low releases, you should do as follow:

- Do not mix high activity with low activity.
- Do not mix oil with water, so sort out your effluents, and then have the adapted treatment.
- Have a large storage capacity, between source terms and the effluent treatment systems, and then again, have a large capacity after the treatment, in between the environment. These recommendations are efficient, and the costs are probably not so high.

5. THE MONETARY VALUE OF THE MAN-SIEVERT FOR PUBLIC EXPOSURE

5.1. Presentation by Ms Caroline SCHIEBER (CEPN)

What I'm going to present, is part of this EC project on optimisation in case of complex exposure situation, and it's a joint research between CEPN and the University of Mons in Belgium (FUCAM). During the previous years we have worked on a system for the monetary value of the man-sievert in case of occupational exposure. The model has been developed and the system has been adopted by various utilities in France, and in other countries. Then the question was: is there any reason to adopt a different monetary value for public exposure rather than worker exposure?. In order to answer to this question, we have used some theoretical developments based on insurance economics, and the concept of the willingness to pay. What is the willingness to pay of a member of the public, or a worker, in order to reduce a probability of damage? Here, the damage will be to reduce a probability of radiation-induced cancer, so in fact, to reduce exposure. This analysis is based on two different criteria: 1) the level of probability, because it appears that even if workers or public are exposed at the annual individual limits of exposure, the public is facing a lower probability of radiation-induced cancer, 2) the possibility of compensated damage. For example, for workers, you can consider that usually, depending also on the practice in the different countries, worker doses will be monitored, and it will be possible, if they declare a radiation-induced cancer, to receive a compensation. So there is a system of compensation which exists in case of occupational diseases. I will quickly present the theoretical developments, and then a numerical application based on the real probability of radiation-induced cancer. We have used also a basic monetary value of the man-sievert based on the human capital approach, or the willingness to pay. Then we have determined multiplying coefficients in case of public exposure situation, that means that from a theoretical point of view, there are some reasons to have a higher value for the monetary value of the man-sievert in case of public exposure than for worker exposure.

Just a quick review of what is the monetary value of the man-sievert. It is used within cost-benefit analysis, and for the purpose of optimisation of radiation protection. Because it is evaluating a detriment, it can be seen as a function reflecting individual or collective preferences, associated with the level of exposures and taking account of the specificity of all exposure situations. So, from a theoretical point of view, if we really want to have an optimisation taking into account the whole benefit, which is not only reduction of probability of cancer, but also social aspects of the benefits when you reduce exposure, this value should integrate several dimensions. One dimension, which is completely independent of the type of exposure situation, is related to the potential health effects associated with the level of exposure. You can also have other dimensions which are specifically related to the exposure situations, for example, social equity considerations, and distribution of individual exposures. For example, for the monetary value of the man-sievert in case of occupational exposure, we have used a function which is increasing with the level of individual dose, in order to reduce this distribution of exposures, and integrate also individual and social risk perception.

These are differences between public exposure and occupational exposure we have explored in this research - there are other differences, but we have focused on these one. First, a difference in terms of initial individual level of exposure. In public exposure situations, you have lower levels of individual exposure than those of the workers, and according to the linear dose-effect relationship, in average, members of the public are facing lower probability of occurrence of potential radiation-induced cancer than workers. The second aspect is this possibility to compensate a worker in case of radiation-induced cancer, which is not done for the public mainly because the public is not monitored, so you don't know what is the dose received by the public. For the numerical applications, we have used both expected utility theory, and non-expected utility theory. I will present only expected utility theory. We have selected the following utility function and a relative risk aversion coefficient:

$$U(W) = \frac{1-\beta}{\beta}.W^{\beta}$$

This utility function means that the utility of your wealth (W) depends on the level of your wealth. The relative risk aversion coefficient can be derived from this utility function ($A_r = 1 - \beta$). We have selected four levels for the relative risk aversion coefficient, between 0.5 and 3. For the range of probability, we have evaluated them on the basis of the dose-effect relationship, in terms of lifetime risk, as expressed by the ICRP for an annual individual exposure. For the example, we supposed that people were exposed to an average individual level. We have also made the same exercise with people exposed to the annual limit, but it doesn't make a lot of difference. So, we have assumed that you have members of the public exposed to 0.1 mSv per year during 75 years. This means a lifetime dose of 7.5 mSv, and a lifetime risk of 4.10^{-4}. For workers, if you assume 5 mSv per year, from age 18 to 65, you have a lifetime dose of 240 mSv, and then a lifetime risk of 10^{-2}. Even if they are exposed to a higher level of exposure during a shorter period, the risk is still higher for workers than for the public. What we will do is to evaluate what could be the willingness to pay for members of the public, or for a worker, if we could provide a reduction of the probability of developing a radiation-induced cancer, equal to 1.10^{-4}. This means that for the public, we have evaluated the willingness to pay, in order to decrease the probability of radiation–induced cancer from 4.10^{-4} to 3.10^{-4}, and we have made the same exercise using the same utility function for a reduction of probability for workers, from 100.10^{-4} to 99.10^{-4}. So it is the same reduction of probability, but just starting from a higher or lower level of probability. For the level of wealth and loss of wealth, we have estimated an initial level of wealth of six million francs based on the monetary value of life, estimated using the human capital approach, and we have used also an average individual financial wealth of 0.5 million francs, which comes from national statistics. In case of radiation-induced cancer, there is a loss of life expectancy, which has been evaluated also using the human capital approach, which means using the Gross Domestic Product per inhabitant, in order to value one year of life. The GDP is equal to 135 thousand francs, and you obtain the value of loss of wealth by multiplying it to the number of years lost with the cancer, which is approximately fifteen or sixteen years. The loss of wealth is then equal to 2 MF.

Other assumptions: we have taken three cases of compensation for the workers. First, no compensation at all, so the loss is equal to two million francs. This was done in order to test only the effect of the first criteria, which is reduction of initial level of probability. Then we have tested two systems of compensation, one was where workers are compensated to 50 % of their loss, so the adjusted loss is only one million francs, and the other one, compensation of 75 % of the loss, and an adjusted loss of 0.5 million francs.

The main results:

First case: no compensation system, for the public and the workers. The initial level of wealth and the level of loss of wealth are the same in both cases. Table 1 presents on the first line the willingness to pay for the public in order to have a reduction of probability from 4.10^{-4} to 3.10^{-4} of having a loss of 2 MF, given different values of the relative risk aversion coefficient. As the relative risk aversion increases, there is a higher willingness to pay to reduce the probability of damage. We have estimated it for public non-compensated, and workers non-compensated. It appears that, when you make the ratio between the two willingness to pay, there is not really a large difference between these two willingness to pay. It's only a little bit higher for public than for workers. This is because when you have a lower probability of damage, you will accept to pay more for the same reduction of probability than when you are facing, at the beginning, a higher level of probability of damage. This means that, for example, in one case if you have eighty percent of chance to develop a radiation-induced cancer, and you can reduce this probability from eighty percent to seventy percent and in another case you have ten percent of probability of having a cancer, and you can reduce it from ten to zero, it's better. In relative perception, you will pay more to go from ten to zero than from eighty to seventy, because from ten to zero you have no risk at all. From eighty to seventy, you still have a risk, so you will agree to pay something, but you will agree to pay less than for a complete removal of the risk. In fact, we have seen that this difference in case of public or worker exposure is not very significant.

Table 1. Willingness to pay for a reduction of probability - No compensation for public and workers

	Willingness to pay for a reduction of probability of 1.10^{-4}			
	Relative risk aversion coefficient			
	Ar = 0.5	**Ar = 1**	**Ar = 2**	**Ar = 3**
Public non compensated (initial probability: 4.10^{-4})	0.0002202	0.0002432	0.0002999	0.0003747
Workers non compensated (initial probability: 100.10^{-4})	0.0002197	0.0002421	0.0002963	0.0003663
Ratio Public/Workers	**1.002**	**1.005**	**1.012**	**1.023**

What is much more significant, is the possibility to compensate the loss. When you make the same exercise, i.e. to evaluate the willingness to pay for a reduction of probability of loss, it appears that when the workers can be compensated, so in this case their loss will be only one million francs, they agree to pay far less in order to reduce their probability (see Table 2). In this case, the ratio between public and worker is situated between two and three, according to the relative risk aversion coefficient.

Table 2. Willingness to pay for a reduction of probability - 50% loss compensated for workers

	Willingness to pay for a reduction of probability of 1.10^{-4}			
	Relative risk aversion coefficient			
	Ar = 0.5	**Ar = 1**	**Ar = 2**	**Ar = 3**
Public non compensated (initial probability: 4.10^{-4})	0.0002202	0.0002432	0.0002999	0.0003747
Workers compensated (50%) (initial probability: 100.10^{-4})	0.0001044	0.0001092	0.0001195	0.0001311
Ratio Public/Workers	**2.108**	**2.228**	**2.510**	**2.859**

Finally, if you can compensate the workers with seventy-five percent of their loss, then you increase again the differences between the willingness to pay for the public to reduce their exposure and that of the workers. You have a factor between 4 and 6.5 (see Table 3).

Table 3. Willingness to pay for a reduction of probability - 75% of loss compensated for workers

	Willingness to pay for a reduction of probability of 1. 10^{-4}			
	Relative risk aversion coefficient			
	Ar = 0.5	Ar = 1	Ar = 2	Ar = 3
Public non compensated (initial probability: 4.10^{-4})	0.0002202	0.0002432	0.0002999	0.0003747
Workers compensated (75%) (initial probability: 100.10^{-4})	5.106E-5	5.212E-5	5.444E-5	5.685E-5
Ratio Public/Workers	**4.312**	**4.663**	**5.508**	**6.590**

Figure 1 presents, according to the different values of the relative risk aversion coefficient, the ratio between the willingness to pay for the public, to reduce their exposure, and the willingness to pay of workers to reduce their exposure.

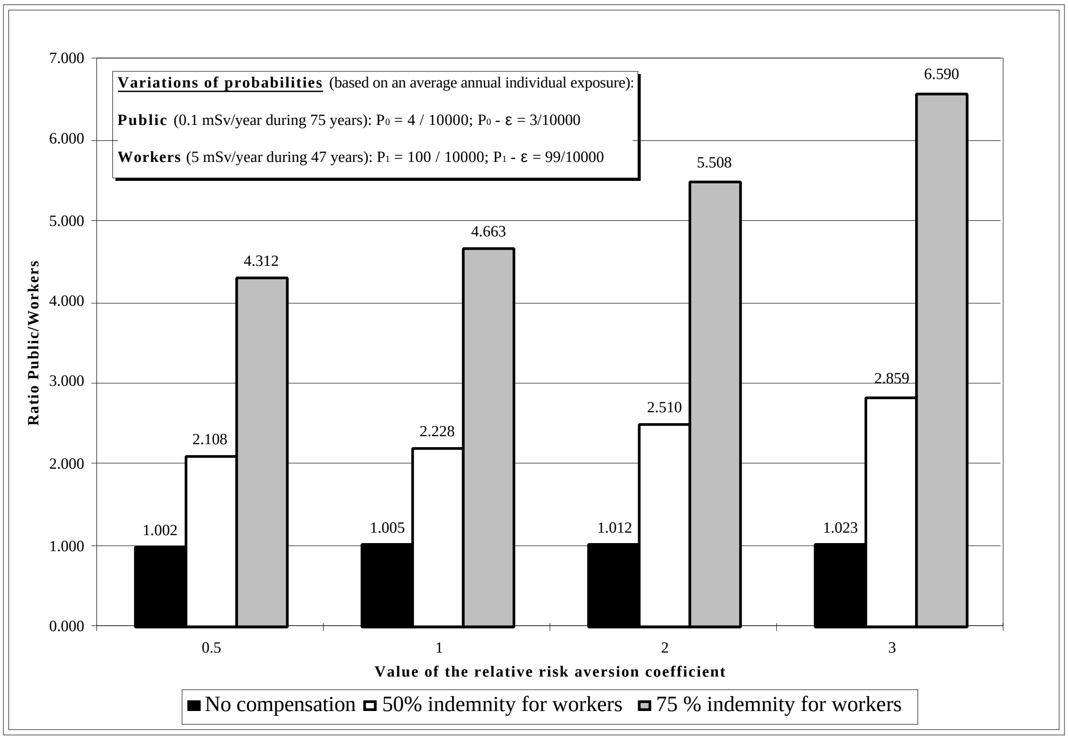

Figure 1. Ratio of the WTP for a small reduction of probability of occurrence of a radiation-induced cancer, according to increasing values of the relative risk aversion coefficient and to the compensation system adopted

Lets come back to the monetary value of the man-sievert. We have taken a basic monetary value of the man-sievert corresponding to the value of potential health effects, using the human capital approach: 160 kF/man.Sv on the basis of 16 years of loss of life expectancy and an annual GDP per capita of 135 kF, as well as a probability of 7.3 10^{-2}/Sv to develop a cancer, in case of public exposure. Using the revealed preference approach, we have a monetary value of health effects of three million francs. This is the result of a willingness to pay study. This gives a monetary value of up to 220 kF/man.Sv. We have seen that the willingness to pay to reduce an exposure varies between public and worker with a factor 1 to 6 (1 is with no compensation, and as soon as you have compensation for workers, it is between 2 and 6). Then, because we agree to pay more to reduce the probability, the monetary value for the public should be multiplied by the coefficient we have found when calculating ratios. The proposal we made was to adopt three possible values for this multiplying coefficient: 3, 5 and 6, assuming that relative risk aversion coefficients are usually between two and three, and that compensation of workers in the French legislation is usually greater than fifty percent. Finally, if we take the initial value of 160 to 220 kF/man.Sv and according to the different multiplying coefficients we have selected, we can propose to adopt at a minimum value for public exposure between 500 kF/man.Sv and 1.3 MF/man.Sv (see Table 4). This means that if this value could be used in cost-benefit analysis as one criteria between all the criteria, when making, for example, comparison between options which will increase the detriment of workers and reduce the detriment of the public, we should not use the same monetary value for this detriment. We should have a higher monetary value for the detriment of the public than for the detriment of workers.

Table 4. Evaluation of the monetary value of the man-sievert for public exposure

Basic value	Multiplying coefficient		
	3	5	6
160 kF/man.Sv	480 kF/man.Sv	800 kF/man.Sv	960 kF/man.Sv
220 kF/man.Sv	660 kF/man.Sv	1 100 kF/man.Sv	1 320 kF/man.Sv

5.2. Discussion

Augustin JANSSENS: Maybe I should have known this for a long time, but what do you understand with this compensation system for workers? What in practical terms is the compensation?

Thierry SCHNEIDER: In the French system, as soon as the occupational disease is recognized, there is a compensation according to the degree of incapacity. In the UK system, the compensation is proportional to probability of causation. In this model, we consider, that as soon as you are in position to make a link between exposure and the occurrence of the disease, then you will be in position to get a compensation, which is not the case for public exposure where you will never be in a position to make a clear link between the exposure and the disease, because you have no monitoring, then it's just a theoretical model, except if you have a significant level of exposure for public. Furthermore, we consider that the levels of compensation from insurance companies are in the range of fifty to seventy-five percent of the willingness to pay that we obtain with enquiries on detriment, because in fact, if we check compensation system in France, it's mainly based on wage and the loss of wage, incapacity and disability of working, and then it takes into account part of social aspects, but it's not necessarily a real full compensation.

Wolfgang GOLDAMMER: Maybe I got something wrong, but isn't there a contradiction between what you presented first, where you compared workers and the public, where you have this 5 mSv as a basis for the workers, and then you derived this factor of three to six, that the monetary value of the man-sievert for the public should be higher, and that resulted in this range of 500,000 F to 1.3 MF. But for the workers, we generally assume a very progressive value, and if one looks at the 10 mSv, there is several million francs.

Caroline SCHIEBER: This is what I tried to explain. Two different aspects have been analysed. First is, what do we agree to pay for a reduction of probability of damage, starting from two different initial levels of probability. You agree to pay more to go from ten to zero percent of probability than from eighty to seventy. Even if it's not a lot more, we have compared public and workers and the ratio between the two willingness to pay was only 1.001, or 1.002. Then the multiplying coefficient of 2 to 6 reflects the difference we obtained when comparing two different systems of compensation from which we conclude that we should have a greater value for public.

When we consider only workers, starting from a basic monetary value, which is set using human capital approach, for example, and based on the probability of cancer for workers (which is lower than that for public) you want first to reduce the collective exposure, but you have other objectives when you apply the cost-benefit analysis which are to reduce also the dispersion of individual exposure, within a given group. Here it's not between workers and public, it's inside the group of workers, for which you are considering the protection. Furthermore because of equity, you want to reduce, in priority, the dispersion of exposure within the highest individual levels of exposure. In fact, this increase means that starting from a basic monetary value, estimated for example, on pure economical data, you agree to pay more to reduce exposure, because you have dispersion of exposure within a given group, and if everybody had the same level of exposure, you would apply only one single value. When you are considering worker exposure, any protection option will change the distribution of individual exposures. When you consider radiation protection options for public, usually you will reduce the source of the exposure, so you will have the same proportion of reduction of exposure for all members of the public.

Roger COATES: Just an observation that is that if you change the detriment valuation from discharges by factors of three, or thereabouts, it doesn't affect any of the decision making that Alain Brissaud will have to make. I don't think that it affects any of the decision making that I will have to make. I'm not convinced it affects any of the decision making on nuclear discharges. It may affect decision making in other parts of the public exposure scenarios, but I think it has no change to nuclear discharges.

Neale KELLY: I think Roger's absolutely right. This work will have no material impact on decisions on discharges, save in exceptional circumstances. However it does provide a theoretical basis, to show that what we're doing is adequate. It provides a solid basis which we can move off from and it will limit the extent to which the process can be subjected to valid criticism.

Jacques LOCHARD: I would like to reinforce what Neale has said. I think the merit of such studies is just to know a little bit the range and to consolidate some possible debates. We had more or less the same process with the aversion coefficient for evaluating the economical costs of an accident. A few years ago, in the community of the economists in Europe, there was some sort of consensus to say you can't stick only on the direct cost of an accident, if you make any anticipation of the total impact of a large nuclear accident. It will come to a certain level, and then they said, but there is an aversion coefficient there, and as there was no theoretical background to say that there is aversion there, they were just sending values like a factor of a hundred or even more. Based on that, you come to tremendous numbers. After a similar process of trying to find some foundations about this aversion coefficient, we came down to a factor twenty, and then there was a discussion, and there was a debate about the model proposed and so on, and then there was a final consensus that finally twenty was not that bad. I think this is the merit of this process, which is important. I think this is really important, to take these exercises in this perspective.

Wolfgang GOLDAMMER: I agree to this merit of these kind of studies. I see a direct relevance to other sorts of exposure. It’s true that most people in this room here are mostly thinking about releases, but that doesn’t mean that most of the people in the world are exposed significantly by releases, and it’s just the other way around. I mean, releases from reactors, or other nuclear installations. In our German situations, there’s hundreds of thousands of people exposed from uranium mining, there’s many people exposed from Naturally-Occurring Radioactive Materials, with doses in the range of one millisievert or even higher, and for decisions in this area, so remediation decisions, or decisions about NORM, this type of consideration is extremely relevant, I think. Factors of two or three may not change anything in your case, Roger, but they change lots in our case. So I would think that for this type of question, it’s very relevant what you are doing here. It’s not academic at all, in my view.

6. FINAL DISCUSSION

Thierry SCHNEIDER: For the final discussion of this seminar, I suggest a few issues which could be discussed:

- What is the decision-making process for selecting some ALARA options as far as public exposure is concerned?
- The concept of individual dose versus collective dose. Maybe we should put also the problem of becquerels. Which kind of indicators can we have at this stage?
- The problem of trade-off which was mentioned by different speakers this morning. Trade-off between public and workers, between release and waste, between short term and long term, and we should also add between chemical and radioactive releases, what does it mean with other kinds of risk?
- The stakeholder involvement in the decision-making process. What means acceptability and with this respect, what is the decision-making process?

First, I would like to ask to Pascal Deboodt to give a few comments on the first issue.

Presentation by Pascal DEBOODT (SCK• CEN, MOL)

Pascal DEBOODT: This contribution has been prepared a few hours before the meeting. I would like to ask all participants to consider my presentation more as an “oral brainstorming”. Sometimes, ideas are directly related to the topics this meeting is dealing with. Sometimes, I have tried to enlarge the context of our discussions and also to pay more attention to the way we have to follow to really come in touch with the public, as far as the management of public exposures is concerned.

First to be sure that I really understand what has to be discussed today: we are people from the nuclear sector, and we want to go to the public. I think it’s the goal of today, and maybe of also last year, the first meeting. And you are starting from the nuclear sector, when we have the ALARA philosophy and we want to implement into the public. But what is the meaning of the ALARA principle?

The goal of today was to see if economic factor is the main factor, if it has to be considered or not. I definitely take the decision that it’s only one of the aspects, and I think it’s one of the reasons for the discussion of this morning. So I would like to discuss some questions related to the social aspects.

The ALARA implementation remains always a difficult task. Why? If it's easy in the nuclear sector to say «We will implement this philosophy with the procedure», I'm not sure that if we want to go to the public we will have really the opportunity to find people who can implement such a thing.

Second point, if you want to go to the public, and I think it's the purpose of today, we also have to be very careful about the information and the language that we will use. I'm sorry, but we are always speaking about 10^{-6}, 10^{-7}. What's the meaning of that for someone who is doing some shopping? We also have to look at the integration of all kinds of risks. For someone who belongs to the public, nuclear risk is a kind of risk. But depending on how to record for the mass media, you will provide more importance to this or to another. And so integration of all kinds of risks has also to be taken into account. It may be a very simple task, but workers belong also to the public. When they go home, they belong to the public, and so we have to be coherent. The priorities may rapidly change. So how can you be sure that all the modelisation that you are making now will still be true or valuable in the following months or year?

Some characteristics of the nuclear sector: Up to now the main risk in the nuclear sector is the nuclear one. But we don't have to forget that in case of release, there is a transfer of risk. So we transfer some nuclear risk to other risks. The responsibility of decision-makers in the nuclear sector seems to be very well defined. We also make use in the nuclear sector of optimisation, and there are a lot of theoretical developments to try to define the best monetary value of the man-sievert. I want now to concentrate myself on the releases. I think that we may note that the releases are controlled transfer. So, we already have a control at the beginning. Normally, we must have such a control. And then the releases must be optimized.

I am going now into the public and I have some questions. For the public what's the main risk? I am someone of the public, and what's for me the main risk at a given moment? I'm the local public, do I consider more the individual risk or the social risk, which also is very dependent on a lot of ideas? Who are the decision makers in this case? The answer is sometimes very simple, politicians, but I'm not sure that it's always the case.

Third point, we have now with the new regulations one millisievert for the public. It will be very difficult if you are dealing with training or information to the public to give an explanation. Why do we reduce this value from five to one millisievert for people of the public, reduction factor of five, and for the workers who are only working with 2.5?

Once again, it has to do with the information and the language that you have to use for the public. I think that we have to be very careful if we want to transfer our thinking directly into the public. If we want to go to the public, we have to find a very good language, and that's an example where we will have some problems.

And then three questions: Have we already optimized all the risk in the nuclear sector? We want to go to the public, but I'm still asking myself, have we already optimized all the risks in the nuclear? I'm not only speaking about nuclear risks. I know that the ALARA principle has to do with radiation protection, but don't we have to look at a short extension of generalisation of the ALARA principle?

Then we don't have to forget some aspects related to non-nuclear applications like mines, phosphates and medicine sectors. What's the ALARA philosophy in this context? And for the third question: Do we have to generalise the monetary value of the man-sievert, and how do we do that? The last presentation was one of the possible answers to this.

So, it's not a structured presentation, it's more the result of a brainstorming, some things are relevant, some others are absolutely not, but this was only to provoke some discussions. Thank you for your attention.

Thierry SCHNEIDER: Thank you, and especially to prepare this material quite urgently. Someone would like to react on this aspect, to start the discussion? So the idea is to see if we have some further elements concerning the use of economic tools, also the concept of individual versus collective dose, and if we want to come back on what we heard this morning, I think there is still some elements to be clarified.

Augustin JANSSENS: It's not easy to start discussion on what is a very, very complex matter, and the first bullet point is in fact embracing the whole issue somehow. What I haven't heard this morning, and which I think is a major distinction between ALARA for public exposure and for workers, is that, well, ALARA is in the context of optimisation, and optimisation is optimisation of protection. It is not justification of the practice. In the case of workers, you can optimise protection by changing the behaviour of the workers, shortening the exposure time, for instance, by making the interventions more efficient. In the case of public exposure, you can't. If the public is exposed, then you cannot influence the behaviour (except in the case of emergencies where you relocate people). You can also shield a source so that the exposure of workers is reduced. In the case of public exposure, you can't do all that. The only means of controlling public exposure is by reducing the effluents (leaving aside the exposure from transport). Reducing the effluents in essence reduces the exposures but not the radioactive source. You're just making a choice whether to dilute and disperse the source or to keep it on site. Inevitably, if you deal with ALARA for public exposure, you're trading between workers' exposure and public exposure, and between the exposure of current and future generations.

A lot of effort has been put into reducing the effluents, and in reducing public exposure as a result of that. My personal feeling is that what is at stake is not so much optimisation of protection, but rather the justification of the practice, to make sure that nuclear fuel reprocessing, nuclear electricity generation, is not endangered by public perception, endangered by the public feelings about the exposures. So that brings us into politics, one way or another. It's not just the politicians who deal with politics, but I think also the utilities who have their policy views on how to manage their industry in order to ensure that it has a future.

Jacques LOCHARD: I think it would be quite interesting to go along the line proposed by Augustin, and maybe to start on this strong statement that maybe ALARA is a political principle. Not political in the term of playing with politics, but it's a real political principle. It's how you make decisions in the city, how you make responsible decisions to live together with people, and ALARA is just a key word, and in the past it is clear there was some, maybe, illusion. I was one of these who were going around saying that we have the key for ALARA, cost-benefit analysis, and the economic theory, rationality. And then we were not that stupid not to say it's purely economic, and we tried to consider some perception elements.

And now I think it was a major progress to recognize that ALARA is just a political process where having elements of information, having tools like the monetary value of the man-sievert, individual dose, collective dose, whatever type of indicators or criteria, facing a complex system where you touch something, you change something else somewhere, all this transfer. The question is how those who have an interest there, who have a stake there, who are concerned with, how they can find a solution in the past. The process of making a decision about what we think was good, was done totally outside of any discussion. There was no transparency. It was not bad, it was just the way it was used. There were good scientists, good technicians, good experts, good politicians. They were making a decision, everyone was happy. Now it doesn't work any more. It works in many, many cases in our society, but for this problem of releases of installation, it seems that there are a lot of problems to use this old way of doing things.

Its difficult, because I think people who are involved are not confident about the process. So, I think the problem is a political issue, it is how to design a process by which the decisions will be made where the interest of all those who are concerned can be properly embarked. The utilities want to produce electricity, and then they want to do it efficiently, to make money with that, and for them, the economical dimension is a crucial one. You can spoil all business by putting stupid norms on the system, so your interest is clear. There is interest of the government, not to misuse of social resources, and so on. But you have also the concern of the people. Maybe we are at risk by living there, are we properly protected? So I think really the ALARA principle is for the public, it's also for the workers, but the scene is less complex, and the scene can be put more easily into some sort of negotiation process which is more easily handled.

For the public, it seems that in cases where you have lost confidence you need to develop it as an institutional process. How to take people together, what type of element can be helpful in this process where at the end you will get out with a solution which is reasonable for all stakeholders, and will allow to proceed further with confidence. I think this is the challenge, and I think we are doing a real step forward if we recognize, maybe it's a little bit brutal, but to say that ALARA is a political principle somewhere. It's political in the sense of making decisions at the level of society. As long as we think by having a good monetary value of the man-sievert we will solve the problem, we will be in a trap.

Roger COATES: I think I'd like to start by just making the comment that the presentation that I put together this morning did not mention for one moment, really, issues of public perception and stakeholder involvement. The presentation was focused around what can economic theory bring to the decision process.

So I think I ought to say that certainly I believe, and BNFL believes, that the whole process of how you involve the stakeholders, the public, the different sectors of the public, is an important issue, and it is the aspect that makes public decision-making so much more complex than occupational exposure. I don't think, really, the same sort of processes actually align very closely at all. So the presentation I was giving this morning was from one side of the equation, and it was not meant to touch upon how we involve public, and to what extent you can do that, and to what extent it's appropriate to do that.

There are other decision conferences, there's a whole range of discussions that take place, a whole range of views on how to do that, but I didn't see that as the focus of this particular meeting, so I didn't address it this morning.

Mark DUTTON: I'd just like to very much agree with Roger. I think the concept of ALARA in public exposure is totally different from the concept of worker exposure. I was just reminded, going back ten years or so now, of the discussion that was going on the discharge authorisations for Sizewell B. And we were arguing that if you didn't use any of the plant and the liquid waste management plant at all, your dose to the critical group would be 16 µSv a year. It wasn't much above the 10 µSv a year that the IAEA suggested to be below regulatory concern. And however good or bad that argument was, the minister said, what do they do in Europe, since we've never had one of these reactors that anybody else build before, but this was the first, so what do they do in Europe? And I don't know whether they told him what the Germans were doing, but he was told that the French were discharging 200 GBq/year. And as far as I'm aware, the discharge authorisation for Sizewell has always been 200 GBq/year. And it was perfectly obvious then that the driving force was there was no way a Minister of Environment in the UK could justify to the public, regardless of the dose, discharging any more activities in the environment that was achieved on French plants. I think it's true to say that every decision associated with discharges to the environment has a very, very strong politically-driven impact on the conclusion, and very much more so than the technical impact that usually dominates the decisions on worker exposure.

Jacques LOCHARD: Just a reaction and a question on that point. I think what is interesting also is the way the decision has been taken and applied. Apparently, there was no public debate about it at that time. People accepted, and there was no discussion about it. So it works. The question we are facing is when you have to decide about a certain level, you come to a conclusion and nobody agrees about it. This is where the problem is really important. We have this debate, for example, today at La Hague plant. It's extremely difficult within the old classical process where, after a technical study, a group of experts says "this is the right way to do it", balancing the interests of the operator, taking into account international recommendations and the national regulation. It doesn't work now, because there is no more confidence, because releases from La Hague are something that goes beyond the problem of that plant. So how do you proceed there? How, for example, the monetary value of the man-sievert could be embarked into a process, and what type of process? Is it a conference of consensus with members of the public? I think this is where it is interesting, and of course there is no clear solution at the moment, but we see more where we should go.

Neale KELLY: For me ALARA has to be applied to safety and not just to protection. The ALARA principle is exemplary, and is difficult to disagree with. Its trouble, however, is in the application. One of the problems rests in the radiation protection community, who feel as though they own this principle. This principle has been around in UK legislation for a long time; it's not a just radiation protection principle, but rather a common sense principle. Personally I have no difficulty with decisions being made about Sellafield discharges, about OSPAR etc. Whatever emerges from that whole process is what I'd described as optimisation in the real world we live in, taking due account of the social, economic and political pressures that exist. I may not like the outcome, but it is the result of the ALARA process.

The issue of ALARA, apart from a very few special cases, is not, in my view, a matter for the radiation protection community alone. It is a dialogue between operator, regulators acting on behalf of society, and society itself if it wishes to participate directly. For me, the challenge is: "how can we find mechanisms to have these issues debated properly and efficiently?". The radiation protection community is not necessarily best placed to deal with social factors in decision making. We need to find efficient mechanisms whereby the different needs of industry, society in general represented by regulators etc., really can function, so that we spend society's resources in an efficient way. This problem is not owned by the radiation protection community, it's a much wider issue.

Bertrand MUNIER: Perhaps it is useful that there is a dose of dissenting in this assembly, so maybe I can dissent a little bit with what has been said lately. I would not present the ALARA principle as a political process. Not that I don't believe that it will be embedded within some political process at some point, clearly, but I would say the interest of the ALARA process is that, precisely, before decisions were made, as you said, by people in charge of running the plants, the nuclear system etc., without asking anybody how they felt about these decisions. Now the ALARA principle introduces precisely one way to limit that power of the people politically in charge. And I include under politically in charge you. Why? Because, for instance the evaluation of a monetary value of man-Sv is of course theoretical development, clearly, but all this we can go and we can measure in several ways, and we can get figures, and we can tell people in charge, well, at this point, if you want to do that, OK, but then look. In fact, according to the public, you are losing more than what you're bringing. So, ALARA should be looked at as a way to limit the arbitrariness of decision makers.

Now, to answer some of the earlier questions. For instance, do we include some social aspects or not? Well normally, if the measurement is done correctly, cost-benefit analysis includes all the people express, the willingness to pay for all what they refer to as link to the consequences of the process they are asking about. Now you can tell me, "but they don't know". All right, and this is one of the reasons why the politicians in charge still have something to say, can correct these measures, but then they have to explain why they did to correct them, why did you include something more or something less? Because the public doesn't know this and doesn't know that, and they have to justify them.

Joe McHUGH: I find myself agreeing with elements of what everyone's said, actually. I'd like to emphasise that we need to be careful with the terms we're using. Some people, I think, are advocating a very wide idea of optimisation and ALARA, that it's the whole process, and I wonder if that's wise. As radiation protection professional, I wonder if we don't need to desegregate the process of decision making into the issues that we think are relevant to justifications, and those that are concerned with optimisation. Then, from a radiation protection perspective, say this is the view that radiation protection professionals would come to. But then we put that to the real decision makers who are, as someone's already pointed out, usually government ministers. That's more transparent, it seems to me. It seems that if we were to break up the process of decision making and say, well, this is what optimisation in the radiation protection sense would tell you is right, but we recognize there are lots of other factors. I don't know if that goes down well with all of you. I think we're in danger of getting confused between the narrow and the wider views of what we mean by optimisation.

Neale KELLY: I like breaking up, and I share your view that it is good to break up a problem, break it into its parts and put them back together again, but I'm afraid in the radiation protection community we are faced with these words: "this level is reasonably achievable taking into account social and economic factors". To practice radiation protection for me means you must take social factors into account, and all I'm going to say is that the radiation protection community is not necessarily best placed to do that. The radiation protection community is no better placed than other professional and interest groups to exercise social judgements.

Roger COATES: I'm quite happy to accept the conventional definition of economic and social factors. The angle that I've been coming from, specifically in the context of this seminar, is if we concentrate on the economic factors, all I've heard for the last twenty years in the economic factors is collective goals, cost-benefit analysis. And the key points that I was trying to draw out in the presentation I made this morning is that's one of the factors, but can economic theory tell us anything, can it make any other contributions. Yes we've got social judgements that have got to come in, yes we've got stakeholder involvement that's got to come in, but if we just concentrate on that first part of the ALARA equation, economics taken into account, can economics add anything other than collective dose, cost-benefit analysis? Can it add any contribution to the amount of money to pay for individual levels of risk? Can it add any contribution on opportunity costs of spending money on hospital beds or reducing becquerels discharge? For twenty years we've had collective dose, cost-benefit analysis as the only contribution coming out of economists, and I'm just asking, is there a wider contribution?

Thierry SCHNEIDER: I suggest now to move to the question of trade-off between discharge and waste, and I will ask Mark Dutton to discuss that issue.

Presentation by M. Mark DUTTON (NNC)

Mark DUTTON: This is very old now, but if you take the main streams that go into the liquid waste management system of a PWR, then, the two tools you have to reduce efficient are demineralisers and evaporators (see Table 1). The first option was we won't use either, because there's no justification for using either. And if you can't get away with that, or even if you try to get away with that, you can start saying what are the consequences of applying evaporators or demineralisers or both to each of your main waste streams, and then start looking at what it means in terms of waste, what it means in terms of operator dose, and what it means in terms of cost. And also, of course, what it means in terms of discharges.

Table 1. Best Estimate Discharge from Sizewell 'B' for Six Treatment Options (Bq/y)

Waste stream	No purification below the discharge limits	Demineralise equipment drains	Demineralise floor and equipment drains	Evaporate equipment drains	Evaporate floor and equipment drains	Evaporate floor drains and demineralise equipment drains
Boron recycle system	1.0E08	1.0E08	1.0E08	1.08E08	1.0E08	1.0E08
Equipment drains	1.2E11	5.9E10	5.9E10	1.6E08	1.6E08	5.9E10
Floor drains	3.9E10	1.3E11	1.7E10	1.3E11	5.5E07	5.5E07
Chemical drains	6.0E07	6.0E07	6.0E07	6.0E07	6.0E07	6.0E07
Laundry and hot shower wastes	1.0E10	1.0E10	1.0E10	1.0E10	1.0E10	1.0E10
Secondary wastes	3.0E09	3.0E09	3.0E09	3.0E09	3.0E09	3.0E09
Sub-total	1.7E11	2.0E11	8.9E10	1.4E11	1.3E10	7.2E10
C-14	2.4E10	3.0E10	3.0E10	7.2E09	-	2.2E10
Total	1.9E11	2.3E11	1.2E11	1.4E11	1.3E10	9.4E10
H-3	2.1E13	2.1E13	2.1E13	2.1E13	2.1E13	2.1E13

If you just think for a minute about waste, there are some wastes that "it's the nature of the beast", you can't do anything about. So that for CVCS residents, for example, if you've got a PWR you will have CVCS resin waste, and how much of it is another matter. That depends on how many demineralisers you put in the system, but you will have that form of waste whatever you will do. But when it comes to the liquid waste management system at the end of the process, before you discharge, whether you have primary resin from demineralisers will depend on whether you use them or not, and whether you have concentrates from evaporators will depend on whether you use them or not.

Without taking these figures too literally, on Table 2 you can see figures of a few cubic meters if you use a demineraliser in your liquid waste management system, and you can see an order of magnitude more if you use an evaporator in your waste management system. And evaporators for most, nearly all radionuclides is a much more efficient way of removing them then demineralisers, with some major exceptions. So there are some real questions to be asked and to be answered.

Table 2. Estimated Annual Arising of Solid Waste

Waste stream	Sizewell 'B'	N4	Konvoi	Mitsubishi Westinghouse APWR	System 30+	AP600	BWR
CVCS resins	3 m^3	8 m^3	3 m^3	3 m^3	3 m^3	3 m^3	3 m^3
Non-CVCS primary resins (BRS + FSPCUS)	6 m^3	4 m^3	2 m^3	6 m^3	2 m^3	1.5 m^3	7 m^3
LWMS primary resin	1 m^3	2 m^3	-	1 m^3	1 m^3	4.2 m^3	(Note 1)
Primary filters	15	30	15	15	15	0.1 m^3 (Note 2)	0.1 m^3 (Note 2)
Evaporator concentrates (if used)	15 m^3	15 m^3	15 m^3	15 m^3	-	-	40 m^3
Centrifuge residues (if used)	-	-	2 m^3	-	-	-	
Miscellaneous contaminated items	5 m^3	5 m^3	5 m^3	5 m^3	5 m^3	5 m^3	5 m^3
Secondary resins	5 m^3	5 m^3	5 m^3	5 m^3	30 m^3	21 m^3	(Note 3)
Dry low active wastes including air filters after compaction	70 m^3	70 m^3	70 m^3	70 m^3	70 m^3	70 m^3	70 m^3
Secondary filters	25	50	25	25	25	25	0 m^3
Miscellaneous activated components	2 m^3	2 m^3	2 m^3	2 m^3	2 m^3	2 m^3	2 m^3

Notes: 1. Resin fines produced on regeneration included in non-CVCS primary resins
2. Filters back-flushed
3. Included in non-CVCS primary resins

On Table 3, two waste streams are considered, the equipment drains, which is radioactive but otherwise clean water, and the floor drains which clearly could have a high particulate content, and if it's too high it might not be suitable for putting through one of these alternatives. But if we ignore that just for the moment, the first column presents an estimate of the benefits and the value is of the order of 100 pounds. The value of the operator dose, associated with these alternatives is usually greater than the dose saved for the public except two cases where the operator dose is actually less than the public dose. But one of the things of interest is, what's the cost associated with additional waste. Now, in a country like the UK, if the waste is low-level waste, we know where it can go, and we know what costs are associated with this. With intermediate level waste, it's a very big issue, I've absolutely no idea what the costs are. I think the basis of these costs was that they went to Drig, which is the low-level waste repository. If you are going to sort of think about the cost to the utility, it's not the dose issue that's important to them, even if they were going to take that into account, it's actually the cost of the waste of which they have to dispose. This study was done a little bit of time ago, so I'm sure these numbers are greatly out of date. So it's the waste issue that indicates that with the exception of using a demineraliser, the use of an evaporator is getting a very expensive means of removing the waste, relative to the value you get.

Table 3. Estimates of the Benefits, Detriments and Costs of Additional Processing of the Most Active Liquid Streams for Sizewell 'B'

Processed waste stream	Process option	Benefit		Detriment				Cost-benefit ratio
		Collective dose saved (person-mSv/y)	Value (£/y)	Operator dose (person-mSv/y)	Value (£/y)	Cost of additional treatment (£/y)	Total value of detriment (£/y)	
Equipment drains	Demineraliser	3	60	0.5	25	12,300	12,325	205
Equipment drains	Evaporator	4	80	4	200	95,000	95,200	1190
Equipment and floor drains	Demineraliser	4	80	1	50	24,600	24,650	30 ?
Equipment and floor drains	Evaporator	5	100	10	500	190,000	190,500	1905
Equipment and floor drains	Demineraliser for equipment drains, evaporator for floor drains	5	100	7	350		107,650	1080

In terms of dose, Figure 1 presents a number of options that were looked at for the same radwaste plant. Here, ALARA is interpreted as the balance between the value of the benefits and the cost of implementing the measure. It's a straightforward balance, cost-benefit ratio. You can see there's only one case where the public dose saved is greater than the worker dose that is received. And in every case where an evaporator is involved, the worker dose is much greater than the public dose that's saved.

Figure 1. Liquid Waste Treatment Options - Assessment of the Net Benefits - Detriments

Of course a lot of this depends on the assumptions you make about evaporator breakdown and the doses associated with evaporator maintenance. But the issues are quite clear. A lot of this was done before, based on what I call "safety case information" before the plant operated, so you then ask yourself, "it's been going for a while now, what actually happened in practice?" How did the utility and the regulator? First of all, what decision did they reach, and how did they reach that decision? And because those are what I call "safety case figures", the actual activity on the plant, as you might expect, was less than the assumptions that were in those initial studies. So you were dealing with less activity in the first place. The other thing is, again because they're safety case studies, they use fairly conservative values for the benefit to be gained from the equipment. So they're rather conservative in terms of the decontamination factors you would achieve. And in practice, if you have a demineraliser, you get a much bigger decontamination factor if there's a lot of activity to remove, and a relatively small one, like one, if you have next to nothing to remove. The eventual outcome was very pragmatic. They agreed to sample waste streams regularly. If the activity content was greater than an agreed value, the demineraliser would be used, if it was less than that agreed value and the benefit was therefore pretty small, the demineraliser would not be used, and the evaporator was not used at all. A lot of other techniques were looked at, and it was argued that their technical state, their cost, did not justify them being used in the context of what's known as the best practicable means.

Now the question that interests me today is: can that still be the story with the OSPAR Convention? And it's a real question for UK utilities, it's also a real question I guess for BNFL. The department called Environment, Trade and the Regions, has written to the operators and said, in the light of this convention, what are you going to do because long before 2005 there's a firm commitment that each signatory will say what it's going to do. But long before 2005, the government has to come back to the members of the convention and indicate the approach.

So you ask yourself the question, what are we going to do? The first position that any utility will do is what was presented by EDF this morning to optimise the use of existing plant. But what we're doing already is enough to meet the OSPAR Convention. We can get away with doing nothing. I think the reprocessing plants might have a little bit more difficulty in sustaining that argument, but it's clearly a position that can be taken. But it would have to be justified, of course. Now, in the case that I described for Sizewell, you have plant at the station which works perfectly well, for which there's been a very good reason for not using it up to now. So, the second option, if you have to do something, is instead of optimising the use of existing plant to maximize the use of existing plant. In other words, apart from the fact it'd have virtually no effect whatsoever, it'd just be a sheer waste of time, is to use it flat out. And regardless of the cost and regardless of the operator dose… As I say, just use it continuously, and you get what you get. And that's that sort of approach too. And of course, it raises the question, what's wrong with the approach presented by A. BRISSAUD, why can't EDF sit there and say, what we achieve, we do enough, why should we do any more?

So there has to be, first of all, some sort of basis for deciding where you draw the line. You can go further on, because it gets very expensive if you start building extra buildings. We're having enough trouble with the economics of nuclear power at the moment, without increasing the costs. But if you think about what's practical, the next stage is to use what I've called here "skid-mounted plant". You can buy transportable plant which you can take to plants that have got liquid radioactive wastes, and you can pass them through extra demineralisers and evaporators. You can remove the activity and take your plant away, and you haven't actually had to invest in the capital cost of extra buildings and extra permanent plant. And plant like that has been used in several places in Europe and has been taken for example, to clear up the stuff that's come off the Russian sub marines. So, there's no doubt that it's practical. There'll be a very real and severe cost of that. But it's an option.

So far, of course, here we're talking about proven technology, absolutely no question as to whether the technology works. But we've done absolutely nothing about some of the element of the optimisation study presented by EDF. We've done nothing about Tritium, which in terms of becquerels is by far the greatest number of things that's thrown into the sea, albeit it has a negligible effect on the population. We've done nothing about Argon 41 and a whole host of other things that we've done nothing about.

Now the plant that we've actually got in our operating power stations, much more so than reprocessing plant, is basically the technology of the 'sixties and the 'fifties, I mean in terms of concepts. They're much more efficient than they were, but in terms of what they actually do, it's exactly the same sort of plant, and there is a question, "has there been development in the technology since those days which here and now we can't put our hands on our hearts and say, it couldn't actually make things better". I mean, you don't have to do much of a literature review, and you find there is plant which can remove tritium. Now, whether you're sensible to apply it to 40,000 or 80,000 cubic meters per year, that's another issue, but there is plant that pulls tritium out of water, and we've installed it at ISPRA. And you can say the same thing about all the other nuclides. So it's not self-evident that there isn't plant around which in the light of the present political situation we could justify not even looking at.

So I'll just end by saying that there are some real questions to be asked, I don't think we can be complacent. I think that there's very good grounds for having a hard look at the technology that's available, the state of that technology in terms of does it require more R and D to be implemented, or whether it's virtually proven, and its costs, of course, because there's no way that you can have infinite costs associated with any industry. The last thing we want is to get into a position where we shut our industry down. A very important part of the costs is the associated solid waste, because once you start, in real terms, pulling activity out of gases or liquids, you will end up with solid waste and you will have to pay for its disposal. So there are also very big questions about if you were forced to use a given technology, what solid radioactive waste will be produced, and what technology is available for minimising it. And particularly in Scandinavia, Finland and Sweden, there's a lot of work going on at the moment in terms of minimising the volumes of solid waste. So, I think there are some real issues, and I'll end with a plug that it will be very good to face them together.

Thierry SCHNEIDER: Thank you, Mark, I think that your presentation clearly points out some of the main issues for the practical implementation of ALARA for public exposure and it's really some work for the future which has been pointed out.

I think it's now time to close this seminar and I would like to thank all of you for your fruitful contributions to the issue of the management of public exposure associated with the releases of nuclear installations.

APPENDIX

LIST OF PARTICIPANTS

Decision Makers Seminar - ENS Cachan - 28 May 1999

List of participants

M. Alain BRISSAUD
EDF/SEPTEN
Responsable Radioprotection
12-14 avenue Dutriévoz
F-69628 VILLEURBANNE CEDEX
FRANCE
Tel : +33 4 72 82 71 75
Fax : +33 4 72 82 77 02
E-mail : alain.brissaud@edf.fr

M. Roger COATES
BRITISH NUCLEAR FUELS plc
SELLAFIELD
SEASCALE
CUMBRIA CA20 1PG
UNITED KINGDOM
Tel : +44 19467 74250
Fax : +44 19467 74552
E-mail : roger.coates@bnfl.com

M. Pascal DEBOODT
Radiation Protection Department
SCK.CEN
Boeretang 200
B-2400 MOL
BELGIUM
Tel : +32 14 33 2853
Fax: +32 14 32 1624
E-mail: pdeboodt@sckcen.be

M. Jean-Michel DELIGNE
DSIN/FAR
Route du Panorama
BP 83
92266 FONTENAY-AUX-ROSES CEDEX
FRANCE
Tel : +33 1 43 19 71 76
Fax : +33 1 43 19 71 30
E-mail: jean-michel.DELIGNE@industrie.gouv.fr

M. Mark DUTTON
NNC LTD
Booths Hall
Chelford Road
KNUSFORD
CHESHIRE WA 16 8 QZ
UNITED KINGDOM
Tel : +44 1 565 843 827
Fax : +44 1 565 843 727
E-mail : mark.dutton@nnc.co.uk

M. Wolfgang GOLDAMMER
BRENK Systemplanung
Heider-Hof-Weg 23
D-52080 AACHEN
GERMANY
Tel : +49 221 947 3047
Fax : +49 221 947 3049
E-mail : w.goldammer@t-online.de

M. Philippe HUBERT
IPSN/SEGR
Centre d'Etudes Nucléaires
BP n° 6
F-92265 FONTENAY-AUX-ROSES CEDEX
FRANCE
Tel : +33 1 46 54 79 11
Fax : +33 1 46 54 88 29
E-mail : philippe.hubert@ipsn.fr

M. Augustin JANSSENS
EC/DG XI C-1
Wagner Building C-353
Rue Alcide de Gasperi
L-2920 LUXEMBOURG
LUXEMBOURG
Tel : +352 4301 36395
Fax : +352 4301 36280
E-mail : augustin.janssens@cec.eu.int

M. Neale KELLY
EC/DG XII-F-6-Bureau MO75 4/18
Rue de la Loi, 200
B-1049 BRUXELLES
BELGIUM
Tel : +32 2 295 64 84
Fax : +32 2 296 62 56
E-mail : george-neale.kelly@ cec.eu.int

M. Florentin LANGE
GRS
Schwertnergasse 1
D-50667 KÔLN
GERMANY
Tel : +49 221 2068 788
Fax : +49 221 2068 888
E-mail : lag@grs.de

M. Christian LEFAURE
CEPN
Route du Panorama - BP 48
F-92263 FONTENAY-AUX-ROSES CEDEX
FRANCE
Tel : +33 (0)1 46 54 79 08
Fax : +33 (0) 1 40 84 90 34
E.mail : lefaure@cepn.asso.fr

M. Jacques LOCHARD
CEPN
Route du Panorama - BP 48
F-92263 FONTENAY-AUX-ROSES CEDEX
FRANCE
Tel : +33 (0)1 46 54 86 65
Fax : +33 (0) 1 40 84 90 34
E.mail : lochard@cepn.asso.fr

M. Joe McHUGH
Environment Agency
Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol BS32 4UD
UNITED KINGDOM
Tel. : +44 1454 624097
Fax : +44 1454 624319
E-mail: joe.mchugh@environment-agency.gov.uk

M. Daniel MENEZ
SGN
1, rue des Hérons
F-78182 ST QUENTIN EN YVELINES
CEDEX
FRANCE
Tel : + 33 (0)1 39 48 77 96
Fax : +33 (0)1 39 48 75 17

M. Bertrand MUNIER
Ecole Normale Supérieure Cachan
Département d'Economie et de Gestion
GRID
61, Av. du Président Wilson
F-94235 CACHAN CEDEX
FRANCE
Tél : +33 (0) 1 47 40 55 97
Fax : +33 (0) 1 47 40 23 48
E-Mail: munier@grid.ens-cachan.fr

Ms Christine SAUER
EC/DG XI C-1
Wagner Building C-353
Rue Alcide de Gasperi
L-2920 LUXEMBOURG
LUXEMBOURG
Tel : +352 4301 36356
Fax : +352 4301 36280
E-mail : christine.sauer@ cec.eu.int

Ms Caroline SCHIEBER
CEPN
Route du Panorama
BP 48
F-92263 FONTENAY-AUX-ROSES CEDEX
FRANCE
Tel : +33 (0)1 46 54 87 78
Fax : +33 (0)1 40 84 90 34
E-mail : schieber@cepn.asso.fr

M. Thierry SCHNEIDER
CEPN
Route du Panorama
BP 48
F-92263 FONTENAY-AUX-ROSES CEDEX
FRANCE
Tel : +33 (0)1 46 54 76 59
Fax : +33 (0) 1 40 84 90 34
E.mail : schneider@cepn.asso.fr

Ms Jane SIMMONDS
NRPB
CHILTON
DIDCOT, OXON 11ORQ
UNITED KINGDOM
Tel : +44 1235 831 600
Fax : +44 1 235833 891
E-mail : jane.simmonds@nrpb.org.uk