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RWMC Regulators' Forum (RWMC-RF)

REGULATORY RESEARCH FOR WASTE DISPOSAL – OBJECTIVES AND INTERNATIONAL APPROACHES

The present report outlines the potential merits of R&D work carried out by the regulator. It summarizes the results of a questionnaire that was circulated among the members of the Regulators' Forum of NEA's Radioactive Waste Management Committee in 2009, and it presents the conclusions of discussions within the RWMC-RF. The detailed answers to the questionnaire are also provided.

The only change in this version of the document is to update an oversight in the title.

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FOREWORD

The Regulators' Forum (RF) of the NEA Radioactive Waste Management Committee (RWMC) is a well-established forum of high-level regulators for radioactive waste management and decommissioning of nuclear facilities. The RF was created in 1998 and current representation brings together regulatory bodies from 17 OECD countries. The forum provides its members with an opportunity for open discussion and learning about national experience and good practice in regulation with a view to refinement of regulatory systems in this field. Effective interaction is promoted among regulators, implementers, R&D specialists, policy makers, and social scientists at workshops and in the context of other RWMC activities.

Since its inception, the RF has been examining the nature of the regulatory system and how the regulatory function is fulfilled as regards radioactive waste management. The RF has particular interest in safety criteria, in the regulatory of waste retrievability, optimisation and long term monitoring of geological repositories as well as emerging regulatory practices in the field of decommissioning.

The question of active involvement of nuclear regulatory and supervisory bodies in research and development (R&D) projects has become a topic of interest in recent years and it was the subject of a specific session at the Tokyo Workshop organised by the RF, 20-22 January 2009. There was consensus at the workshop that competence and independence are key requirements for any regulator, and that regulatory research helps in many ways to fulfil these requirements. Limited resources and the need not to overstep its role, however, oblige the regulator to focus on key questions and key safety issues. The regulator's duty is to identify areas where uncertainty should be reduced but, ultimately, the reduction of uncertainties is the responsibility of the implementer. It was also observed that it is difficult for the regulator to keep up with the variety of research in safety assessment, and that closer international cooperation may help.

The subject of R&D for the regulator was also debated during a topical session of the annual RF meeting in 2009 based also on a questionnaire. The present report outlines the potential merits of R&D work carried out by the regulator; it summarizes the results of a questionnaire that was circulated among the members of the Regulators' Forum of NEA's Radioactive Waste Management Committee in 2009; and it presents the conclusions of the RF. The detailed answers to the questionnaire are also provided.

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INTRODUCTION

The question of active involvement of nuclear regulatory and supervisory bodies in research and development (R&D) projects has become a topic of increasing interest in recent years. The way in which research is included in regulatory activities varies from country to country. The range spans from countries with no regulatory R&D activities to countries with extensive activities which are often carried out by independent research organisations acting on behalf of the regulatory body. In few countries the regulator and implementer have their research carried out by the same research institutes.

The present report outlines, in Part I, the potential merits of R&D work carried out by the regulator and, in Part II, it summarizes the results of a questionnaire that was circulated among the members of the Regulators' Forum of NEA's Radioactive Waste Management Committee in 2009. Part III presents the conclusions of the study. The detailed answers to the questionnaire are reported in the Appendix.

PART I: OBJECTIVES AND MERITS OF REGULATORY R&D

It is the duty and responsibility of the implementer to design, construct, operate and close a repository for radioactive waste in such a way that safety is ensured during all pre- and post-closure phases. This includes the obligation to carry out the necessary R&D work which provides the scientific and technical basis for this purpose. The scope of work must be comprehensive in order to achieve the envisaged goal, and there should be no need for the regulatory body to undertake a full parallel R&D programme. Nevertheless, R&D work is essential for the regulator's scientific and technical ability, because it maintains or improves the regulator's *competence*, it contributes to the regulator's *independence* and it helps to achieve *public confidence* in the regulatory system. Past experience, including the reactor area, shows that the safety research sponsored by the regulatory and supervisory bodies has contributed to improved safety.

More specifically, the following observations can be made:

- *Competence*: The stipulation of meaningful and practical standards and requirements for safe geological disposal of radioactive waste requires a high level of expertise and experience. The critical review of the safety case, which is usually the responsibility of the regulator or the supervisory body, requires the know-how and expertise of peers, i.e., of specialists having a similar level of expertise to the implementers. Both the standards and the safety case will undergo changes over the time that is associated with repository development. Research helps to acquire and maintain the necessary in-house competence, including access to the scientific community.

Another issue the regulator needs to consider is the qualification of its workforce. In order to recruit talented scientists it is important for the regulator to offer attractive jobs and working conditions. Most young scientists will find it attractive to work for an employer who undertakes demanding research projects in which they can be involved actively.

- *Independence*: The regulator sets the standards and requirements for safe geological disposal, and reviews the safety case. The regulator's review needs to be distinct and separate from the implementer's development of the safety case. Therefore, it is important that the regulator is entirely and truly independent of the implementer – this, in fact, is the key to credibility. In many ways, regulatory sponsored research helps to identify the issues most importance to safety, to improve the quality of regulation by providing in-depth understanding of safety cases, to identify problems before they become significant safety or regulatory concerns as well as for more timely regulatory decisions.
- *Confidence*: Public confidence is of key importance when complex issues are at stake. The public wants and needs a competent and independent regulator. To the extent that research helps to acquire and maintain competence and independence, it also contributes to the stakeholders'

confidence in the regulator. Maintaining public confidence requires, in addition, regular interactions of the regulator with all stakeholders, including appearances in public.

Additional observations

In principle, the research conducted by the implementer/waste producers has to cover all the scientific aspects needed to demonstrate the safety of the repository. The implementer, like the regulator, may also use results from external research conducted by academic or other research institutes. The R&D programme conducted by the regulatory body should aim not at “filling gaps in science” but at investigating some specific issues where alternative methods/analyses are required to inform regulatory decision. Additionally, there may be a case for the regulator to initiate research in new areas that may have been overlooked by the implementer in order to check and show their potential importance. The implementer should then take over the initiative. There are, however, differing views amongst regulators on whether or not it is the duty of the regulator to carry out such complementary work.

Another issue is the source of the budget from which research for regulatory purposes should be funded. Frequent sources of funding are the waste producers and the national budgets. National budgets are usually more restricted and less flexible than funds from the waste producers.

PART II: RESULTS OF THE QUESTIONNAIRE ON REGULATORY R&D

Definition

How is regulatory R&D defined in your country?

There are differences in the definition of regulatory R&D in the countries taking part in the survey. This is partly due to different legal provisions, and partly due to differences in the extent of regulatory R&D. For example, legal provisions exist in Finland (Nuclear Energy Act, Section 55 and 53b), Japan (NISA/METI) and UK (Environment Act 1995). In France, the regulatory research conducted by IRSN is financed on its own, independent budget; the ASN participates in the main orientations of the R&D programs conducted by IRSN as member of the Committee for orientation of the research programmes of IRSN. In Switzerland, ENSI has issued a strategy paper on "Regulatory Safety Research". In Hungary, regulatory R&D is defined as a basic technical activity (BTA) for the control of the safe use of nuclear power. In Germany, the focus of research lies on special issues of interest to the regulator, e.g. safety criteria for the development and review of regulations, further developments of disposal strategies, and the preservation of the technical competence of the TSOs regarding the development of methods and safety assessments.

How can regulatory R&D be distinguished from R&D by the implementer?

The difference between regulatory R&D and an implementer's R&D often lies in the way the programmes are financed (e.g. public funding vs. funding by the implementer) as well as in the focus of regulatory R&D, which has usually a specific orientation towards safety issues and informing regulatory decisions.

Budget

Is there a distinguishable annual budget for regulatory R&D in your country, and what is its amount?

The budgets set aside for regulatory research differ strongly between countries and depend on the extent of the research activities. For example, in Finland the framework budget is roughly specified by law. In Hungary, a differentiation is made between R&D and basic technical activities (BTA).

Do you think this budget is sufficient? If not, why not and what would be an appropriate R&D budget?

The budgets available are generally seen to be sufficient for the ongoing R&D programmes. In Switzerland, however, a budget extension, especially for RWM, is considered desirable. Such a budget extension is viewed possible as a stepwise process. In the USA, the current budget suffices for the review of the license application of Yucca Mountain. In the UK, an increase in budget is likely to be required as the implementer's programme for developing a geological disposal facility progresses.

Topics

What are the current topics covered by regulatory R&D in your country?

The research topics include the development or updating of regulations, the scientific derivation of criteria and indicators for long-term safety, and the investigations of specific questions on repository systems (Finland, France, Japan, USA). Further topic areas concern operational safety, waste behaviour, transport mechanisms of radionuclides, the classification of scenarios with regard to their probability of occurrence, and closure techniques. It is worth noticing that in Hungary, the lifetime extension of the Paks NPP as well as issues relating to new nuclear power plants are included in the regulator's R&D programme.

What topics are planned for the future?

Finland has established a rather detailed programme on future research issues focussing on the disposal of spent fuel. Specific tasks have also been formulated in Switzerland and the USA.. In Japan, the recommendations of the "Specified Radioactive Waste Final Disposal Act" apply.

Justification

What is the reason for covering the mentioned topics by the regulator, and not by the implementer?

The reasons why the topic areas mentioned under 3. are dealt with as part of regulatory R&D are closely linked to the answer to the question of „How can regulatory R&D be distinguished from R&D by the implementer?“ (see 1. b). These are mainly topical areas that are of essential interest to the work of the regulator and that are not already covered by other research activities (e.g. fundamental research that is not part of any particular projects). Regulatory R&D helps the regulator to strengthen its expertise and to maintain a high level of technical and scientific know-how. This effect is important and should not be underestimated.

Organization

What organizations are performing regulatory R&D in your country?

In some countries, the regulator has access to a dedicated research institution (e.g., France: IRSN) to carry out regulatory research. In other countries, external institutions such as TSOs, research centres and universities carry out such R&D work on behalf of the regulator. However, the organisations performing regulatory R&D are often state bodies (BfS in Germany) or TSOs and research centres (GRS, IRSN, JNES, KYT, etc.) supporting regulatory bodies and working in the different fields on behalf of the respective ministries. For example, in the USA the "Center for Nuclear Waste Regulatory Analyses" supports the NRC. In Finland, Hungary and Switzerland, work on behalf of regulators is also carried out by universities.

Who guides them, and how close is the supervision (if any)?

The organisations are guided by the regulator himself (e.g. Switzerland, Germany, UK) or by committees in which the regulator is directly represented (e. g. the Committee for orientation of the research conducted by IRSN in France) or indirectly represented (e.g. Finland, Japan). The commissioned organisation usually informs the regulator about the progress made at regular meetings or by means of quarterly or annual reports or in interim and final reports.

Outcomes for regulation

What are the achievements of regulatory R&D so far for regulatory purposes in your country?

The research results contribute generally to the development or updating of the nuclear regulations and in this respect especially to the quality of the scientific basis. However, special results of regulatory R&D, e.g. relating to issues surrounding the disposal of HLW or spent fuel, or special topics in connection with the operation of repositories, also contribute to the general development of the state of the art in science and technology.

What was it able to solve?

In general, the results of regulatory R&D contribute to the enhancement of the regulator's technical competence and thereby to maintaining his independence in dealing with the applicant. There are specific results as well, such the validation of rock mechanical models at the Mont Terri rock laboratory (Switzerland).

PART III: CONCLUSIONS

The way in which research is included in regulatory activities varies from country to country. The range spans from countries with no regulatory R&D activities to countries with extensive activities which are often carried out by independent research organisations acting on behalf of the regulatory body. In few countries the regulator and implementer have their research carried out by the same research institutes.

The question of how much regulatory research is needed is difficult to answer on a general basis. The extent of the work that a regulator needs to undertake on verification of safety issues and the investigation of issues not addressed by the implementer may be considered as discretionary.

It appears obvious that the regulator must achieve, also through research activities, the objectives of competence and independence and public confidence over the time during which a repository will be built, operated and closed. The research needed for this purpose is the least the regulator must undertake. A programme and budget are needed to maintain an adequate research infrastructure including staff, facilities and analytical tools.

APPENDIX

Questionnaire Answers (as of 30 October 2010)

Responses received: Finland, France, Germany, Hungary, Japan, Switzerland, Sweden, UK, USA.

1a. Definition:

How is regulatory **R&D** defined in your country?

In **Finland** section 55 of the Nuclear Energy Act for the Radiation and Nuclear Safety Authority's (STUK) provides regulatory support R&D: *In order to carry out its regulatory tasks, the STUK shall in particular...carry out research and development necessary for supervision and participate in international co-operation in the waste management field.*

Section 53b of the Nuclear Energy Act provides for the obligation of the licensee generating nuclear waste to finance R&D needed for maintenance of adequate national competence in the waste management field:

A licensee with waste management obligation is obliged to participate in financing research aimed at ensuring that the authorities have such sufficient and comprehensive nuclear engineering expertise and other facilities at their disposal that are needed for comparisons of the various ways and methods of carrying out nuclear waste management.

The regulatory support R&D activities aim at

- deepening the regulatory reviews (external review teams)
- follow-up of the site investigations
- development of regulator's independent assessment capabilities
- resolving key safety issues
- fostering build-up of new expertise.

In **France** the program law on waste management (2006-739 of 28th June) defines the main objectives for research and development programs. Concerning high level waste, it outlines the necessity to develop studies and research for the three main following topics :

- separation/transmutation. These studies must be conducted in relation with those on new reactors (Gen IV). The objective is to be able to define an industrial path for these technologies by 2012 and implement a prototype in 2020
- reversible disposal in the view of starting the licensing procedure for a facility en 2015
- storage so that facilities should be available both to respond to quantitative and qualitative needs.

The law also outlines the need to develop studies and research on other type of waste: long-lived low level waste, mining waste, waste containing tritium, sealed sources, ...

All those research programs and studies are followed up in the framework of the national plan for management of radioactive materials and waste (PNGMDR) with is elaborated every three years. The PNGMDR is followed by a decree that prescribes the research and studies that should be conducted by the actors (ANDRA, CEA, AREVA, ...) on the different waste.

The PNGMDR takes into account the work of a specific committee, the COSRAC, which has been created

especially on the subject of research in the field of radioactive waste.

The CNE, which is the national commission for evaluation of the research programs on radioactive waste management, evaluates the researches conducted within the framework of the program law on sustainable waste management. Its report is transmitted to the Parliament and defines, based on the evaluation of the results of the research programs, some recommendations for further programs to be conducted or new axis of researches to be investigated. The CNE is consultative and can't directly ask the interested parties for conducting specific additional regulatory or private research.

More specifically, the regulatory research aims at providing some technical expertise to IRSN which is the technical support of the French nuclear safety authority (ASN). Based upon this expertise, ASN can make decisions regarding the licensing of new facilities or the approval of new waste packages for example. The research carried on by IRSN is therefore based upon the actual and future needs identified regarding the law, the development of new facilities or new waste management programs developed by the implementers.

The ASN does not conduct any research activities by itself, but has been asked by the government in November 2007 to take position on the objectives of the public research programs conducted in the field of radiological protection and nuclear safety (and thus on radioactive waste management).

Moreover, the research programs conducted by the implementer (ANDRA) regarding geological disposal (for example R&D programs conducted in the Bure laboratory) have been assessed prior their implementation by the Standing Group of Experts for waste disposals. ANDRA periodically gets the ASN and CNE informed of the progress of the programs and ASN conducts some inspections in the Bure Laboratory to ensure the programs are implemented in accordance with the initial case.

The research program is based on the following issues: studies and demonstration of the feasibility of a geological disposal in the Bure Laboratory, monitoring of the disposal, site investigations, long term waste behaviour and monitoring, modelling.

In **Germany** regulatory research is defined as research on regulatory specific topics such as R&D on safety criteria for development and improvement of regulations as well as further development on waste management strategies and to maintain competence of the TSO's in safety assessments and methodology.

Regulatory R&D in **Hungary** is defined as **basic technical activities (BTA)** that serve the regulatory control of the safe use of atomic energy.

“Regulatory R&D” is called “regulatory supporting research” in **Japan**, which is defined as such research that is implemented by the governmental budget, based on regulatory needs of the regulatory body, NISA (Nuclear and Industrial Safety Agency, part of Ministry of Economy, Trade and Industry (METI)) aiming at “Establishing safety criteria by Regulatory Agency” and “Maintaining and Developing the safety regulatory infrastructure”.

Switzerland: Regulatory R&D is defined in a recent strategy paper of ENSI as “regulatory safety research” supported by federal authorities in order to improve nuclear safety.

Strictly speaking, in the **USA**, NRC **does not** have a R&D program for Yucca Mountain. NRC performs confirmatory investigations and analyses, which focus on regulatory needs to assess uncertainties in public and worker health and safety issues, site characterization, and long-term safety.

UK: The Environment Agency in England and Wales has a duty under the Environment Act 1995 to undertake research related to its functions. It commissions or otherwise carries out research under a published research programme. The research programme includes work specifically in support of radioactive substances regulation including geological disposal of radioactive wastes.

In Scotland, the Scottish Environment Protection Agency (SEPA) also has a duty under the Environment Act 1995 to undertake research in support of its functions in radioactive substance regulation. Current Scottish Government radioactive waste management policy does not include an option for geological

disposal and SEPA does not undertake research into this option.

Also under the Environment Act 1995, the Environment Agency and SEPA can enter into voluntary agreements with organisations such as waste producers or implementer for geological disposal to provide **regulatory** advice on environmental matters and charge a fee for such advice. Voluntary agreements can include provision of funding for independent research and development studies to inform regulatory advice. The Environment Agency has this provision in its agreements with the Nuclear Decommissioning Authority (NDA) for **regulatory** scrutiny of the NDA's process to assess disposability of waste producers' proposals for conditioning and packaging radioactive wastes and for **regulatory** scrutiny of the NDA's programme as **implementer** for a possible geological disposal facility.

1. Definition:

b) How can regulatory R&D be distinguished from R&D by the implementer?

Finland: The **regulatory** support R&D activities aim at: deepening the regulatory reviews (external review teams), follow-up of the site investigations, development of regulator's independent assessment capabilities, resolving key safety issues fostering build-up of new expertise.

While the **implementers'** R&D program is focussed on production of new scientific knowledge, technical solutions and assessment methods, regulator's R&D is more of confirmatory nature and aimed at fostering independent expertise.

France: *Regarding financing of the R&D programs :*

The program law of 2006 creates a special fund (provided by a tax on nuclear facilities) for financing the researches on storage and disposal for high level activity radioactive waste conducted by ANDRA.

Moreover the **industrial** companies, such as AREVA, EDF or CEA conduct their own research activities.

The **regulatory** research conducted by IRSN is financed on its own budget.

Regarding the fields of research programs :

The **regulatory** research does not aim at covering all the fields covered by the private research, for different reasons : objectives are different from the implementer's ones, financial and technical means are not as important as those of the implementer, and some of the fields investigated by the **implementer** do not have direct link with safety issues.

The main objectives of the **regulatory** research are to keep enough competences and knowledge in the critical safety issues to be able to assess the safety demonstration of the **implementer**.

Germany: R&D work of the **implementer** focuses on concrete licensing projects in order to demonstrate safety for a certain site. **Regulatory** research concentrates on improving competence of the regulator and TSO's independent from certain licensing procedures.

Hungary: **Regulatory R&D** is up to the regulator's needs. The priorities and main directions are laid down in the regulators' policy documents on **BTA**. The **implementers** report the R&D financed by them to the regulator, so there is no duplication of efforts.

Japan: The **regulatory** supporting research conducted by the regulatory body is clearly distinguished from R&D by the **implementer** from the viewpoint of budget and needs.

Sweden: With respect to scientific issues **Sweden** has no clear distinction between regulatory R&D and R&D by the implementer. But, the main aim behind R&D pursued by the regulator and by the implementer can be distinguished between. The implementer's R&D could be described as technology development and the regulator's R&D as critical analysis of this development.

Switzerland: **Regulatory** safety research focuses on topics which are of specific interest to the **regulator**. However, the **regulator** could alternatively ask the **implementer** to investigate these topics. Hence, there is **no clear distinction between the regulator's and the implementer's R&D**. One important aspect of regulatory R&D, however, is that the regulator can, by carrying out research, improve his expertise and stay

at the front of science and technology.

USA: NRC's confirmatory investigations are focused on providing information that NRC can use to support the review of licensing documents. Whereas, R&D by the **implementer** is primarily focused on demonstrating that a geologic repository built at the Yucca Mountain site would protect public health and safety. For the **implementer**, this R&D could also include programs for examining further design changes to improve safe performance or increase operational efficiencies.

UK: The **Environment Agency's** research is an internally funded programme that currently focuses on issues of **regulatory** concern identified from operational work such as waste conditioning and packaging or more strategic programmes such as geological disposal. Research on geological disposal informs **regulatory** scrutiny of the **implementer's** programme for developing a geological disposal facility. The research is also used to develop information and advice provided to Government, communities and the public. **Regulatory** research is not intended to provide a basis for parallel safety case for geological disposal. The **implementer** is responsible for developing that safety case and commissions its own research programme to inform safety case development.

Where appropriate, the **regulator** participates in collaborative projects with, for example, involving overseas partners, other regulators, universities and research organisations. Provided regulatory independence is not compromised, the regulator can work on international collaborative research projects with the **implementer** or waste producers

2. Budget:

a) Is there a distinguishable annual budget for regulatory R&D in your country, and what is its amount?

Finland: For STUK's regulatory support activities (referred to in Section 55 of the Act), there is no strictly defined annual budget but the spent money depends on the current needs. In practice the budget is nowadays around **1 Mio. €**. STUK's regulatory support activities are charged directly from the utilities.

For the KYT program (referred to in Section 53b of the Act), the annual budget is by law set as **0,08 %** of the current waste management liability. For 2009, it means about **1,7 Mio. €**.

France: The regulatory research conducted by IRSN is financed on its own budget. ASN participates in the main orientations of the R&D programs conducted in general (not only on disposals) by IRSN as member of the Committee for orientation of the research programs of IRSN. **Germany:** Regulatory research budget is not clearly distinguished, mostly defined in annual plans. The annual budget for regulatory R&D in the field amounts around **6 Mio. €** (only for GRS, additional amounts for BfS and Öko-Institut)

Hungary: Yes, there are separate budgets for BTA and R&D activities at both HAEA and NPHMOS.

HAEA: between 2005-2008 **3.5 Mio. €** (4 years).

NPHMOS: about **1.4 Mio. €/year** (annual budget separated for the NRIRR).

Japan: The amount of Japan's national budget for the regulatory supporting research on radioactive waste is about 2,000 M yen (ca. **15.3 Mio. €**) (1€ = 130 yen) in FY 2008 (April 2008 – March 2009). This covers research on near-surface disposal, intermediate-depth disposal, geological disposal, clearance and decommissioning.

Sweden: In Sweden there is a separate annual budget for regulatory R&D. Its amount is decided on a yearly basis by the Government. For 2009 the budget was approximately 2 M€ for the waste management R&D.

Switzerland: The current annual budget for regulatory research is 4.4 Mio. CHF (2.8 Mio. €). This amount covers all areas of regulatory research. Currently, the amount allocated to research in radioactive waste management is roughly **0.5 Mio. CHF** (0.3 Mio. €).

USA: NRC's confirmatory investigation budget is approximately ¼ of the NRC annual appropriation from the Nuclear Waste Fund.

United Kingdom: The Environment Agency does not have fixed annual budget for regulatory research on radioactive waste management. Current expenditure of a few 100k Euro per year reflects the early stage of the new geological disposal programme in the UK. Annual funding requirements are decided on the basis of regulatory needs which may include work focussed on operational issues such as waste conditioning and environmental radiological protection or strategic work on geological disposal.

Additional research funding may be provided through voluntary agreements with organisations such as the Nuclear Decommissioning Authority as **implementer** for geological disposal. Under such agreements, any research commissioned by the **regulator** must be aimed at informing the **regulatory** advice that is being sought by the particular organisation and the funding cannot be used for other research purposes.

2. Budget:

b) Do you think this budget is sufficient? If not, why not and what would be an appropriate **R&D** budget?

Finland: For STUK's regulatory support activities (referred to in Section 55 of the Act), there is no strictly defined annual budget but the spent money depends on the current needs. In practice the budget is nowadays around **1 Mio. €**. STUK's regulatory support activities are charged directly from the utilities.

For the KYT program (referred to in Section 53b of the Act), the annual budget is by law set as 0,08 % of the current waste management liability. For 2009, it means about **1,7 Mio. €**.

France: The regulatory research conducted by IRSN is financed on its own budget. ASN participates in the main orientations of the R&D programs conducted in general (not only on disposals) by IRSN as member of the Committee for orientation of the research programs of IRSN.

Germany: Yes, all in all sufficient

Hungary: HAEA: yes, it is sufficient.

NPHMOS: it is sufficient for the basic activities listed in the next point.

Japan: We will appropriately assure research budget which is commensurate with regulatory needs.

Sweden: Sweden has a sufficient R&D budget for waste management. The Swedish system allows for extra resources in connection with review of applications, e.g. the upcoming review of the application for a spent nuclear fuel repository. These extra resources partly comes from an application fee (paid by SKB in the case of the spent nuclear fuel repository), and partly from the Nuclear Waste Fund (SSM applies for resources). These extra resources can, if it is considered necessary by the SSM, be used for regulatory R&D.

Switzerland: The budget is sufficient for the current purposes. However, it may be desirable to increase and extend the regulatory research activities, especially in the area of **RWM**. This would require more personnel to take care of the additional projects, which is why such an **increase** would be a **stepwise process**. An increase of the research budget does not seem impossible in Switzerland.

USA: NRC's confirmatory investigation budget has been, and is currently sufficient to support regulatory needs for review of the **Yucca Mountain** license application.

United Kingdom: Research budget is sufficient to meet the Environment Agency's current **regulatory** needs but an increase in budget is likely to be required as the **implementer**'s programme for developing a geological disposal facility progresses.

3. Topics:

a) What are the current topics covered by regulatory R&D in your country?

Finland: Most of STUK's regulatory support is targeted to the international teams assisting STUK in the review work and maintaining the open issues tracking lists related to spent fuel disposal

- Olkiluoto site investigations group (**SONEX**)
- Engineered barrier system and technology group (**AEGIS**)
- Safety assessment group (**SAFARI**).

Some money is allocated for studies aiming at resolving urgent safety issues and for the development of STUK's independent assessment capability.

France: As said before, the technical support has to focus its research programs on high priority items and critical topics related to safety issues, mainly to ensure sufficient understanding of complex phenomena and to be able to verify the performance of the components of the disposal. The subjects of research investigations can be:

- confinement properties of the host rock of a geological disposal
- EDZ
- Waste deterioration
- Reversibility
- Sealings
- Modelling of transfers

IRSN can also carry out experiments in the experimental station of Tournemire. These topics are linked with the progress of the disposal project. Next step (end of 2009) will be the assessment of the safety options for operating, for long term safety, and for reversibility and the definition of a more restrictive zone for further geological investigations. Therefore the IRSN research programs are conducted with the objectives of assessing these safety issues.

Germany:

- (1) Calculation guidance for radiation exposure in the long term.
- (2) Justification of distinction between probable and less probable scenarios.
- (3) Improvement of safety assessment methodologies and tools.

Hungary:

(a) Main topics at **HAEA** for **2009-2012**:

- i. Development of the regulatory framework
- ii. Life-time extension of the Paks NPP
- iii. Preparation for new NPP units
- iv. Preparation for decommissioning of nuclear facilities, Radioactive Waste Management
- v. Operational safety of nuclear facilities
- vi. Beyond design basis accidents, severe accidents
- vii. Emergence preparedness

(b) Recent topics at **NPHMOS**:

- i. Development of radiation measurement techniques
- ii. Biosphere modelling
- iii. Radiation exposure from different pathways
- iv. Isotope migration experiments
- v. Biodosimetry
- vi. Emergency preparedness

Japan:

NISA has intensively discussed regulatory research and its implementation structure in Radioactive Waste Safety Subcommittee since October 2008, and issued "Regulatory Supporting Research Plan on Radioactive Waste Management (2010-2014)" in October 2009. The main contents are as follows.

1) Study for the review of the appropriateness of results of the preliminary investigations and the detailed investigations by the implementer in implementing stepwise evaluation based on siting requirements of the "Specified Radioactive Waste Final Disposal Act"

2) Studies of fundamental requirements including safety design, basic concept of safety assessment towards safety review for licensing application

3) Developing of "Regulatory research report on geological disposal" *and transmitting the report to international communities such as OECD/NEA

* "Regulatory research report on geological disposal". The report "Regulatory research report on geological disposal" represents the regulatory status for geological disposal in accordance with activities such as developing the safety case published by the implementer. The report also makes communications between the regulatory body and the implementer transparent, and gains public understanding on safety regulation of geological disposal.

4) Establishing the quality assurance system through accumulation of outcomes of domestic and international researches available for safety regulation

And NISA has intensively discussed regulatory research and its implementation structure in Decommissioning Safety Subcommittee since February 2009, and issued "Regulatory Supporting Research Plan on Decommissioning (2010-2014)" in November 2009. The main contents of this report are research for decommissioning program of nuclear fuel cycle facilities, research for termination of decommissioning, research for appropriate management of decommissioning waste and so on.

Sweden: In Sweden the current topics covered by regulatory R&D are:

Spent nuclear fuel issues

- Biosphere – radionuclide migration
- Communication
- Consequence analysis – model development
- Geosphere – influence of time on safety barriers and assessment of bedrock movements
- Review and assessment methods
- Review of the capsule and buffer
- Review of the complete site investigations
- Safety analysis methodology
- Spent nuclear fuel and radionuclide chemistry

Decommissioning issues

- Financial aspects of decommissioning/dismantling
- Responsibility and clearance

Switzerland: Several projects in the area of RWM are being carried out on the hydraulic and rock mechanical behaviour of Opalinus Clay in the Mont Terri rock laboratory. Further projects deal with

management questions of radioactive waste such as organic matter and corrosive metals as well as with numeric modelling work investigating the impact of gas on the integrity of the buffer and host rock barrier system.

USA:

- Approximately 1/3 of the investigations are focused on pre-closure/operational topics, 2/3 on post-closure
- Focus on understanding uncertainties in key performance attributes, such as long-term materials properties (i.e. fuel dissolution, corrosion)

UK:

The Environment Agency's current regulatory research programme covers four main areas:

- Support to meet operational needs, for example, in regulatory scrutiny of proposals for conditioning and packaging wastes for future disposal;
- Strategic, largely generic, work on geological disposal of higher activity wastes;
- Developing and implementing improved assessment methods for environmental radiological protection;
- Support for reviews of safety cases for near-surface disposal of solid low-level radioactive waste.

3. Topics:

b) What topics are planned for the future?

Finland: The **KYT** program includes currently the following projects, which are mostly related to spent fuel disposal:

- deformation mechanism of a disposal canister
- stress corrosion of copper caused by sulphides
- long-term durability of copper
- coupled behaviour of bentonite buffer
- THM modelling of bentonite buffer
- formation of colloids and role in radionuclide transport
- rock stress measurement by acoustic emission
- rock engineering classification using statistical analysis and 3-d site data
- in-situ investigations of rock in the Grimsel laboratory
- retardation of trivalent actinides on clay and oxide mineral surfaces
- coupling of 3-d porosity of rock to modelling of matrix diffusion
- gases and biochemical processes in geosphere
- geomicrobiological and molecule-microbiological monitoring of deep geosphere
- fate of carbon-14 in soil-plant-atmosphere continuum
- ageing of reinforced concrete structures in bedrock
- regional socioeconomic impacts caused by SF disposal.

France: Future axis of research will be partly defined by the schedule of the program law which states that :

- a public debate will take place in 2013 and a law on reversibility will be defined by 2015 (sufficient progress on the topic of reversibility will therefore be necessary to ensure adequate regulation on the subject regarding to technical and operational feasibility)
- the safety case for licensing should be presented by the implementer in 2014 for a technical assessment to be conducted in 2015.

Germany:

1. Calculation guidance for radiation exposure in the long term
2. Justification of distinction between probable and **less probable** scenarios
3. Improvement of safety assessment methodologies and tools

See above “Answers to Question 3. Topics: a) to be continued”

Hungary:

- **HAEA:** see topics above (a) to be continued
- **NPHMOS:** see topics above (b) to be continued

Japan:

See topics above “Answers to Question 3. Topics: a) to be continued

Sweden: In Sweden an application for a spent nuclear fuel repository is expected by the end of 2010. In general terms future topics can be described as the current topics (answer to question 3a) but further developed and/or oriented towards direct support for the review of the application.

Regarding issues not connected to the application the following are examples of topics that are planned for the future:

- Decommissioning – radiological mapping of a facility’s different stages of decommissioning and dismantling

Studies of financial security and prerequisites for funding in the long term (in financial terms), including retrospective studies

Switzerland: Topics planned for the future include

- Arrangement and inventory of pilot facility of the repository (According to the Swiss legislation a repository must contain a pilot facility in which the behaviour of the waste and the barriers is to be monitored.)
- Monitoring concept and devices
- Aspects and requirements for retrievability of emplaced waste packages
- Rapid closure of a deep repository during operation.

USA:

- Confirm barriers perform as expected (required by regulation)
- Future topics are dependent on the Department of Energy’s performance confirmation program, and issues that may arise during licensing.

UK: As the programme for developing a geological disposal facility proceeds, increased resources are likely to be required for regulatory research targeted on issues such as site characterisation or engineered barrier performance. Such regulatory research would support scrutiny of the implementer’s proposed design of a geological disposal facility and its developing environmental safety case.

4. Justification:

What is the reason for covering the mentioned topics by the regulator, and not by the implementer?

Finland: The justification is explained in response to question 1. The regulatory tasks require versatile in-depth expertise that can only partly be covered by the regulatory staff. Public confidence in the regulatory body requires that its judgements are based extensive and independent expertise.

France: As mentioned the research programs conducted by the implementer is much broader and complete than those of the regulator. It has been assessed with the objective of covering all the important issues and has to be consistent with the objectives defined by the program law on waste management.

The research and development programs implemented by the technical support of the regulator is conducted mainly in the view of understanding the complex phenomena and being able to assess the safety demonstration.

Germany: Competence restricted to the regulator; need of application of methods, models and codes by the **TSO** different from the implementer.

Hungary: The above mentioned topics (*Question 3a) & b)* were chosen by the regulators and are thought essential for their regulatory and licensing work (regardless of whether the implementer also studies certain specific questions or not).

Japan: As was discussed in the First OECD/NEA/RWMC-RF Workshop in Tokyo on *20-22 January 2009*, the regulator needs to implement independent research in order to acquire and maintain the competence necessary for the regulation.

Sweden: In general terms the chosen topics are justified by their aim of being critical analyses of the implementers' suggestions for management of radioactive waste.

Switzerland: Topics which are not specific regulatory topics (i.e., the investigations of the Opalinus Clay) are tackled in order to improve the expertise of the regulatory body and its experts.

USA:

- Although the burden of demonstrating safety lies with the applicant, NRC recognizes that independent, confirmatory information is an important component for establishing reasonable expectation that the applicant will meet the safety standards.
- The focus for NRC's program is to support a licensing review, whereas the applicant's is to establish technical bases for repository development.
- The Regulator does not rely solely upon R&D conducted by the implementer, but performs independent confirmatory investigations.

UK: Independent regulatory research provides an important tool to support scrutiny of the implementer's proposed design for a geological disposal facility and its developing environmental safety case. Involving regulatory staff in research studies provides a valuable means of increasing knowledge and understanding of issues that are important to the long-term environmental performance of a geological disposal facility. This helps build regulatory competence, which should increase stakeholders' confidence in regulatory scrutiny of the implementer's environmental safety case.

5. Organization:

a) What organizations are performing regulatory **R&D** in your country?

Finland: The host of the **KYT** program is the **Ministry of Employment and the Economy (MEE)** and it is steered by a group consisting of representatives from MEE, **STUK** and the utilities. Main participants in **KYT** are Finnish research institutes and universities. International review of the program was carried out in 2008.

STUK has neither internal research staff nor a designated technical support organisation. STUK's regulatory support is allocated partly to individual experts and partly to Finnish research institutes. STUK alone decides the allocation of the resources and the supervision is similar to that of STUK's other activities.

France: **IRSN** is the main organization for regulatory research in the field of nuclear waste management.

Germany: BfS, GRS, Öko-Institute

Hungary: (1) Mainly national research institutes (i.e.: Hungarian Academy of Sciences KFKI, Atomic Energy Research Institute Research, VEIKI Institute for Electric Power Research, Institute of Nuclear Technology at Budapest University of Technology and Economics, Institute of

Isotopes Ltd.)

(2) NRIRR (it is the main R&D organization of the radiation safety regulator)

Japan: The Nuclear Safety Commission of Japan (NSC) shows the directionality of safety research in Japan through "Nuclear Research Programs Important to Safety". Based on this, NISA promotes regulatory supporting research in cooperation with Japan Nuclear Energy Safety Organization (JNES), Nuclear Safety Research Center (NSRC) of Japan Atomic Energy Agency (JAEA) and the Research Core for Deep Geological Environments (RCDGE) of National Institute of Advanced Industrial Science and Technology (AIST).

JNES, *Japan Nuclear Energy Safety Agency*
 supports NISA by providing technical advice
 inspection of nuclear facilities

AIST, *National Institute of Advanced Industrial Science and Technology*
 research institute
 AIST/RCDGE : geoscientific research for geologic disposal

<Development of geological characterization methodology>

Long-term geological evolutions are modelled, and hydrogeology, geology and geochemistry are characterized.

Research topics include;

- Uplift and erosion
- Volcanic activity
- Geochemical evolution of deep groundwater
- Colloidal and biological effects

JAEA, *Japan Atomic Energy Agency*
 research institute

JAEA/NSRC : research on engineered barrier performance and development of safety assessment method deals with all types of radioactive wastes

<Safety assessment methodology development>

Mathematical models are developed to predict long-term performance of disposal system, incorporating data/model/ scenario uncertainties and long-term barrier evolutions.

Research topics include;

- Safety assessment modelling
- Site- to regional-scale hydrogeological modelling
- Waste form and engineered barriers performance
- Radionuclide transport

Sweden: In **Sweden**, SSM maintains regulatory R&D for nuclear waste management. However, SSM has neither internal research staff nor a designated technical support organisation in the nuclear waste area and therefore rely on external domestic and foreign experts to perform regulatory R&D activities.

Switzerland: Regulatory R&D is usually outsourced to universities or consultants. The current regulatory research in the Mont Terri rock laboratory is carried out by the Institute of Geology of ETH Zurich.

USA:

- The Center for Nuclear Waste Regulatory Analyses (hereafter the Center) provides technical assistance to support NRC’s confirmatory investigations.
- The Center conducts independent investigations driven by regulatory needs, which is not “research.” NRC staff sometimes participates directly in these investigations.

UK: The Environment Agency commissions regulatory research in radioactive waste management from universities, research organisations and consultancies within the UK.

5. Organization:

b) Who guides them, and how close is the supervision (if any)?

Finland: The host of the **KYT** program is the **Ministry of Employment and the Economy (MEE)** and it is steered by a group consisting of representatives from MEE, STUK and the utilities. Main participants in KYT are Finnish research institutes and universities. International review of the program was carried out in 2008.

STUK has neither internal research staff nor a designated technical support organisation. STUK’s regulatory support is allocated partly to individual experts and partly to Finnish research institutes. STUK alone decides the allocation of the resources and the supervision is similar to that of STUK’s other activities

France: Up to recently, no formal process was in place for ASN to take position on the research programs conducted by IRSN even though these programs were periodically presented and discussed within the two parties. A Committee for orientation of R&D was created in 2009 within IRSN, ASN is an active member of this committee

Germany: BMU, relatively casual

Hungary:

- (1) HAEA guides and coordinates the above organizations through contracts.
- (2) NPHMOS guides the NRIRR.

Japan: NISA does, and it is conducted by a support of JNES.

NISA promotes regulatory supporting research through NSRC/JAEA and RCDGE/AIST under technical support of JNES for NISA based on "Regulatory Supporting Research Plan on Radioactive Waste Management (2010-2014)".

NSRC/JAEA and RCDGE/AIST prepare operation plans on the approach and need for the work to be performed. The works performed by JAEA/NSRC and AIST/RCDGE are reviewed several times a year by NISA/JNES. And Radioactive Waste Safety Subcommittee in NISA has also checked these activities.

Sweden: In **Sweden** the regulatory R&D is guided by the regulatory body SSM. Generally the supervision is close with regular reporting to the SSM.

Switzerland: All regulatory R&D projects are guided by the regulatory body.

USA:

- The Center is a **Federally Funded Research and Development Center (FFRDC)**
 - FFRDCs are unique organizations that assist the United States government with scientific investigations and analysis, development and acquisition, and/or systems engineering and integration. FFRDCs address long-term problems of considerable complexity, analyze technical questions with a high degree of objectivity, and provide creative and cost-effective solutions to government problems.
 - FFRDCs operate as long-term strategic partners with their sponsoring government agencies and

are organized as independent entities with limitations and restrictions on their activities.

FFRDCs are prohibited from manufacturing products, competing with industry, or working for commercial companies

- A competitive contract was awarded to the Southwest Research Institute for operation of the Center.
- NRC provides technical guidance to the Center at least annually, which details the work requirements and priorities.
- The Center prepares operation plans which discuss the approach and need for the work to be performed. If programmatic changes are needed (i.e. budget or technical) new written guidance is issued.
- There are NRC project managers that monitor, and often contribute to, the technical teams at the Center.
- Quarterly management meetings between NRC senior management and Center senior management.

UK: The Environment Agency's regulatory research programme is overseen by an internal Programme Board comprising technical specialists, policy and operations. The Programme Board agrees the individual projects that comprise the research programme, reviews progress against the planned work programme and ensures projects deliver high quality outputs to inform regulatory advice and decisions.

6. Outcomes for regulation:

a) What are the achievements of regulatory R&D so far for regulatory purposes in your country?

Finland: Given that the volume of the regulatory R&D is only about 10 % of that of the implementers' program, the achievements cannot be very visible. Obviously the regulatory support has improved the quality and scientific basis of the regulatory documents, and the feedback given in those documents has affected the implementer's program. Also, the regulatory R&D has helped in building up new domestic expertise in the WM area.

France: The main achievement was the assessment of the "dossier 2005" presented by ANDRA.

Germany: Development and improvement of guidelines for disposal of high level waste and for decommissioning.

Hungary:

(1) Supervision and revision of Nuclear Safety Codes.

(2) Development of regulations and appropriate support for licensing and supervising process.

Japan: Introduction of upper-bound radionuclide concentrations for disposal based on the basic policy in NSC, upper-bound radionuclide concentrations were determined for low-level radioactive waste disposal for near-surface and intermediate-depth repositories. The upper-bound concentrations are part of requirements for license applications. The methodology to derive the concentrations was the result of JAEA's regulatory research funded by NISA. The methodology and the evaluation were accepted by NSC, and the values of concentrations introduced in the "Law for Regulation of Nuclear Source Materials, Nuclear Fuel Materials and Nuclear Reactors" (effective March, 2007)

Sweden: The achievements of regulatory R&D in Sweden so far are regulators with good insight into the critical issues of the suggested waste management system for spent nuclear fuel. Further, regulatory R&D has produced modelling tools alternative to tools used by the implementer, and these are an effective aid in regulatory review work.

Switzerland: Regulatory research is important to follow the current state-of-the-art of science and for training purpose for experts working for the regulator. Basic results of research were used when the regulator developed and specified the detailed safety requirements for radioactive waste disposal in the new regulatory guideline G03 or when the regulator reviewed the safety assessment report of Nagra for the disposal of HLW in the Opalinus Clay of the Zürcher Weinland ("Project Opalinus Clay").

USA:

- Key regulatory products, such as development of regulations, standard review plans, and review guidance.
- Independent bases to evaluate modelling of repository performance.
- Independent technical basis to support the review of risk-significant components in the preclosure and postclosure safety case.
- Technical documents supporting rulemaking activities (e.g., specification of deep percolation values to be used in million-year performance assessments for Yucca Mountain)
- Technical documents to assist NRC in its pre-licensing activities with the Department of Energy in key areas such as: corrosion, thermal-hydrologic processes, ground-water modelling, performance assessment techniques.

UK: The Environment Agency's regulatory research is used to inform either regulatory decisions or scrutiny of the implementer's work. Several of our reports have been influential in raising the profile of important regulatory issues, for example, package longevity, the effects of gas generation and repository design. Much of the regulatory research has helped to build expertise within our Nuclear Waste Assessment Team to support review of environmental safety cases for disposal of radioactive wastes either to near-surface facilities or to a geological disposal facility.

Knowledge built up from our regulatory research programme informed development of the two Guidance on Requirements for Authorisation documents, one covering near-surface disposal facilities and the other covering geological disposal.

6. Outcomes for regulation:

b) What was it able to solve?

Finland: Given that the volume of the regulatory R&D is only about 10 % of that of the implementers' program, the achievements cannot be very visible. Obviously the regulatory support has improved the quality and scientific basis of the regulatory documents, and the feedback given in those documents has affected the implementer's program. Also, the regulatory R&D has helped in building up new domestic expertise in the WM area.

France: The regulatory **R&D** does not substitute itself to the implementer's research. It helps the regulatory body to ask for more detailed justifications to support the safety demonstration. This can lead the implementer to conduct new **R&D** programs.

Hungary:

- (1) Licensing of the removal of damaged fuel assemblies at unit 2 in **Paks NPP** (elimination of consequences after a serious incident during fuel cleaning in 2003)
- (2) Support of the authority in the various phases of the licensing procedure in the **Bátaapáti** repository case.

Japan: Determination of upper-bound radionuclide concentrations for intermediate-depth disposal and near-surface disposal (pit-type and trench-type) has made clear legal classification among geological disposal, intermediate-depth disposal and near-surface disposal (pit-type and trench-type) in Japan.

Sweden: The knowledge created by the regulatory R&D will enable SSM to review the application for a spent nuclear fuel repository during 2010 and beyond in a thoroughly knowledgeable way. For example the alternative modelling capacity that SSM has enables a deep insight into SKB's modelling work. That deep insight wouldn't be possible without SSM's own modelling capacity funded by regulatory R&D.

Switzerland: Results of regulators research in the Mont Terri rock laboratory was used to validate rock mechanical models of ETH Zürich analysing the effect of excavation-induced perturbations in the

Opalinus Clay (Excavation Damaged/disturbed Zone) and its importance and relevance as preferential fluid pathways.

USA:

- Problems turned into our achievements. NRC able to provide an independent technical basis to complete the licensing actions.
- Examples:
 - Enhanced the use of natural analogues to better understand uncertainties in long-term geological and materials process.
 - Independent laboratory experiments to support review of key processes in material properties, fluid flow, radionuclide transport, and geologic phenomena.
 - Advanced numerical modelling for evaluating uncertainties in reactive flow and transport, mechanics of rock and materials deformation, geochemical dynamics, fluid flow, and atmospheric transport.

UK: The aim of much of the Environment Agency's regulatory research in radioactive waste management is not to solve particular problems but to inform regulatory decisions or advice related to waster producers' proposals or regulatory scrutiny of the implementer's approach to developing a geological disposal facility and the supporting environmental safety case. Building regulatory expertise and competence is a more important aspect of regulatory research at the present stage of the programme for implementing geological disposal.