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RWMC Regulators' Forum (RWMC-RF)

REGULATORY RESEARCH FOR WASTE DISPOSAL – OBJECTIVES AND INTERNATIONAL APPROACHES - DRAFT

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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 the potential merits of R&D work carried out by the regulator, and summarizes the results of a questionnaire which was circulated among the members of the Regulators' Forum of NEA's Radioactive Waste Management Committee in 2009.

Objectives of R&D by the Regulator

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. 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 actively involved.

- *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. At the same time, independent research contributes to better decisions. 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. Past experience, including the reactor area, shows that the safety research sponsored by the

regulatory and supervisory bodies has contributed to improved safety. The stakeholders must be convinced of the independence of the regulator. Certain stakeholders may acknowledge the R&D work performed or managed by the regulator as "independent research".

- *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, however, regular interactions of the regulator with all stakeholders, including appearances in public.

Further Issues

There may be further reasons why the regulator may carry out its own R&D projects, among which is the verification of key safety issues or the investigation of topics not addressed by the implementer, i.e., to fill scientific gaps. But there are different views on whether or not it is the duty of the regulator to carry out such complementary work.

A further 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.

Conclusion

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 over 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.

Evaluation of the questionnaires 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), France (Programme law on waste management), Japan (NISA/METI) and UK (Environment Act 1995). 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 distinguished 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 France, the research topics are stipulated by law ("programme law" 2006-739 of 28th June). 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.) 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 indirectly represented (e.g. Finland, France, 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).

APPENDIX

Status of Questionnaire Answers (29 January 2010)

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

1. Definition:
a) 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.

1. Definition:
a) How is regulatory **R&D** defined in your country?

The PNGMDR take 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 **b**asic **t**echnical **a**ctivities (BTA) that serve the regulatory control of the safe use of atomic energy.

"Regulatory R&D" is called "regulatory support research" in **Japan**, which is defined as such research that is implemented by the government 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

1. Definition: **a)** How is regulatory **R&D** defined in your country?
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

1. Definition: **a)** How is regulatory **R&D** defined in your country?
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**: As mentioned above, the **regulatory** support research conducted by the regulatory body is clearly distinguished from R&D by the **implementer** from the viewpoint of budget and regulatory 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 distinguished 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** does not participate in the evaluation of this budget nor in the definition of the research programs either within national framework or international ones.

Germany: Regulatory research budget is not clearly distinguished, mostly defined in annual plans. The annual budged 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 support 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 and 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** does not participate in the evaluation of this budget nor in the definition of the research programs either within national framework or international ones.

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.

3. Topics:
a) What are the current topics covered by regulatory **R&D** in your country?

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:

1. Development of geological characterization methodology (AIST)
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

2. Safety assessment methodology development (JAEA)
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** 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

Decommissoning 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 an 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

3. Topics:
b) What topics are planned for the future?

Japan: Planned topics are as follows;

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"

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

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

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

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 is 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: To ***Question 3 b):*** Answers 1 and 2: Competence restricted to the regulator
To ***Question 3 b):*** Answer 3: 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 **M**inistry of **E**mployment and the **E**conomy (**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. Based on this, NISA promotes regulatory support 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). See "Japanese framework on geological Disposal Research and Development" for reference.

JNES, *Japan Nuclear Energy Safety Agency* (ca. 430)

- supports NISA by providing technical advice
- inspection of nuclear facilities

AIST, *National Institute of Advanced Industrial Science and Technology* (ca. 3.100)

- research institute
- geoscientific research for geologic disposal

JAEA, *Japan Atomic Energy Agency* (ca. 4.000)
- research institute
- research on engineered barrier performance and development of safety assessment method
- deals with all types of radioactive wastes

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.

5. Organization:
a) What organizations are performing regulatory **R&D** in your country?

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 **M**inistry of **E**mployment and the **E**conomy (**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 now, the ASN has not formally given its position on the research programs conducted by IRSN even though these programs are periodically presented by IRSN and discussed within the two parties.
ASN has been called upon by the government to play a more active role in the definition of the orientations that should be given to the public research in the field of radiological protection and nuclear safety. ASN is thus at the moment considering how it could be more involved in this issue and fulfil these new expectations.

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.
Competitive contracts from NISA of METI and/or JNES have been awarded to JAEA and AIST for operation of NSRC/JAEA and RCDGE/AIST. NISA guides researches through NSRC/JAEA and RCDGE/AIST in technical support of JNES for NISA.
NSRC/JAEA and RCDGE/AIST prepare operation plans on the approach and need for the work to be performed. The works performed by NSRC/JAEA and RCDGE/AIST are reviewed a few times a year by NISA/JNES. NISA's standing subcommittee (Radioactive Waste Safety Subcommittee) 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.

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

USA:
- The Center is a **F**ederally **F**unded **R**esearch and **D**evelopment **C**enter (**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.