Agence pour l'énergie nucléaire
Nuclear Energy Agency
OECD

Deep Disposal of Spent Fuel and High-level Waste

… Status and Issues in Safety Case and Safety Regulation, and Implications for Safety Research by Regulators

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Overview of presentation

- **Part I - The OECD and the NEA**
- **Part II – CURRENT STATUS AND ISSUES**
- **Part III - FINAL REMARKS**

OECD/NEA Membership

- Australia
- Austria
- Belgium
- Canada
- *Chile*
- Czech Republic
- Denmark
- Finland
- France
- Germany
- Greece
- Hungary
- Iceland
- Ireland
- Italy
- Japan
- Korea
- Luxembourg
- Mexico
- Netherlands
- *New Zealand*
- Norway
- *Poland*
- Portugal
- Slovak Republic
- Spain
- Sweden
- Switzerland
- Turkey
- United Kingdom
- United States

Not member of NEA

- OECD Strategic Objectives

- Promote sustainable *economic growth*, *financial stability* and structural adjustment
- Improve *human capital* and *social cohesion*, and promote a sustainable environment
- Contribute to *shaping globalisation* through the expansion of trade and investment
- Enhance public and private sector *governance*
- Contribute to the development of *non-member economies*

The OECD Nuclear Energy Agency (NEA)

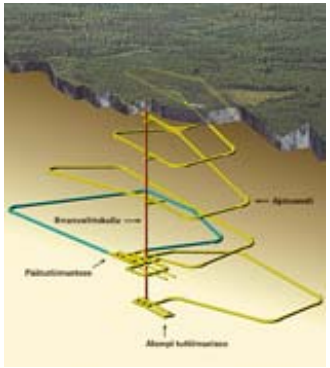
- To assist its member countries … the scientific, technological and legal bases required for the use of nuclear energy

- To provide authoritative assessments and to forge common understanding on key issues, as input to government decisions on nuclear energy policy, and as input to broader OECD policy analyses

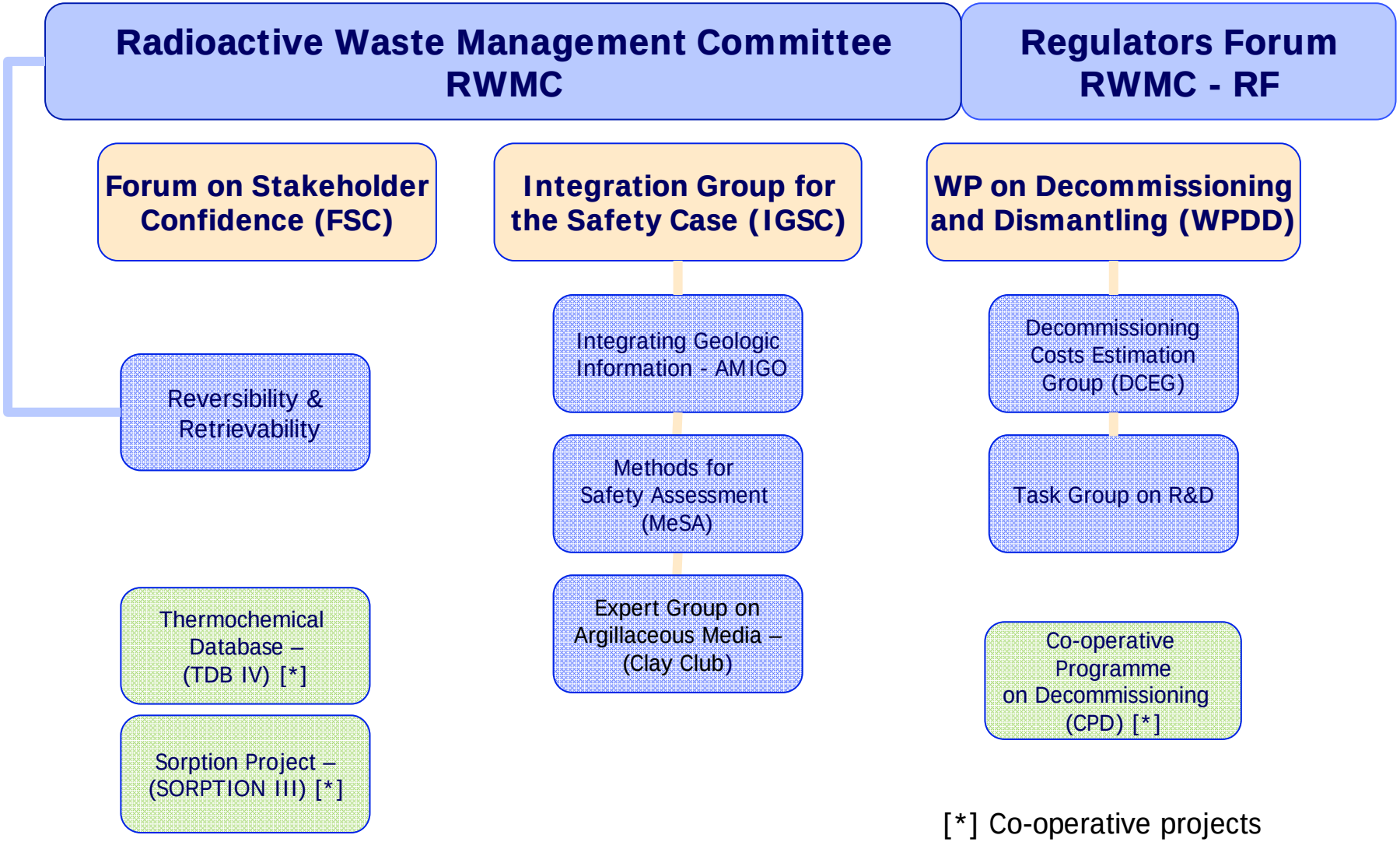

Depleted uranium
URANIUM ENRICHMENT
Enriched uranium hexafluoride
FUEL FABRICATION
Fresh fuel
Uranium hexafluoride
Plutonium
PRODUCTION OF ELECTRICITY
CONVERSION
Spent fuel
Natural uranium
Recycled uranium
REPROCESSING
INTERIM STORAGE
SNF
URANIUM MINING AND MILLING
High-level waste
Spent nuclear fuel (SNF)
WASTE DISPOSAL

Management of Radioactive Waste and Materials - Goal

- Assist members in the area of management of radioactive waste and materials, focusing on the development of strategies for the safe, sustainable and broadly acceptable management of all types of radioactive waste, and in particular long-lived waste, and spent fuel

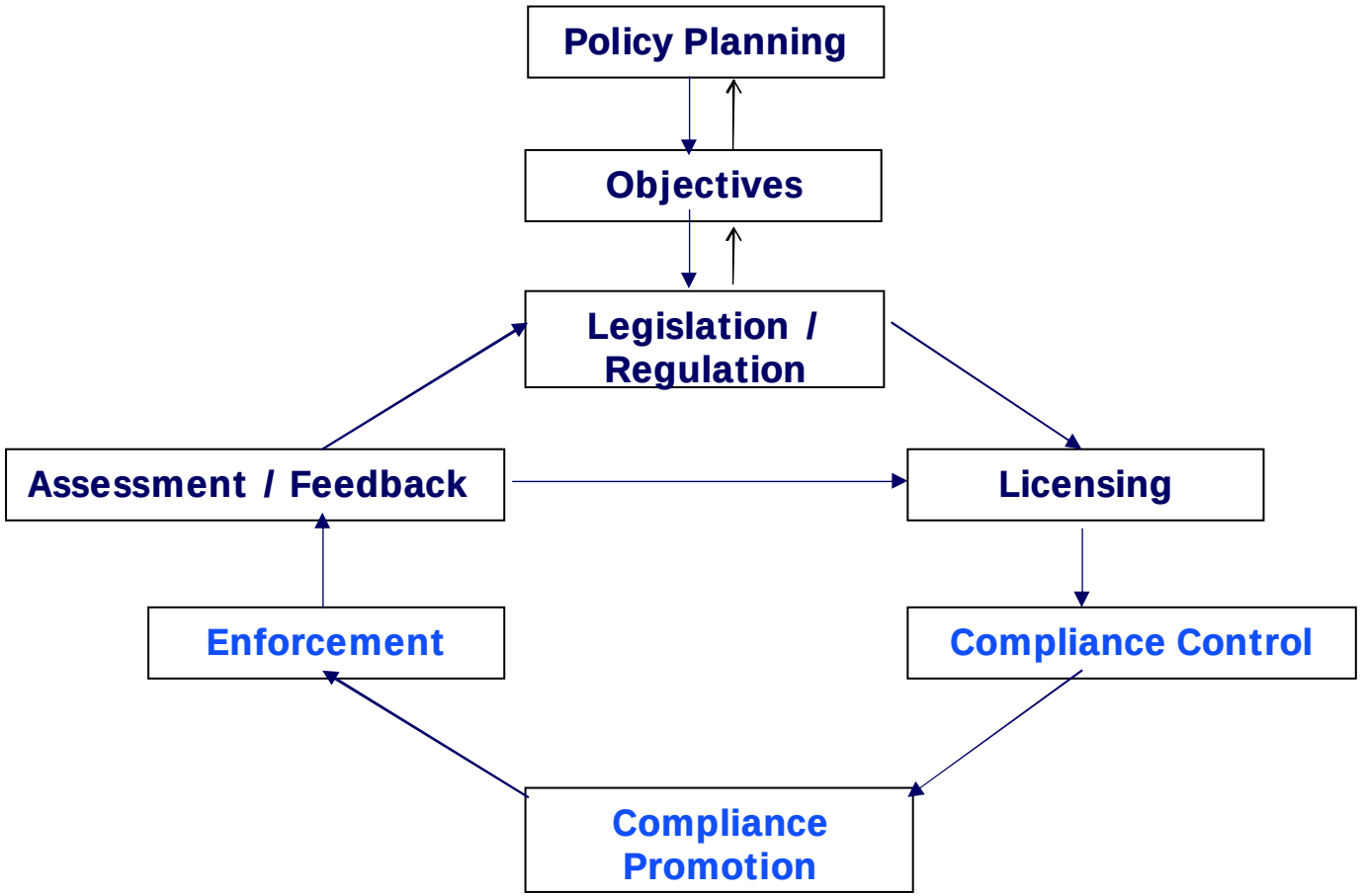


Radwaste and Decom at NEA



[*] Co-operative projects

The Regulatory System and Cycle



Many players in the regulatory system

- AEC, Atomic Energy Commission
- AIST, National Institute of Advanced Industrial Science and Technology
- CRIEPI, Central Research Institute of Electric Power Industry
- JAEA, Japan Atomic Energy Agency
- JNES, Japan Nuclear Energy Safety
- METI, Ministry of Economy, Trade and Industry (NISA, ANRE)
- MEXT, Ministry of Education, Culture, Sports, Science and Technology
- MLIT, Ministry of Land, Infrastructure and Transport
- NSC, Nuclear Safety Commission
- NIRS, National Institute of Radiological Sciences
- NSRA, Nuclear Safety Research Association
- NUMO, Nuclear Waste Management Organization of Japan
- Parliament (Diet)
- RWMC, Rad. Waste Management Funding and Research Center
- …. *REGIONAL and LOCAL Authorities*

All regulatory players need some research to support …

- Development or revision of policy and legislation
- Development or revision of regulation
- Review of license application and for tracking decisions
  - Development of understanding of major safety features
- Keep track of evolving scientific knowledge and societal requirements, e.g., on the role of the major players

There are constraints on the research to be carried out by technical regulator …

- Be informed of, but not develop, process understanding and complex models
- **Ok** to checking on specific claims by the implementer, but **no** to taking a lead in technical areas
- Focus on safety-relevant aspects, and make sure it is the authority views and not necessarily that of its support organisation. Exemple of GPD in France.
- Limited to certain (late) parts of the process

Technical support, for the most part.

Many important decisions are made by others, and not necessarily on technical grounds. The regulator can only vouchsafe that a given solution is "safe enough", and not necessarily "the best".

A case can be made for the regulator…

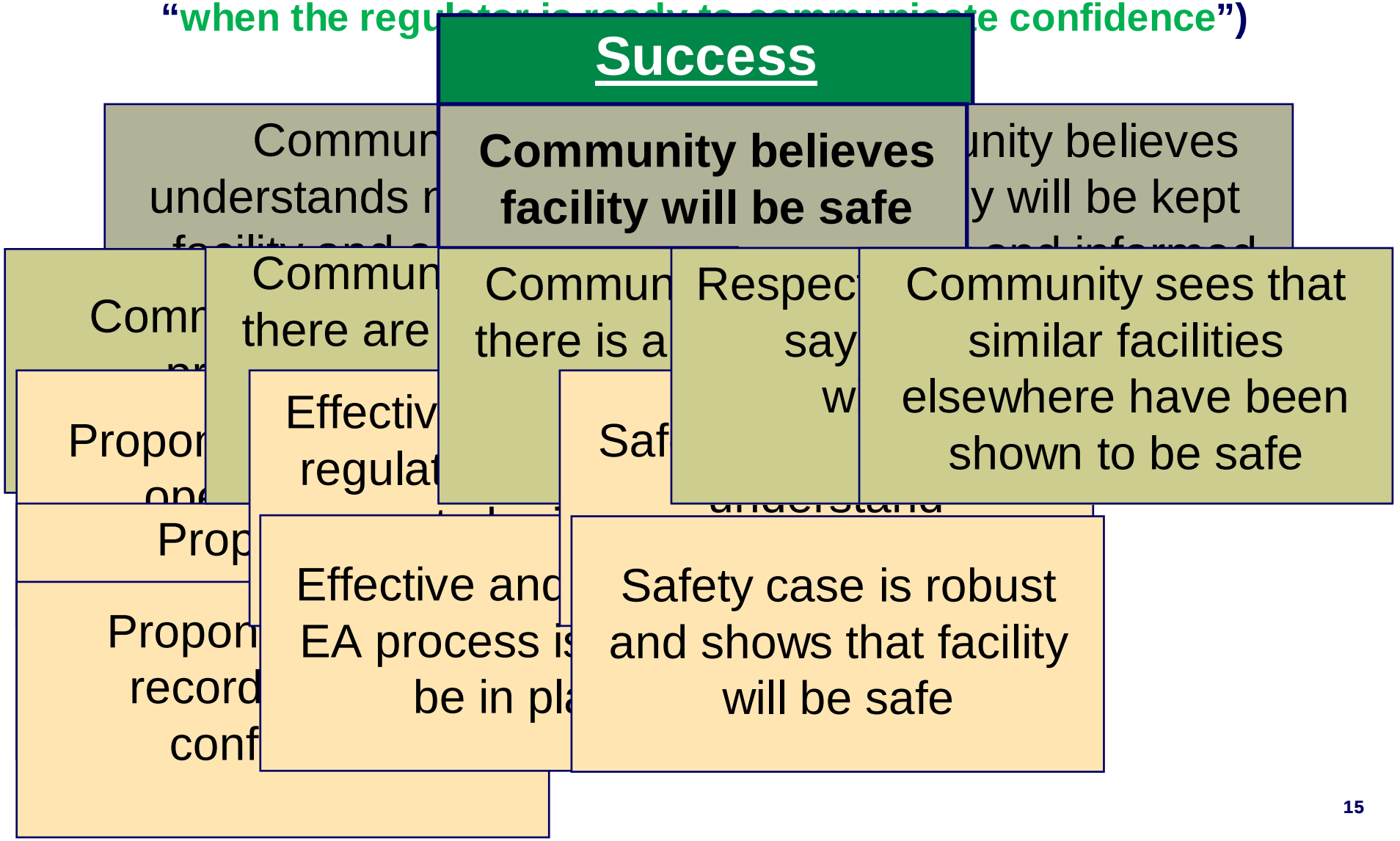
- To **INITIATE** research, in order to force industry to get into a research topic, or to create a national or international breeding ground for ideas and create a broader base of expert resources.

- To **obtain** additional technical support
  - when taking up new responsibilities
  - to prepare for carrying out future duties/tasks better

Human resources are fundamental…

- … the regulator needs to employ experienced personnel who know the strength and limitations of research
- …train and keep this personnel
- … ensure that lessons learnt and decisions made are properly archived and transferred
- [*all of this may require some research by itself*]

Success in Communicating Safety (安心) (it is instructive to replace "community" by "regulator" in this overhead, and "success" with "when the regulator is ready to communicate confidence")



Industry's challenges in Communicating Safety (both安全 and 安心) (They are challenges for the regulator too)

- Public lacks familiarity and comfort with things nuclear
- Public does not have time to try to understand issues
- Public has inherent reluctance to trust any proponent*
- Conveying the concept that disposal facilities will be **safe** for the long timeframes for which radioactive wastes can remain hazardous**
- The media often seeks to report on conflict and dire consequences to promote story interest, resulting in the public not knowing whom to believe and becoming more apprehensive

* but it may trust better the regulator ; ** challenges "from within"

Part of the challenges come “from within”...

- Are we clear on what are “*Safety, Protection , Optimization, Health Detriment, Environment*”?
  - These concepts are typically not (well) defined in regulation, especially disposal regulation
- Are short term practices (and concepts) really applicable to all time scales, or do they have to be adapted or evolve ?
- Do we have clear understanding and objectives for formulating regulatory criteria that are transparent and implementable ?

Challenges from within: The example of “dose”

- **Dose** : As used in regulation it is “effective dose”; this is a management tool good for short term and not a direct/good measure of health detriment. (ICRP)

- Calculated effective dose is **certainly not** a measure of health detriment beyond a few generations (**ICRP**, **HPS**)

- Dose criteria are just **indicators** of safety ***amongst others***. They are thus to be used in **a comparative fashion** and not in the absolute, e.g., to convince of the quality of the solution. **The best solution is not necessarily the one with lowest dose** (ICRP)

… "safety indicators" (from IAEA 2007 Glossary)

"Such quantities are most commonly used in situations where predictions of *dose or risk are unlikely to be reliable*, e.g. long term assessments of repositories. They are normally either:*

(a) Illustrative calculations of *dose or risk quantities, used to give an* indication of the possible magnitude of *doses or risks for comparison with* criteria+; or

(b) Other quantities, such as radionuclide concentrations or fluxes, that are considered to give a more reliable indication of impact, and that can be compared with other relevant data**."

* In fact **even if** they were reliable, they would **not** be a measure of health detriment ; + firstly among themselves; primarily, natural background

Challenges from within: The example of “safety”…

- **Safety** in the technical sense is related to control of sources and presence of regulator. What we do for AN-ZEN (安全) (namely, quality assurance, controls) is **not** extendable indefinitely in time.
- **Safety**: for a certain time it must also be AN-ZEN (安全), but it must be AN-SHIN (安心) all the time (also of the regulators!)
- AN-SHIN (安心) requires additional effort to ANZEN (安全) [AN-SHIN refers both to the physical system and to the decision making system and its components]

Challenges from within: possible research priorities...

- **Are fundamental concepts the same in the short and in the long term? How do they change with time scales? In particular**
  - **Effective dose ; potential dose**
  - **“Safety”**
  - **Health detriment**
  - **Optimization**
  - **Environment (e.g., only man or also … plants?)**
  - **…**
- **Important evolution in radiation protection thinking during the past 15 years**

"Safety" Case (IAEA glossary, 2007)

- "A collection of arguments and evidence in support of the *safety of a facility or activity.* This will normally include the findings of a *safety assessment*[+] *and a* ***statement of confidence***[++] in these findings.
- For a *repository, the safety case may relate to a given stage of development. In* such cases, the *safety case should acknowledge the existence of any* unresolved issues and should provide guidance for work to resolve these issues* in future development stages." * the fact that research is never abandoned is a confidence factor;

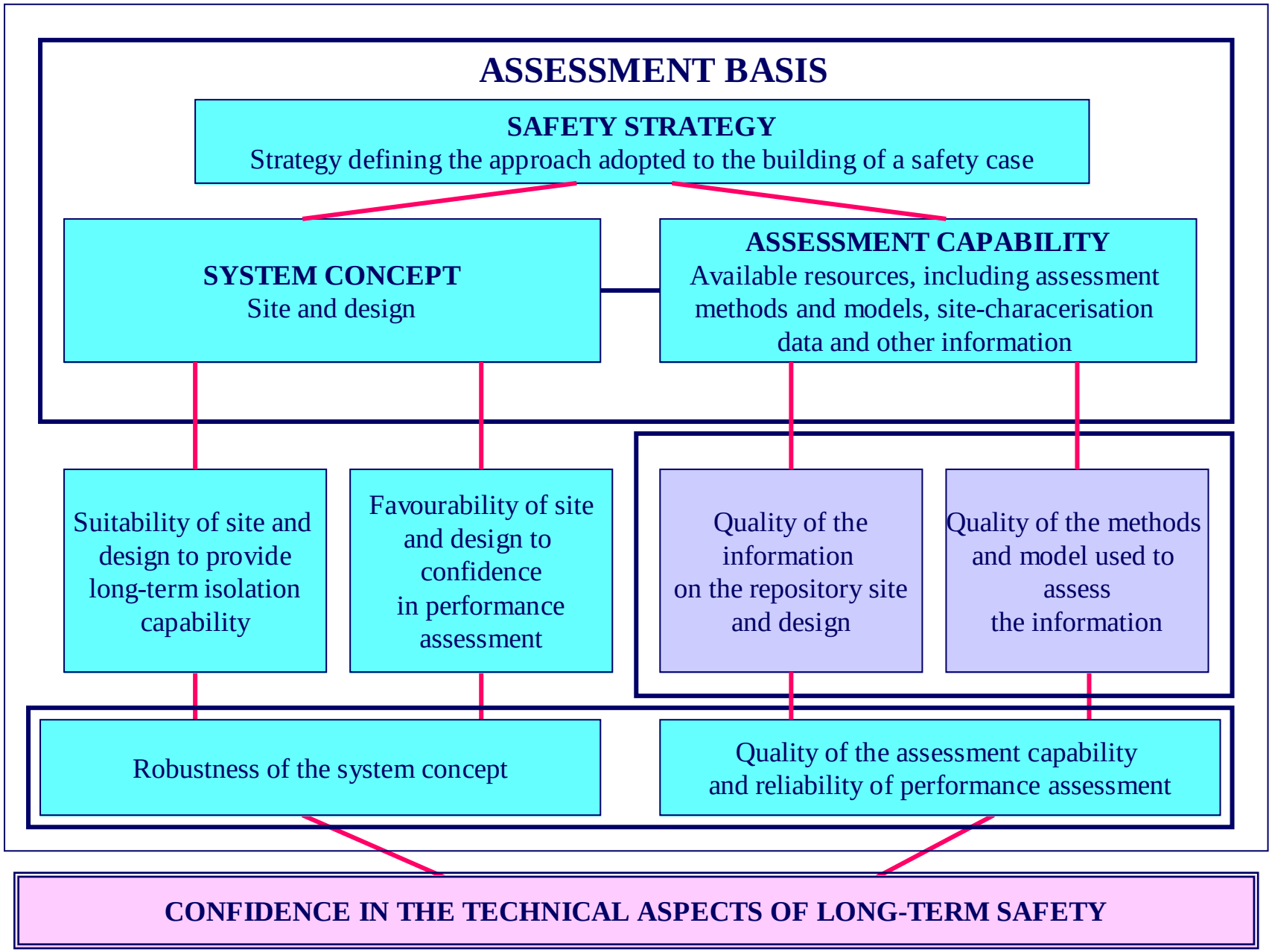
Challenges from within: Confidence by the regulator (direction:安心)

- The regulators have a special role in society: they have the competence, the tools and mandate to do what society needs before it takes a decision – i.e., to determine how confident we can be in a given solution

- The regulators must first determine their own confidence and then communicate it.

- The regulators need to make the assessment process transparent:
  - which are the confidence criteria to be evaluated for the different parts of the system and, in particular, for the safety case.
  - How these criteria are met in each case

from NEA Confidence document of 1999



NEA Peer Review Guidance questions

http://www.nea.fr/html/rwm/docs/2005/rwm-peer2005-2.pdf

[also: Pescatore, 2005]

- We developed 40 questions which regulators can ask to test the quality of the safety case and assess their confidence in it
- See application of those questions in the NEA peer review report of Nagra's "Entsorgungsnachweis"

⌦ What is the strategy for achieving safety (安全), i.e., an intrinsically safe system (robust system concept)?

- through the choice of site, design, and materials, avoiding or forcing to low probability or consequences most phenomena and uncertainties that could be detrimental to safety and its evaluation

⌦ WHAT IS THE STRATEGY TO ARGUE SAFETY (both 安全 and 安心)

- Declare role of barriers and system functions
- Identify and explain assessment cases
- Verify quality of tools, data, analyses
- Explain that PA is for **testing** system performance
- Analyse system *beyond* design basis and regulatory compliance points
- Use other indicators of safety and performance…..

Confidence criteria of the regulator…

- ... Confidence statement, etc.

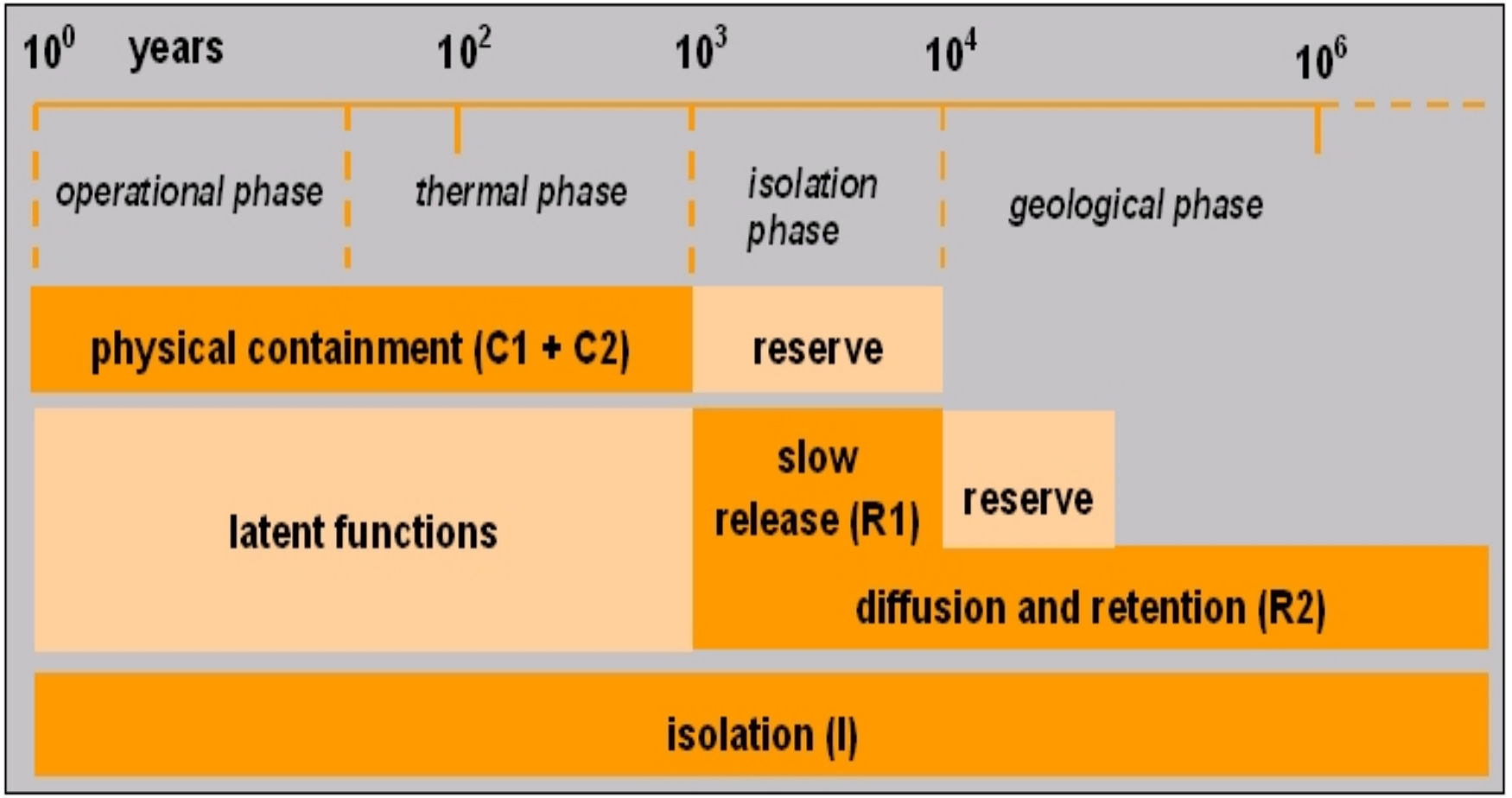
- ... Would be a good research area for **preparing the regulatory review** of safety cases and for preparing statements directed to the implementers, public, and politicians.

- The preparation of these criteria would be **a good basis also for interaction** with the above constituencies

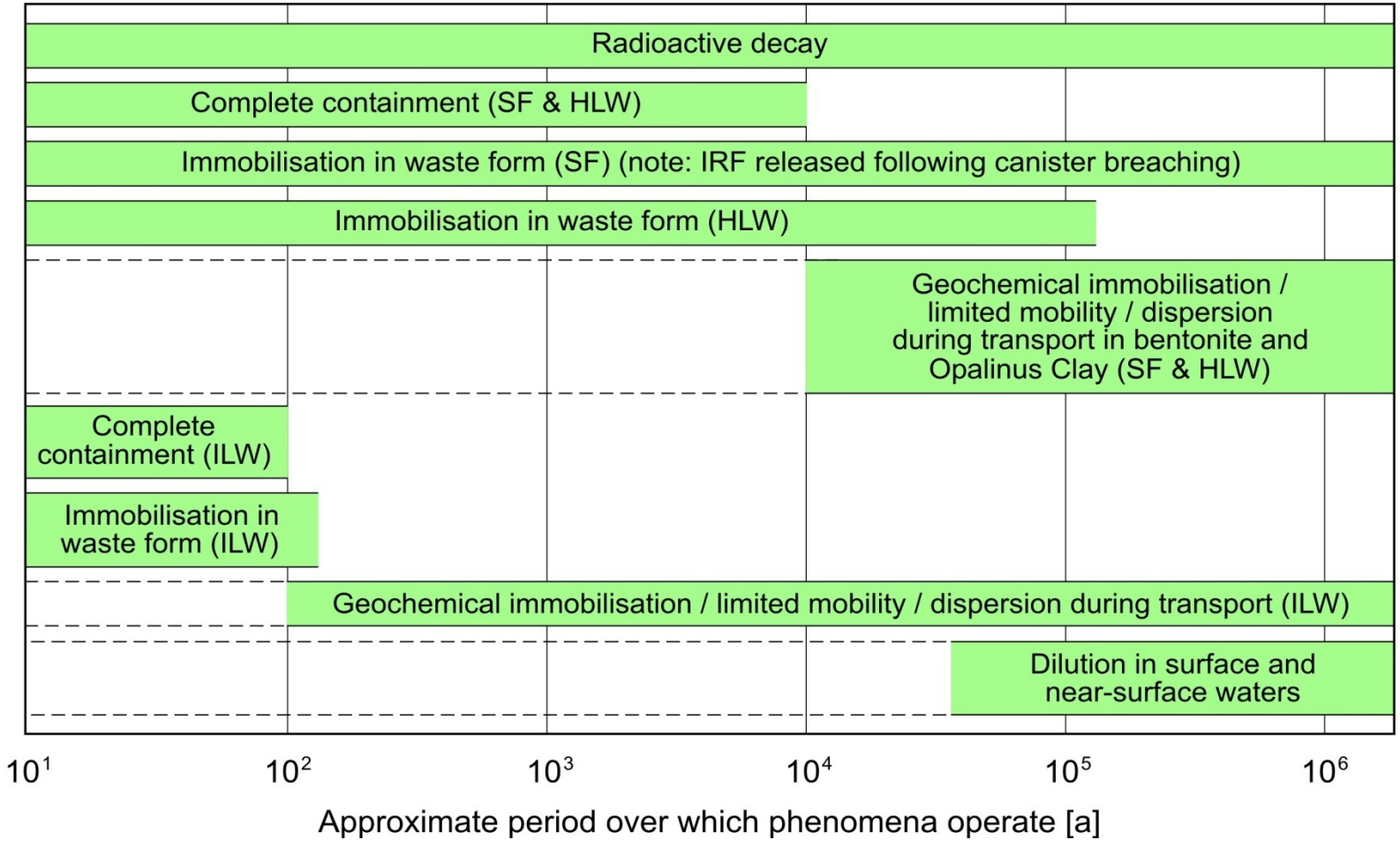
A safety case …

- Should document understanding or lack thereof
- Understanding will vary according to the time periods considered
- It is desirable to identify various time periods (or to request such identification) during which specific safety functions or processes may be relied upon.
  - Implementers are doing this already; regulators could encourage this practice.

Safety functions by time period (SAFIR-2)…



Safety processes by time period (Nagra) …



"Early times… and far-away times"

- Post-closure safety analyses tend to focus on the period between 1,000 and 1,000,000 years

- The periods beyond 1,000,000 years and before 1,000 years are however also important to regulators and the public for different reasons.
  - Regulators will need to show interest here.

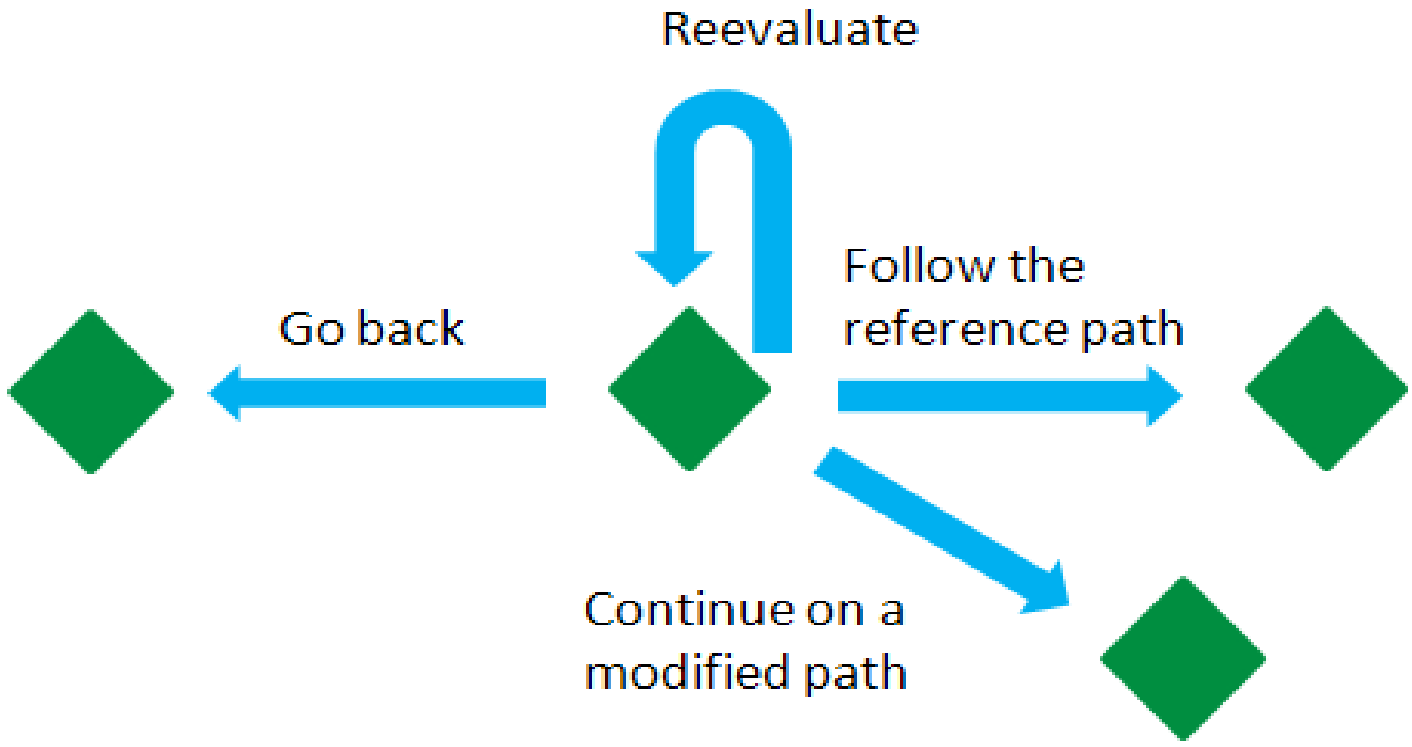
Challenges from within: During the first couple of hundred years …

- The full regulatory cycle can, should, and will be applied.
- Three issues seem important and not fully worked out:
  - The position of the regulator regarding **retrievability** till closure
  - The position of the regulator regarding **reversibility of decisions**
  - The position of the regulator regarding the **meaning of closure**

Retrievability of waste packages…

- Regulators ought to be clear about their position:
  - Is retrievability a “safety” (安全 or 安心) feature during operations ? Or not ?
  - Should retrievability be mentioned as existing/required, or should it be left as “understood” that during the operational period “one will always be able to retrieve containers”?
  - Can provision of retrievability during operations help better fulfill the **long-term safety** (安全) potential of the repository?

Reversibility of decisions …



Reversibility of decisions …

- Regulators' commitment to stepwise decision-making
  - A decision to move forward is fully meaningful only if other possibilities can also be envisioned.
  - A decision to go forward actually contains two elements: first, not to go back; second, to go forward on a specific path. Is this reflected in regulatory policy?
  - Does reversibility require retrievability?

Meaning of closure …

- Is closing of the repository, the same as the definitive "closure of the problem"?
- Or the beginning of a new phase? One of safeguards, surveillance, monitoring, active memory keeping,…for as long as possible* ?
  - What kind of regulatory regime would apply? That of an operating facility or that of "cleared" waste or that of exclusion from regulation?
- Can we be definitive now about a "walk away" policy at closure?
  - does national law indeed allow for a nuclear installation of a few Km-sq to become a piece of waste to be "abandoned"? Is closure of repository the same as releasing waste in Nature by dispersion?

* Continued surveillance is the ICRP suggested policy and dose constraint criterion, otherwise a clearance regime may apply….

Challenges from within: Period after closure and before 1000 years

- Period with great complexity of waste-environment interaction, but also one where no radioactive release is expected from HLW repositories
- Period when there is a chance that the regulatory cycle may be applied, and that nuclear competences continue to exist
- Period of most interest to the local public.
- Should we decide now to cease, at closure, monitoring, application of safeguards, etc.?
  - Why not consider that there is time to research monitoring schemes and other technological provisions for surveillance and that future regulators can assess their applicability?
  - Why not to involve the local community and authorities in memory keeping and in monitoring activities, which they typically demand?

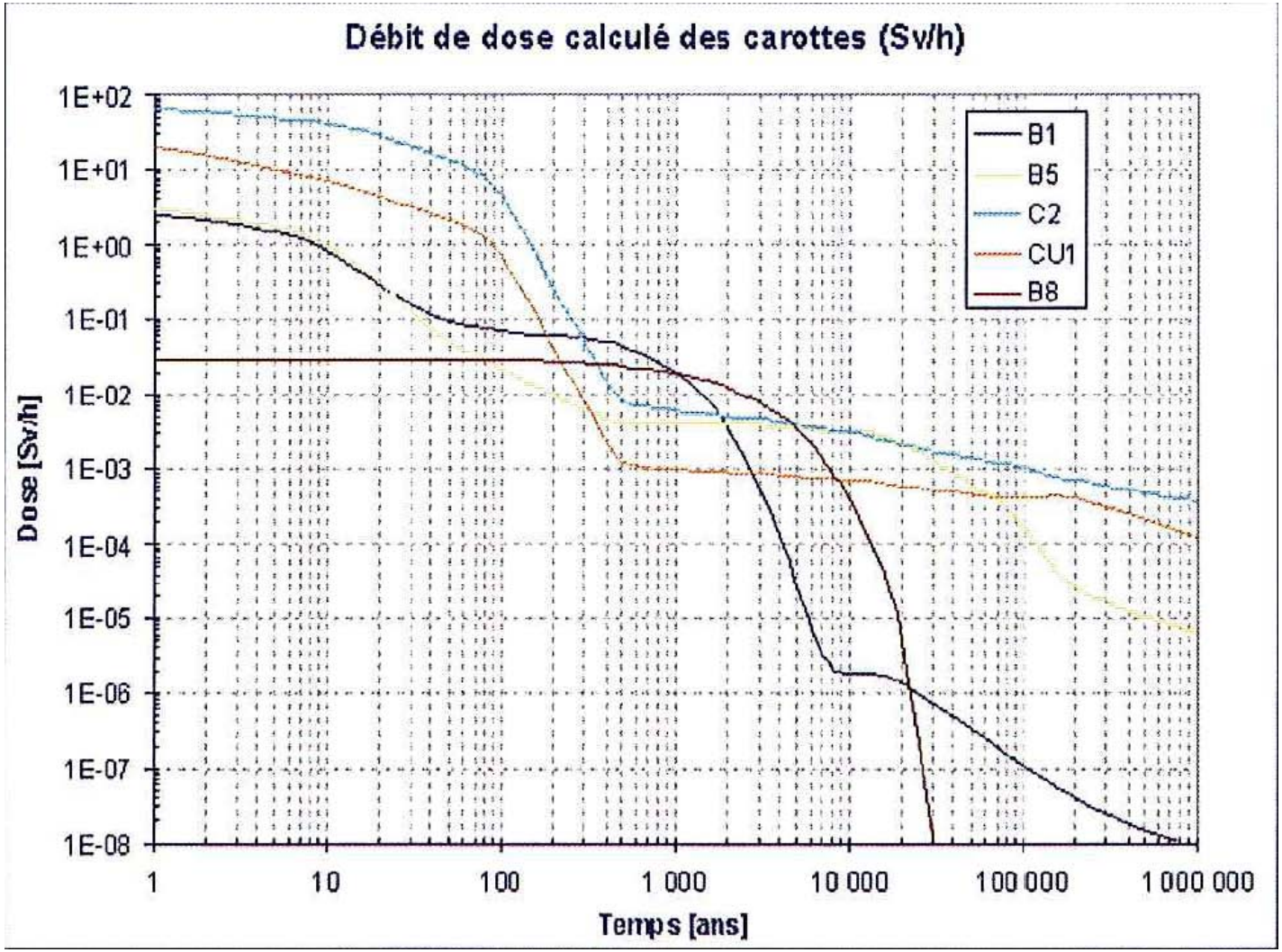
Challenges from within: Period beyond a few hundred thousands years …

- **There must be clarity, by the regulator, regarding whether the waste will ever be benign**
- More research is needed, e.g.,
  - If undiluted, when would the HLW change waste category?
  - When would the chemical toxicity of HLW be equal to, or greater than, its radiological toxicity? "*are we barking at the wrong tree?*"
  - If the potential hazard persists, e.g., during millions of years, can nothing be done to reduce the probability of exposure? [e.g., subduction areas]
  - If the hazard will persist, what ethical principles should we apply now -- even if uncertainties in predictions are high?

Recent (German) data for unshielded HLW glass cylinder …

Dose-rate 10-m away from the source at different times							
Time [years]	**1.0E+3**	**1.0E+4**	**1.0E+5**	**1.0E+6**	**1.0E+7**	**1.0E+8**	**1.0E+9**
Neutron Dose [µSv/h]	1,60E+00	9,54E-02	2,25E-02	3,80E-02	2,00E-03	5,78E-05	4,02E-05
Gamma Dose [µSv/h]	7,07E+01	3,65E+01	1,45E+01	3,04E+00	1,79E-01	2,29E-02	1,89E-02
Total Dose [mSv/h]	**7.2E-2**	**3.7E-2**	**1.4E-2**	**3.1E-3**	**1.8E-4**	**2.3E-5**	**1.9E-5**

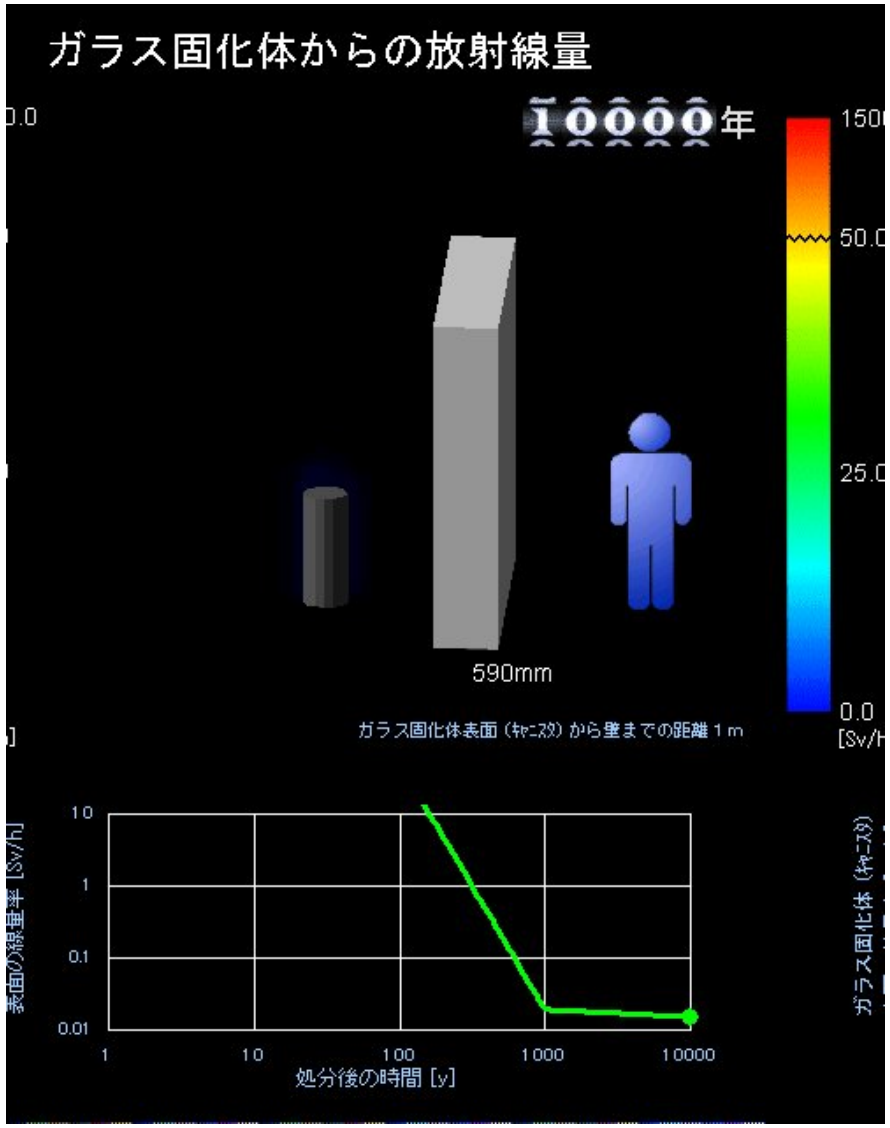
Dose rate to intruder as function of time (40 cm from source; C2=HLW sample of 40-cm Height, 10-cm Radius)



Culprits through the first 1.0E+7 years:

Pa-233; Th-229; Bi-213; Tl-209

“artificial chain radionuclides



Innovating for An-Shin with and for stakeholders - 1

- The public has confidence-needs similar to those of regulators.
  - Like the regulators they are the receivers of the project and need to make a judgement and to keep checking the well-foundedness of their judgement over time.

- Note that radioactive waste has a profound, symbolic dimension, highly visible to the public.
  - www.intoeternitythemovie.com

- The public needs to know and feel that there exists a competent and technically independent regulator, and that this regulator is in the service of the public.

- The regulator has to attend to the public needs.

Innovating for An-Shin with and for stakeholders - 2

- Regulator needs to be visible to the community and respond to their questions
  - On 13th January 2010: the West Cumbria Partnership (UK) heard a presentation from the Health and Safety Executive and the Environment Agency about the role that these regulators would play in regulating a geological disposal facility if it is sited in West Cumbria. The Nuclear Decommissioning Authority (the implementer) also gave a presentation on the issue of retrievability
  - SKI ran an exercise (the DIALOGUE project) with mock hearings to explain their role but also to understand it better.
  - *Large volume of Social Research activities in the Nordic Countries to refine the understanding of the Regulators roles, but also to become more visible and more accountable. Lately also in UK and Germany. In France the Advisory Group to the regulator has an NGO representative.*
  - *The future may bring about a culture of co-decision. Which signs in Japanese society? How to prepare for it?*

CONCLUDING REMARKS

- *Radioactive waste disposal is a "new game" vis-à-vis other nuclear regulatory activities: familiar concepts no longer apply unchanged; the timescales for safety are unique; radioactive waste has bad press; the implementation process is very long (challenge and opportunity)*

- *Regulation and regulators are fundamental to creating An-shin. There are many avenues for research into creating An-shin, they pertain both to the technical field and to social system of decision-making.*

- *Ultimately, the regulators' expectations for judging and for communicating safety are not so different from those of the public.*

- ***Regulators: consider your role not as an administrative function, but as a formidable intellectual adventure in the service of the public** !*

Elements to be represented

EBS & host rock	Hydrogeological system	Surface environment processes	Radiological exposure modes

Changes acting on these elements