THE LINK BETWEEN RESEARCH, DEVELOPMENT AND DEMONSTRATION AND STAKEHOLDER CONFIDENCE: THE PERSPECTIVE OF AN ACADEMIC

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In this paper, we will examine the potential role of science (as seen by an academic) for nuclear waste disposal projects, for the stage of site selection, site reconnaissance, and implementation, by the use of research, development and demonstration operations (RD&D) and how they may influence the stakeholders' confidence.

Science plays an obvious role

The *obvious* role of science in nuclear waste disposal projects can be seen as:

- Use of science and R&D to try to understand the physical system and its behaviour, both in space and through time (past and future).
- Design experiments to display the physical-chemical-biological processes at hand, both now and after waste emplacement.
- Measure the relevant parameters.
- Assess the residual uncertainty in both conceptual model and parameter values.

To convince stakeholders, its is necessary to show that the system is well understood:

- Explain the past geologic history of a site.
- Explain unexpected features (e.g. seismic anomalies, abnormal pressures,…).
- Show the capacity to observe and notice unexpected features.
- Show the capacity to imagine new measurements that can learn something on the system.
- Derive an experiment to scientifically validate a theory.
- Show the capacity to be at the frontier of science.
- Show the capacity to answer unexpected questions from any party.

Some particular examples may be brought here to illustrate the relevance of the above desired actions. During a briefing previous to the visit of the Bure site in clay (France), the public was informed that the clay layer was almost "completely impervious", which in many cases was mistakenly interpreted as implying the "absence of water", with the subsequent surprise when visiting the underground facility. The physical explanation of why there is so much water in the clay (porosity of about 10%), but that this water has a very low mobility requires explanations, and scientific evidence that this water is non-mobile (e.g. with water molecule isotopes).

Another example of unexpected results was the ^{36}Cl measurements at Yucca Mountain. At the time of the measurements, the current theory was that the water in the volcanic tuff was almost immobile. Therefore the ^{36}Cl tracer (coming form the atmospheric bomb tests in the Nevada Test Site in the 1950's) should not be present at depth. But some scientist of the National Labs decided to sample the water in the unsaturated zone and to measure ^{36}Cl. And there it was ! This example shows that allowing scientists to perform experiments that are initially considered as unjustified, just to test hypotheses, or invalidate the current model, is of major importance to understand the system and gain confidence. The same happened concerning migration of Pu in the aquifers, from the underground nuclear tests in the Nevada test site.

A third example at the WIPP site concerns the mechanical behaviour of salt. Initially, the R&D programme very ambitiously decided that the mechanical parameters characterizing the behaviour of salt would be measured from core samples, and then the prediction of the mechanical evolution of the *in situ* excavations would be made before construction by modelling, and then compared with the observations. If the two matched, this would have been a strong demonstration of understanding and of being able to predict. In practice, this was too ambitious, and the match was not perfect, inducing the revision of the mechanical model. But the scientific merit of this protocol in terms of confidence building remains clear.

In summary, for science to perform successfully its fundamental understanding role, two actions are called for:

- The continuous exercise in-the-field of the scientific enquiry process, notably of the capacity for observing and noticing unexpected features and validating theoretical predictions.
- To increase the awareness of the scientific community towards the special nature of the societal decision to be taken, and the level of information and questioning required by the public.

Role of the academic circle in the R&D programmes

In the above, the role of science was emphasized independently of the positions of the scientists involved. Let us now consider the potential role of the academic circle (universities, independent research organisations …) to address the credibility issue. This role can be:

- Increase the credibility of the outcome of R&D first to the rest of the scientific community, and then to the stakeholders, by independently validating the scientific quality of the work performed by the implementer.
- Increase the credibility by acting as peer reviewers, e.g. through publications in the scientific literature by the scientists of the implementers, in the Journal having the highest possible impact.
- Increase the credibility within the implementers-regulators own institutions by helping them attract and keep high calibre scientists, and have them do good work.
- Be the source of interesting problems suitable for training brilliant young Ph.D. students.

With this pre-requisite of acceptance by the scientific community, the credibility by the stakeholders may be addressed, although it is by no means granted. A particular note concerns the need for regulators to carry out a scientific exercise of the same scientific quality than the implementers. Both types of organizations need to attract and maintain the best scientific personnel and the latter cannot be achieved without challenging research and development programmes. They thus need to maintain strong links with the academic circle.

Why should science also develop somehow independently of the project?

Developing a nuclear waste repository project should also include a scientific component that is neither necessarily directly applicable nor useful to the project. Reasons for this can be:

- Potential benefit of R&D to scientific knowledge in general; for instance, if a project is abandoned before its conclusion, for any reason, the only benefit left to society will be the increase in scientific knowledge.
- Purely scientific R&D activity can also be recommended when a project is put on hold, pending political decisions; rather than having the staff kept without prescribed goals, the time may be better spent pursuing scientific objectives.
- Pure scientific R&D activity can also be pursued for the benefit of the convincing power of enthusiasm.
- Pure scientific R&D can be a valid objective, with waste disposal as a means to finance pure research; society is ready to finance research with no direct application, such as astronomy, or archaeology, etc. Why would fundamental research not be financed partly with funds dedicated to an applied objective? In France, for example, there is a small percentage of the costs of building a construction (road, building, train track, …) which should be made available for archaeological research, if initial findings justify it.

Demonstration phases may feedback into R&D (and science)

Demonstration phases are primarily a requirement to show the practical feasibility of a project (e.g. waste emplacement techniques, reversibility…) and will satisfy stakeholders as a part of the credibility (e.g. in France, the reversibility issue is not considered credible by the public, and only a trick to make the project more acceptable; a demonstration would possibly change this). Although demonstration may feedback to R&D programmes by showing unexpected difficulties or features (and inevitably they will), they are more likely to contribute to engineering knowledge.

Conclusion

The above discussion only relates to “hard” sciences. However, social sciences are also concerned by issues of decision making, discussion, acceptance or rejection, with stakeholders and the public. These should not be considered as applied research on the best means to make a given project acceptable, but also as pure research on major societal decision making and governance.

The direct involvement of the physical scientists on the discussion with the stakeholders and the public is also an important issue.