ENSI'S RESEARCH STRATEGY

May 2023

Schweizerische Eidgenossenschaft
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Eidgenössisches Nuklearsicherheitsinspektorat ENSI
Inspection fédérale de la sécurité nucléaire IFSN
Ispettorato federale della sicurezza nucleare IFSN
Swiss Federal Nuclear Safety Inspectorate ENSI

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1

Basics of research and how it is financed

When nuclear energy is utilised, people and the environment must be protected against hazards due to ionising radiation.[1] For preventive purposes, it is necessary to implement all the precautions that are required on the basis of experience and in keeping with the latest scientific and technological developments.[2] According to international guidelines, the respective national authorities should implement measures to build up and maintain the expertise of all involved parties who are responsible for the safety of nuclear plants. Research and development are among the most important means of achieving these objectives.[3]

In Switzerland, the Confederation may promote applied research into the peaceful use of nuclear energy, especially as regards the safety of nuclear plants and nuclear waste management. In this field, it may support the training of specialists or may carry out such training itself,[4] and it can also participate in international projects on the peaceful use of nuclear energy.[5] In addition, the Federal government promotes scientific research into the effects of radiation and radiation protection, together with training in the field of radiation protection.[6] As far as civil protection is concerned, the government also co-operates with the Cantons on research and development, and it supports collaboration at national and international levels.[7]

Under the terms of the credits that are granted, the supervisory authorities are obliged to promote research, teaching and training of experts related to the safety and security of nuclear plants, and in respect of nuclear waste management.[8] These activities should involve applied – rather than basic – research.[9] The supervisory authorities may also commission or take part in research projects focusing on the effects of radiation and radiation protection.[10]

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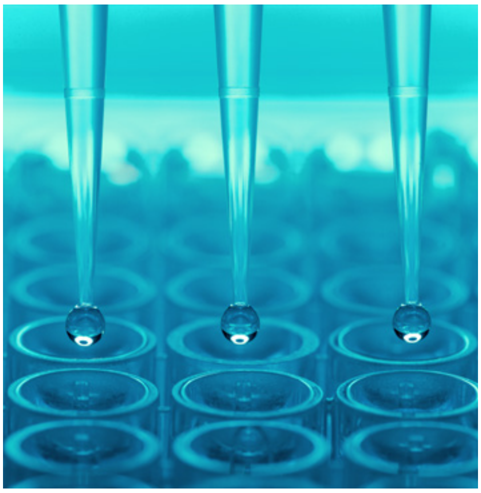
[1] **As per Art. 4, paragraph 1 of the Swiss Nuclear Energy Act (NEA/KEG).**
[2] **As per Art. 4, paragraph 3, letter a, NEA.**
[3] **As per the IAEA General Safety Requirements, Part 1: Governmental, Legal and Regulatory Framework for Safety; cf. in particular Requirements 1, 10 and 11.**
[4] **As per Art. 86, NEA.**
[5] **As per Art. 87, NEA.**
[6] **As per Art. 5, paragraph 1 of the Federal Law on Radiological Protection (LRaP/StSG).**
[7] **As per Art. 4 of the Federal Law on Civil Protection and Protection and Support (BZG).**
[8] **As per Art. 77 of the Nuclear Energy Ordinance (NEO/KEV) and the Explanatory Report on the NEO (Art. 76).**
[9] **As per Art. 86, paragraph 1, NEA and Section 8.8.4 of the Dispatch regarding the NEA.**
[10] **As per Art. 186, LRaP.**

The Swiss Federal Nuclear Safety Inspectorate (ENSI) is the Federal government's supervisory authority for nuclear plants. It performs the tasks assigned to it in accordance with the legislation on nuclear energy, radiation protection, population and civil protection, and the regulations on the transportation of dangerous goods.[11] In order to carry out its supervisory activities in a professional manner, ENSI must keep abreast of the latest developments in science and technology. For this purpose, ENSI may undertake research itself, and it may also support nuclear safety research projects.[12] In addition, the results of research provide the basis for its decisions.[13]



The research projects undertaken or supported by ENSI may also include development work that draws on available knowledge, such as test results, but that essentially delivers new findings, as opposed to the merely applying existing routine for the purpose of services provided (consultations, expert reports, routine measurements, training, etc.).[14] Basic research devoid of aspects that can be utilised for supervisory activities does not fall within the category of regulatory safety research.

Research and development work can be billed only if it falls within the scope of ENSI's remit, i.e., it must relate to safety and security issues.[15] ENSI collects fees from the owners of nuclear plants, nuclear goods and radioactive waste for research and development work undertaken or arranged for individual nuclear plants in the course of its supervisory activities.[16] The Federal government also pays a contribution, which is used to finance additional applied safety research.[17] Moreover, in order to cover the costs of supervisory activities that cannot be allocated to specific nuclear plants, ENSI collects an annual supervisory levy from the proprietors of nuclear plants;[18] this can also be used to pay the costs of research and development work undertaken at ENSI's behest.

ENSI endeavours to ensure that the Federal government finances an appropriate proportion of regulatory safety research.

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[11] As per Art. 2, paragraph 1 of the ENSI Act (ENSIG).
[12] As per Art. 2, paragraph 3, ENSIG and the Dispatch regarding the ENSIG.
[13] As per the ENSI Management Manual, "Basics of Supervision" process (HPB0140).
[14] On the basis of the Policy Paper on Research and Development at Universities of Applied Sciences, Rectors' Conference of the Swiss Universities of Applied Sciences (KFH) (2008).
[15] As per Section 8.8.1 of the Dispatch regarding the NEA.
[16] As per Art. 83, paragraph 1, NEA.
[17] On the basis of Art. 86, paragraph 1, NEA; the funds are transferred to ENSI by the Swiss Federal Office of Energy (SFOE).
[18] As per Art. 83, paragraph 2, NEA, and Art. 3, paragraph 2 of the ENSI Fee Regulations.

2

Objectives

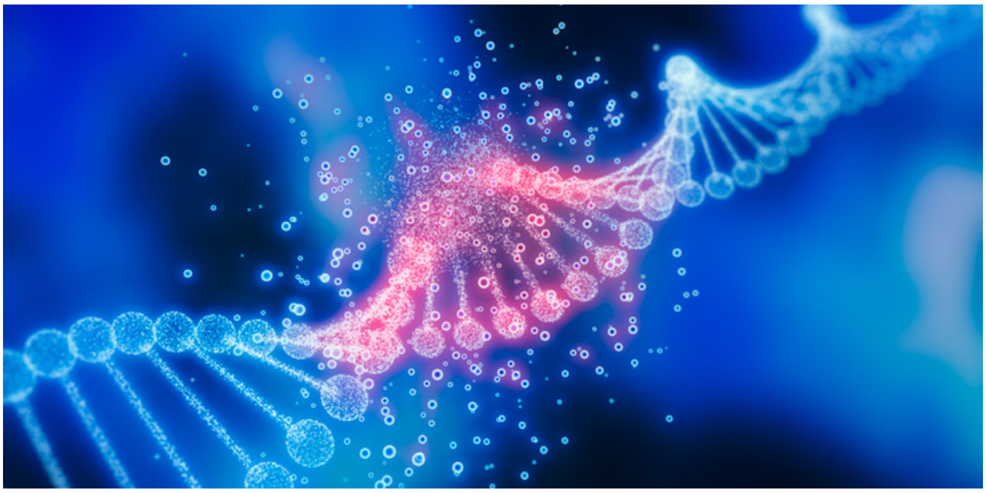
ENSI undertakes and supports projects under the auspices of its "Regulatory Safety Research" programme. In so doing, ENSI pursues the following objectives in particular:

1. **Investigation of unresolved issues:** Questions regarding the safety of nuclear plants that are as yet unresolved arise not only from ongoing supervisory activities, but also in the course of the general development of science and technology. Research projects should make it possible to identify potential problem areas, to develop potential improvements, to reduce uncertainties and to improve processes. In these ways, such projects should play their part in maintaining and enhancing the safety of Switzerland's nuclear plants. In order to identify these issues, ENSI primarily takes account of developments in international bodies, the results of ongoing research projects and specialists' conferences; it also considers recommendations from other Federal institutions, especially those from the Federal Nuclear Safety Commission (NSC/KNS).[19] Specifically, moreover, it aims to close gaps in knowledge which are not covered by the research programmes of the supervised entities.

2. **Practical support for supervisory activities:** Research projects should deliver or continue to develop basic principles and aids that ENSI requires in order to carry out its tasks. This is the most important objective and is also an indispensable prerequisite when allocating the costs of research work (see Section 1).

3. **Maintaining and expanding expertise:** Research projects should help to maintain and expand ENSI's expertise and, as a secondary aim, that of ENSI's own specialists. Research projects carried out in Switzerland are advantageous for this purpose, especially if they include training.

[19] As per Art. 2 of the Ordinance regarding the Federal Nuclear Safety Commission (NSCO/VKNS).



4. **Promotion of independent expertise:** Research projects, especially those which entail practical support for supervisory activities, can, to some extent, create the basis for expert reporting and for the operational monitoring of nuclear plants. In specialised areas where ENSI calls on external experts, research projects should help to develop independent expertise that will prevent potential conflicts of interest.[20] For this purpose, and in order to encourage diversity, ENSI aims to base its research on different institutions.

5. **Promotion of international interchange:** A substantial proportion of international interchange at specialist level takes place in committees and similar bodies which control research and assess its results. This applies in particular to the bodies of the Nuclear Energy Agency (NEA) within the Organisation for Economic Co-operation and Development (OECD). Moreover, many research projects can only achieve helpful results with the help of contributions from multiple countries. Regulatory safety research should foster the international integration of ENSI into specialist networks.

6. **Making ENSI a more attractive employer:** Involvement in research projects includes varied activities aimed at acquiring new knowledge; this work should make ENSI more attractive to new employees, especially younger and highly qualified individuals.

[20] **Cf. also the IAEA General Safety Guide GSG-12 (2018): Organization, Management and Staffing of the Regulatory Body for Safety, Appendix I: External expert support.**

3

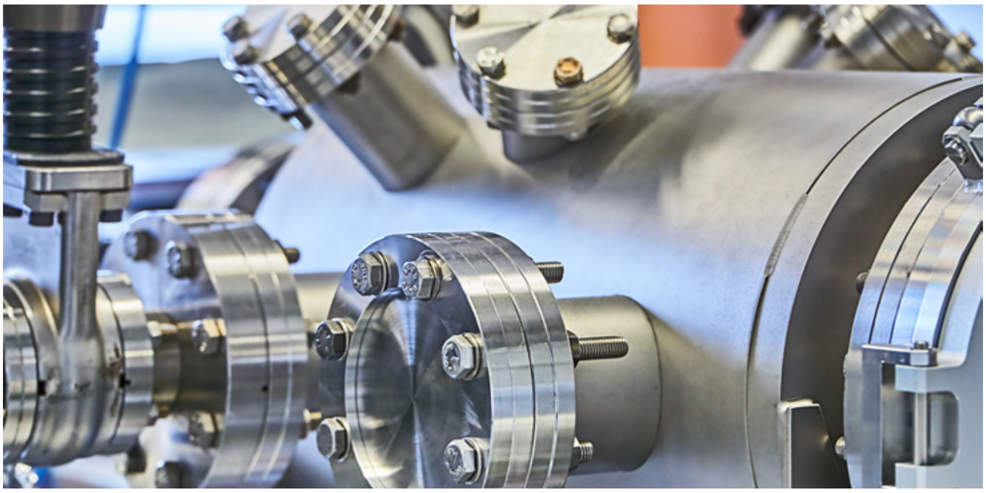
Criteria

In accordance with its legal basis and overall objectives, ENSI assesses support for proposed research projects according to the following specific criteria:

1. **Technical and quality aspects, in particular:**
   a. Specialist / scientific requirement for the project in order to improve the safety of Swiss nuclear plants on the basis of the existing level of knowledge; also, avoidance of undesirable overlaps with ongoing or completed projects.
   b. Expected quality of the work on the basis of the application, publications and other proven achievements, also on the basis of ENSI's past experience with the applicants, where appropriate. This includes both technical aspects and formal criteria, such as compliance with deadlines and reporting.

2. **Relevance to supervisory activities:**
   Utilisation of the project results for specific supervisory work by ENSI that is scheduled in the foreseeable future or is already in progress. This point is especially important for assigning priorities to projects. Assessments should be based on a clear plan for applying the results. Prime examples include:
   a. where the results have an influence on regulations or certain ENSI decisions relating to nuclear installations;
   b. where the research work develops or improves simulation programs used by ENSI and its experts when carrying out safety analyses;
   c. where the research work develops or improves technical facilities or investigative methods used by ENSI and its experts;
   d. where data obtained from research work is incorporated in probabilistic or deterministic safety analyses for nuclear installations as carried out by ENSI;
   e. where the results are used to help plan ENSI inspections or assess in-service inspection programmes and maintenance measures.

3. **Maintaining and expanding expertise:**
   Specific training/educational measures – especially the completion of degree or masters' dissertations and doctoral theses – constitute a key criterion for prioritising research projects. If projects are equivalent in other respects, ENSI gives preference to those that entail training or education in Switzerland.



4. Impact on future recruitment of experts:
   Project applications are reviewed to determine whether ENSI could commission the applicants to draw up expert reports on nuclear plants in the future. ENSI experts must be independent of the parties supervised by ENSI and there must be no conflicts of interest.[21] For these reasons, ENSI gives preference to research projects by institutions whose employees are unlikely to be involved in conflicts of interest in the relevant specialist area if they undertake potential expert work for ENSI at a later stage.

5. Promotion of ENSI's integration into international networks:
   This aspect relates in particular to projects with participation by organisations from various countries, which can therefore deliver results that could not be obtained in Switzerland alone. Examples include comparative calculations by various groups of research institutions or supervisory authorities (known as benchmarks) or the systematic identification and analysis of infrequent types of damage and events in nuclear plants.

6. Demarcation from the remit of supervised parties:
   Research supported by ENSI must not comprise substantial parts of the supervised parties' own duties. Within international projects that also involve representatives of operators or manufacturers of nuclear plants, ENSI advocates the priority of safety aspects and/or support for supervisory activities.

7. Risk analysis:
   In case of foreseeable problems, especially if difficulties have already arisen in connection with comparable projects in the past, the applicants must carry out a risk analysis. Examples include difficulties with the international transport of radioactive samples, or problems with staff recruitment. Applicants must clearly show how they will avoid – or, if necessary, resolve – problems of this sort.

[21] **The ENSI Management Manual, "Procurement" process (HPB0460) sets out detailed criteria for ENSI experts.**

4

Control of research

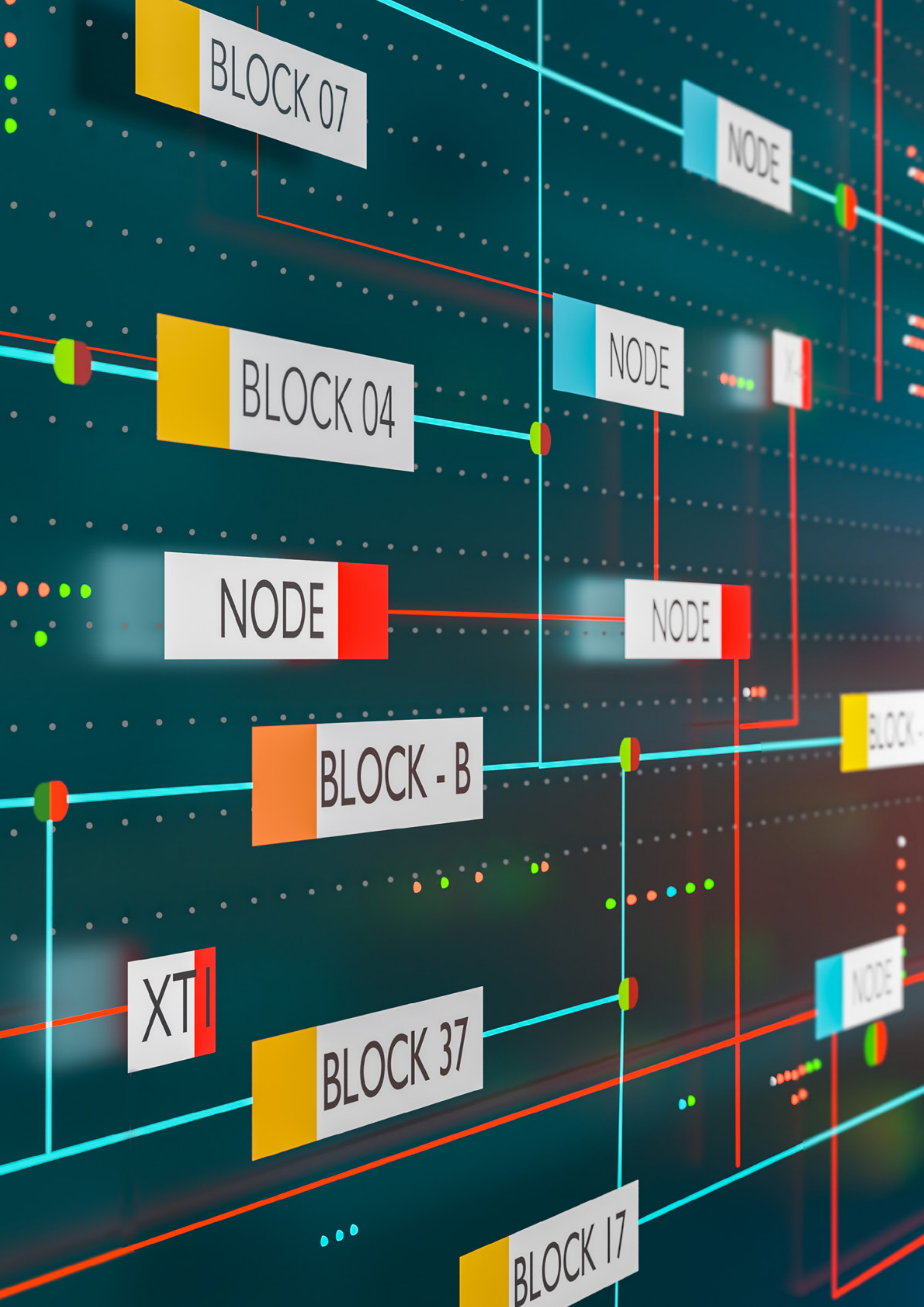
Control of the "Regulatory safety research" programme is based on the ENSI Management Manual (MHB). According to the strategy followed by ENSI, every research project which is not managed by ENSI itself is followed by (at least) one individual from the relevant specialist area at ENSI. The project supervisor monitors the project and ensures that the knowledge gained from it is incorporated into ENSI's ongoing supervisory activities. Involvement in research projects as a means of maintaining and expanding expertise is a key function for specialists.

A central unit – Research Coordination – is responsible for carrying out higher-level tasks and represents regulatory safety research to the outside world. More specifically, this unit is the first internal and external point of contact for project applications, and it manages research results centrally as part of ENSI's knowledge management system. The Executive Board decides on project applications when requested to do so by Research Coordination. In particular, the Executive Board is responsible for prioritising the applications.

ENSI assesses Nagra's research programme as part of its role to comment on the periodically produced waste management programmes of those responsible for disposal. ENSI monitors the content of research programmes undertaken by all supervised parties.

ENSI briefs the public on regulatory safety research at regular intervals. The most important element is the annually published Research and Experience Report, which the Research Coordination is responsible for drafting. The project supervisors also assess research work in their reports and explain how the results of this research will be utilised in supervisory activities. The Research and Experience Report is a tried and tested mechanism that is also recognised at international level. This is shown by the assessment as "good practice" according to the review mission of IAEA Integrated Regulatory Review Service (IRRS) in 2011.[22]

[22] Good Practice GP4 in: Integrated Regulatory Review Service (IRRS) report to Switzerland. Brugg, 20 November to 2 December 2011.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Thematic orientation

ENSI's Research Coordination continuously reviews potential subjects for research in liaison with the specialist divisions. On the basis of the research strategy, the Executive Board adopts a research plan which describes the key research projects for the next four years, with the aim of ensuring that the planning is reliable.

In the coming years, ENSI's research activities are expected to focus on the following subject areas:

1. long-term operation of nuclear power plants, especially matters relating to material ageing;
2. effects of earthquakes on buildings, systems and components of nuclear installations;
3. waste disposal issues relating to the construction of deep geological repositories, including the encapsulation plant and long-term dry storage of spent fuel elements;
4. radiation exposure of humans and the environment.

The most important challenges for the core subject areas covered by regulatory safety research over the next 5–10 years:

The following subject areas and challenges are not listed in order of priority.

1. Long-term operation of nuclear power plants, especially matters relating to material ageing:

This subject is a matter of urgency in view of the open-ended operating licences granted to Swiss nuclear power plants to ensure they can operate safely in future decades. The focus will be on cooling-circuit components, especially elements that cannot be replaced, such as the reactor pressure vessel. The following aspects will be considered particularly closely:

a. the influence of environmental conditions, such as water chemistry, temperature and neutron radiation, on ageing processes;
b. overlapping ageing mechanisms;
c. comparison of components from nuclear power plants that have been in operation for many years with sample material from generic laboratory tests and surveillance samples;
d. analysis of current and novel non-destructive testing techniques with regard to the detection of defects and determination of the size of defects;
e. probabilistic integrity investigations.

2. Effects of earthquakes on buildings, systems and components of nuclear installations:

Earthquakes represent very significant natural hazards. Very powerful earthquakes constitute the major contributor to core damage frequency in probabilistic safety analyses for Swiss nuclear power plants. Swiss research into how earthquakes arise and how seismic waves are propagated underground to the sites of nuclear installations has achieved a high standard that is continuously being expanded. This focus concerns the impact of seismic waves on buildings in nuclear installations and on the safety-relevant systems within these installations. It covers the following aspects in particular:

a. uncertainties and variance figures for the transmission of seismic waves from the subsoil to structures (soil–structure interaction);
b. changes in the condition and behaviour of structures under the impact of accelerations, and the consequences of the latter on how safety-relevant systems/components are anchored in these structures;
c. potential damage to systems/components as a result of these (modified) accelerations and circumstances such as resonance phenomena in particular;
d. strategies to assess the extent to which the events in points 2(a–c) can be simulated in comprehensive, combined simulation exercises.

3. Waste disposal issues relating to the construction of deep geological repositories, including the encapsulation plant and long-term dry storage of spent fuel elements:

To date, ENSI has geared its research into the disposal of radioactive waste towards the assessments required by the Sectoral Plan for Deep Geological Repositories. As the deadline for finding sites approaches, this focus will gradually shift to the construction of deep geological repositories and the encapsulation plant. In view of the plan to commission a deep geological repository for high level waste from 2060 onwards, the periods over which spent fuel elements will need to be stored on an interim basis have also been extended. The key aspects are:

a. methods for monitoring the safety criteria for spent fuel elements during long-term dry storage, as well as for transport and storage containers (temperatures, changes in material properties, fuel rod integrity, etc.);
b. physical behaviour of the Opalinus Clay as a result of tunnel excavation;
c. coupled processes in the dispersal of radionuclides in a deep geological repository and how these are simulated, taking temperature and pressure changes in the near field into consideration;
d. the impact on radiation exposure in the environment of radionuclides that are dispersed in the long term;
e. external influences that, in the long term, may have an adverse impact on the containment effect, such as tectonics, as well as fluvial and glacial erosion processes.

4. Exposure of humans to radiation:

Public awareness of scientific studies into the consequences of radiation exposure in the low-dose range is growing, heightening social debate about the associated risks. The International Commission on Radiological Protection (ICRP) is currently revising the fundamental recommendations to ensure that the latest research results can be taken on board in an appropriate manner. Interpreting these results poses a challenge due to the inherent uncertainties in the database and the complex nature of the subject matter. At the same time, there is growing pressure to use technical resources to reduce radiation exposure still further. The following research disciplines are particularly important in terms of acquiring knowledge and continuing to develop the state of the art with respect to science and technology in the field of radiological protection:

a. epidemiological studies of individuals with occupational radiation exposure, atom bomb survivors and people affected by nuclear accidents, for example;
b. radiobiological studies, such as analysis of radiation damage on genetic material or of metabolites for individuals who have been exposed to radiation;
c. development of radiation-resistant, remote-controlled technology to optimise radiation exposure during normal operation and incidents.

Regulatory safety research is also expected to cover the following specific subject areas:

- integrity of fuel rods during operation and extent of damage in the event of design-based accidents, especially reactivity-initiated accidents (RIA) and loss of coolant accidents (LOCA);
- water chemistry of the cooling circuit in nuclear power plants;
- internal damage and events such as fires and component failure;
- effects of an accidental aircraft crash on buildings, systems and components of a nuclear power plant;
- other natural hazards (apart from earthquakes), including the impact of climate change;
- human factors, especially the reliability of operator actions, alongside organisational aspects and how to preserve knowledge;
- system behaviour, incidents and severe accidents;
- applied radiological-protection topics, including decontamination methods for systems and components.

ENSI does not support research into the new Generation-III reactors or the possible future Generation-IV reactors, as these have no relevance for ENSI's specific supervisory activities. However, ENSI does monitor international developments in this field to ensure it is abreast of the latest state of the art in science and technology.

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