Nuclear Research Institute Rež: Its past and present and future challenges

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Abstract . The paper gives an overview of the history of the Nuclear Research Institute Rež development over forty years of its existence. Its present activities are discussed in some detail. These historical and present activities represent the basis for discussing:

- challenges faced by the NRI
- interactions of NRI with their environment
- collaboration and co-operation

nuclear research centres would continue to be the main source of expertise for power plant operation, radiation and isotope applications, regulatory practices and waste management. Future developments should ensure viability of these centres.

History and present activities

In the beginning, the Institute of Nuclear Physics of the Czechoslovak Academy of Sciences was founded on June 6, 1955 as a centre of all nuclear activities to support their rapid development which had at the time begun.

Subsequently, at Rež near Prague a number of original facilities: 2 MW research reactor, cyclotron, hot and semi-hot laboratories and some other were constructed in a very short time, indeed (for details see the Appendix).

As a result of fast advancement of nuclear power the Institute with 1450 employees, was on January 1, 1972 divided into two unequal parts. The larger one (1050 employees) predominantly engaged in applied research was transferred as the Nuclear Research Institute under the competence of the Czechoslovak Atomic Energy Commission; the smaller part — basic physical research — remained within the Academy of Sciences as two of its Institutes.

On December 31, 1992, the NRI, along with all applied research organisations, has been privatised and became the NRI Rež plc. Present NRI shareholders are actually its main customers: the state (Czech Republic), Czech Power Company (ÈEZ, a.s.), Slovak Power Company (SEP, a.s.) and ŠKODA Nuclear Machinery (a minor shareholder is village Rež.

The NRI activities have always followed the national programme of peaceful use of nuclear energy and the necessary development of the relevant scientific issues has always had a necessary priority. During its forty-five years of existence the Institute's orientation was developing along with the development of Czechoslovak (Czech) nuclear programme, and especially its nuclear power part.

The following diagram summarises the main R&D topics (as well as service oriented effort) pursued by the NRI over 40 years period, as its was summarised at the occasion of its 40th anniversary. In the periods of 1955 — 1972, i.e. when NRI had been an Academy of Sciences Institute, its operation was completely covered by the state budget. Since 1972 up to 1992 the

Institute was operated as a state subsidised organisation (no depreciation, completely state-financed investment and state subsidies for operation of the large facilities). The R&D projects were, with a few exceptions completely covered by the state (Nuclear Safety Research Project, etc.), were as a rule financed by the state (50% of costs) and industry.

At the 1992 transformation, there are no direct state subsidies, as it is common for all applied research institutions in the Czech Republic. This situation is, however, being reconsidered in connection with the preparation of a new state research policy. Thus, the Institute financial sources are either contracts with individual customers, contracts with the state administration bodies awarded as result of a specific tender, or the state financial support for R&D activities (usually limited by up to 50%, as it had been in the past). Revenues from the contracts with the Czech customers in 1998 represented 50.3% and state resources — of 15% order of the total revenues (see enclosed Annual Report 1998).

Such transformation was accompanied (in 1989 — 1993) with reduction of the Institute's staff from 1050 to 600, partially due to outsourcing of some service activities and partially due to an increased staff efficiency.

Current main activities of the Institute are well supported by a number of special facilities:
- experimental reactor (10 MW) with several material testing loops (PWR and BWR simulation),
- zero-power reactor (LR-0),
- cyclotron (for production of PET radiopharmaceuticals),
- electron accelerator,
- Co and other irradiation sources,
- facility for testing the large components integrity,
- molten salt loop for material testing,
- unique system of hot and semi-hot laboratories,
- experimental facilities for nuclear waste solidification (bituminization, cementation and vitrification),
- technological halls,
- laboratories specifically equipped for the production of radiopharmaceuticals, including cyclotron ones (PET),
- analytical and a number of other well equipped laboratories.

These activities are oriented on the following fields:
- support for safe operation of Czech nuclear power plants,
- support of the Regulatory Body activities,
- support for the Waste Management Agency,
- contract based R&D and services for foreign organisations,
- production of radiopharmaceuticals,
- services for basic research,
- know-how transfer to non-nuclear industry (chemical, oil processing, aircraft industry),
- technology supplies,
- support of the governmental activities in relevant policy development.

A major part of this effort are services and production, nevertheless, R&D remain a significant part of the Institute activity. R&D is financially supported by the Czech government, and recently also by the EU (within the framework of 5th EU Framework

Programme). This activity is of course greatly benefits from the international, multilateral and bi-lateral co-operation, as it always had been.

Challenges faced by the NRI

As with many other nuclear research centres, our Institute faces many challenges and connected with them difficulties, some of which are common and some of them are specific.

Our first and most important challenge is to provide such a support to Czech Operator of nuclear power plants (WWER) which shall assure their safe and efficient operation and optimum life utilisation. Along with that we shall participate in maintaining the infrastructure necessary for adequate safety culture and long term needs of the nuclear industry.

According to the state energy policy, the Czech Republic will in the years 2015–2020 need a new electricity generating capacity (as a result of service life exhaustion of many coal-fired plants as well as of exhaustion of the national coal resources). One of the answers to such demand is an innovative nuclear power plant. It is vital importance that Czech industry will participate in such project by supplying some of components. The NRI itself should take part in the global effort directed towards development of a new nuclear source.

Similar challenge represents the back-end fuel cycle. Since the state guarantees the waste management, the first priority is an optimal strategy which recently became a most difficult task concerning both its timing and option selection. No less important is again to assure sufficient participation of the local industry.

Similar challenges as in the nuclear energy exist in:
- radioisotopes application in the health care,
- industrial application of the radiation technologies,
- non-nuclear applications for other industry branches.

Again the same as all other nuclear centres we have to deal with old burdens and liabilities, including research reactor spent fuel.

As an example of successful orientation we could present recent commissioning of our PET Centre (operated in co-operation with Prague hospital Na Homolce).

Interactions of NRI with their environment

For the NRI a most important interactions are those with the Czech universities from where the Institute recruits its young specialists, and basic research (Academy of Sciences). The tool the NRI uses to achieve the related goals is the Scientific Council of the NRI, several members of which come from the universities and Academy of Sciences. It is worth mentioning that The NRI has a detached workplace at the Prague Technical University.

At present, public relations become one of the critical issues of any activity with high-tech having its associated degree of risk. From time to time, the Institute organises „open door day“ for the public when they have an opportunity to visit our facilities. The NRI gradually increases its co-operation with mass media, inviting reporters to the Institute and providing them with the relevant information.

Collaboration and co-operation

In addition to the existing co-operation the NRI is looking forward to strengthen its co-operation in:

- Region-based co-operation, namely focused on WWER reactors operation and
- Technology transfer to developing countries (as an example — our radiochemicals production technology transferred to Egypt).

Other issues

The most important issue, as we can at present identify, is to increase the state financial support of nuclear research centres to assure that the nuclear expertise acquired is preserved and enhanced, so the young generation of scientists, educated and trained in such centres, is prepared to take over and continue our effort in the future.

Conclusions

Experience of the NRI forty years development is in many features similar to that other large nuclear centres. For future development, it is to be very important that such centres should keep their position as main sources of the relevant expertise, especially in the nuclear countries.

To achieve this goal it is necessary to:

- formulate new goals,
- establish international co-operation among the Centres, and
- provide adequate financial resources.

Appendix

THE HISTORY OF NUCLEAR SCIENCE AND TECHNOLOGY IN THE NUCLEAR RESEARCH INSTITUTE REŽ

The NRI in Fifties

Year	1955	1956	1957	1958	1959	1960
Personnel Number	183	466	549	633	716	833

Milestones and topics:

- **June 6, 1955** — NRI Establishment
- NRI enters the framework of the Czechoslovak Academy of Sciences in 1956
- Construction of U-120 Cyclotron laboratory, laboratories for physical research and radiochemistry, linear accelerator laboratory
- **Sept. 25, 1957** — Research reactor VVR-S put in operation

Programmes:

- Development of devices for radioactivity measurement
- Radiochemistry, uranium refining and metallic uranium production, radioisotope separation
- Exploratory studies on power reactors
- Neutron physics, neutron diffusion in water and graphite
- Beta- and gamma-spectroscopy development
- Cosmic rays studies

The NRI in Sixties

Year	1962	1964	1966	1968	1970
Personnel Number	1083	1216	1299	1350	1404

Milestones and topics:

- The hot, semi-hot and alpha-chemical laboratories opened in 1962

Programmes:

- Theoretical and experimental reactor physics, thermal reactor calculations, fast reactor calculations, shielding calculations and experimental verifications
- Reactor technology, heavy water reactors calculation, power reactors operation safety, sodium thermokinetics
- research, studies of organic-cooled heavy water reactor
- Alternative reactor studies
- Reactor materials research, studies of non-metallic reactor fuels, study of clad metallic fuels, research of steels for reactor pressure vessels
- Study of chemical extraction processes for uranium separation from plutonium and fission products
- Spent fuel reprocessing, PUREX method and dry fluoride method
- Fluoro-compounds production for industrial non-nuclear purposes
- Waste management

- Radiation chemistry
- Nuclear spectroscopy
- Low temperature physics and technology

The NRI in Seventies

Year	1972	1974	1976	1978	1980
Personnel Number	1068	1067	1066	1064	1065
Costs (Thousands Kcs)	66.600	139.964	158.936	175.806	236.584

Milestones and topics:

- **Jan. 1, 1972 — The** NRI splits. The greater part under the name NRI with applied research and technology supporting power production is subordinated to the Czechoslovak Atomic Energy Commission, the other part with basic, mainly physical research remains in the framework of Academy as the NPI.
- **July 1, 1973** — Heavy water zero power reactor TR-0 put in operation

Programmes:

- Development of fast breeder reactor for Czechoslovakia, core studies, shielding, experiments on sodium loop and pipeline, complex calculations of fast power reactor, accident and transient processes assessment, thermo- and hydrodynamic experimental research on fuel assemblies, sodium device development,
- Research and development support of A-1 (NPP with a heavy-water gas-cooled reactor) with an aid of the reactor TR-0
- NPP fuel cycle studies, ceramic fuels for fast reactors, mixed fuel preparation using sol-gel method
- Studies of cladding materials in the conditions of fast reactors cores, studies of Zr-alloys
- Spent fuel and radioactive wastes management
- Water chemistry of light water reactors
- Radiation chemistry
- New types of semiconductor detectors development
- Activation analysis
- Services for health institutions, radioisotope production, research, development and production of radiopharmaceuticals and Ir wires for application in medicine and biology
- Application of the sol-gel method in non-nuclear fields

The NRI in Eighties

Year	1982	1984	1986	1988	1990
Personnel Number	1055	1042	1040	1034	892
Costs (Thousands Kcs)	188.023	171.080	159.147	184.292	221.961

Milestones and topics:

- **July 7, 1983** — light water zero power reactor LR-0 put in operation
- **Aug. 8, 1989** — light water research reactor LVR-15 put in operation
- Semi-hot metallurgical line for irradiated reactor materials testing opened
- A mobile calcination unit for rad-wastes solidification developed and manufactured in 1984

Programmes:

- Research, development and services for NPP with WWER reactors, reactor physics, measurements of basic physical parameters of hot zones with WWER fuel assemblies in the LR-0 reactor
- Reactor materials research, reliability and life-time of reactor pressure vessel and fuel assemblies in operational conditions
- Reactor safety, codes development
- Studies of fast reactor hydraulics
- Studies of radioactive wastes management from Czechoslovak NPP, solidification, vitrification, safety assessment of repositories for low and intermediate level waste
- Services for health institutions, radiopharmaceuticals production, irradiation of materials and instruments for medical use
- Irradiation of art monuments, foodstuffs, cable insulators ageing
- Production of semiconductor detectors

The NRI in Nineties

Year	1992	1994	1996	1998	
Personnel Number	737	597	599	625	
Costs (Thousands Kc)	271.663	266.500	395.100	433.300	

Milestones and topics:

- **Dec. 31, 1992** — privatization of the NRI
- A new Quality Assurance Manual issued in 1998
- A facility for stress corrosion cracking testing has been designed, built and exported to Mexico
- A new reactor water loop RVS-4 put in operation in 1998

Programmes:

- Theoretical and experimental reactor physics, fluid flow and heat transfer, reliability and risk analyses, thermal hydraulic analyses, severe accident analysis, fuel behaviour analysis, neutron and photon transport computations, research on accelerator driven transmutation technology applicability, spent fuel storage analysis
- Integrity and materials research, elaboration of a new Supplementary surveillance programme, evaluation of irradiation stability of reactor pressure vessel cladding in-440 reactors, studies of steam generator tubes degradation, assessment of the secondary piping integrity
- Experiments and measurements on the reactor LVR-15, water chemistry and material testing, corrosion tests, neutron fluence determination for the surveillance programme, gamma spectrometry, experimental verification of the epithermal neutron beam characteristic for boron neutron capture therapy
- Fuel cycle chemistry, fluorine chemistry , research on preparation and behaviour of suitable fluoride melt mixtures for the accelerator-driven homogeneous transmutation reactor technology, separation of radionuclides by extraction methods, waste management and technology, solidification and disposal

- Services for health institutions, production of radiopharmaceuticals
- Radiation applications, ageing of safety-related cables for NPP, sterilization of medical materials, testing of the reliability of electrical components and chemical stability of materials in radiation environment