Nuclear Research and Development Institutes in Central and Eastern Europe

IAEA
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FOREWORD

The science and technology (S&T) sector is constantly and rapidly changing, and with today's challenges is even more complex and diverse than before. The changing S&T paradigm has directly impacted the research and development institutes (RDIs) and in particular the nuclear RDIs.

National science budgets are increasingly constrained resulting in direct cuts in subsidies, pressuring RDIs to seek alternative sources of funding. With the global trend towards more knowledge-based economies, the concurrent demand for innovation has increased in the S&T sector, and furthermore to the RDIs. Hence RDIs, and nuclear RDIs in particular, which fail to adapt to the changing S&T paradigm, risk 'lagging behind' in management, structure, planning, and funding, which all directly affect the sustainability of the institution. After the Second World War, RDIs in Central and Eastern Europe used to receive funding and guidelines from their governments. In the transition to the market economy, the mechanisms used to fund RDIs are changing, and the responsibility for defining the institutes' role and strategy is transferring to the institutes themselves.

Consequently, the IAEA initiated a Technical Cooperation Project in 2004 to support RDIs working in nuclear power and non-power applications in Central and Eastern Europe. There were two major aims of this project. First, was to map the status of nuclear RDIs with current up-to-date data, because although there is a widespread feeling within the nuclear community that some nuclear RDIs are in financial distress, there are no current and verifiable statistical data on this point. Second, was to assist institute managers and senior scientists in nuclear RDIs, to improve their management practices and improve access to national and international funding opportunities.

This report is focused on the first aim, to map the status with current statistical data, of 25 nuclear RDIs in 13 Central and Eastern European countries including Uzbekistan and Kazakhstan, and further looks into the impact of S&T policies on these nuclear RDIs.

The IAEA wishes to thank the 25 institutes involved in the project for their cooperation in all aspects regarding the project and in particular filling out and updating the surveys, as well as the experts who provided inputs and reviewed the report: K. Alldred from the Nuclear Enterprise Group in the USA, S. Fazinic and V. Kotarski from Institute of Ruder Boskovic of Croatia, A. Stritar from the Slovenian Nuclear Safety Administration, G. Cognet from the French Atomic Energy Commission, J. Misak from the Nuclear Research Institute Rez plc in the Czech Republic and J. Gado from the KFKI Atomic Energy Research Institute in Hungary.

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EDITORIAL NOTE

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SUMMARY

The science and technology (S&T) sector is faced today with complex and diverse challenges. National science budgets are under pressure, and many countries are changing how research and development (R&D) is funded, reducing direct subsidies and introducing competition for both governmental and alternative sources of revenue.

On the other hand, the transition toward knowledge-based economies is creating new opportunities in the S&T sector as governments look to it to foster economic growth through innovation. A number of countries in Central and Eastern Europe have recently joined the European Union (EU) which has defined the Lisbon Strategy to create a ‘knowledge triangle’ of research, education and innovation to underpin the European economic and social model, and economic growth. This strategy seeks to increase investment in science and technology across the EU to a target of 3% of GDP by 2010, with two-thirds of funds coming from the private sector. By comparison, funding for R&D in most Central and Eastern European countries is only around 1% GDP, of which about 90% is provided by the governments.

R&D has become more international, reflecting a more interdependent and globalized world. R&D progress is not only of interest to individual countries but also tries to respond to the needs of a broader society. Governments still maintain national networks, but increasingly emphasize international cooperation, both to avoid duplication of expensive infrastructure, and because scientific excellence requires an exchange of ideas and cooperation that crosses borders.

These challenges and opportunities directly impact the research and development institutes (RDIs), including the nuclear RDIs. It is important for the nuclear RDIs to take account of these trends in the broader S&T sector in their vision and strategy. Several nuclear RDIs have become very successful, but others are struggling to adapt. The challenges have been particularly severe in the Central and Eastern European region, where some nuclear RDIs have seen a sharp decline in funds and status, and the loss of some of their most talented scientists, which jeopardises their long term viability, and, in some cases, poses significant safety and security concerns.

Consequently, the IAEA initiated a Technical Cooperation Project in 2004 to support RDIs working in nuclear power and non-power applications in Central and Eastern Europe. A major objective of the project has been to map the status of nuclear RDIs, because although there is a widespread feeling within the nuclear community that some nuclear RDIs are in financial distress, there are no current statistical data on this point. This report provides information about the trends in the nuclear sector and the impact of S&T policy on the nuclear RDIs.

Data Collection

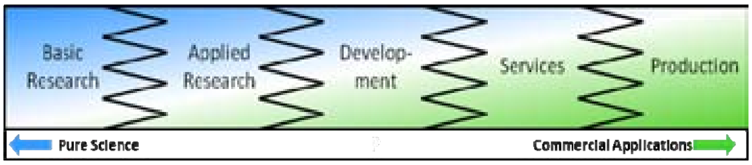
Twenty-five research institutes from fifteen countries participated in this survey. For each institute, data were collected on the mission, the financial resources, revenue sources and revenue trends, human resources and trends, and major research facilities, for the period between 2001 to 2006. Most of the RDIs responded with detailed information, though full information on financial issues was not available in all cases. For the most part this was because the RDIs lacked a robust accounting system, in one case, financial data was not provided because it was considered to be confidential. RDIs were also asked to supply data on selected performance indicators (PI), including numbers of patents applied for and obtained, and the number of publications in respected publications. Sixty percent of the RDIs supplied requested data about legislation, policy, planning, coordination and management, and business skills.

Roles and Types of Institutes

The participating RDIs are active across the R&D continuum of activities from Basic Research, with its emphasis on the underlying science, to Applied Research, Development of new technologies, providing Services to other sectors, and Production and sale of products (for example

radiopharmaceuticals), which have a progressively increasing emphasis on commercial applications. Almost all RDIs have activities in more than one segment, though few attempt to cover the full continuum of activities.

The R&D Continuum of Activities

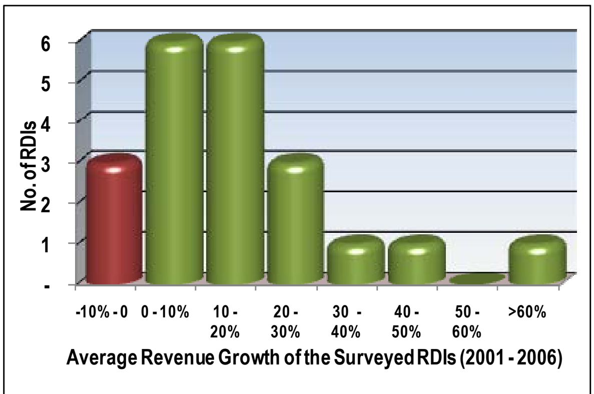


One of the major challenges facing the nuclear RDIs is maintaining the ***fit*** between the institute's mission as perceived by its stakeholders, its strategy as defined by the institute management and the policies on such issues as staff incentives and control of IPR that are needed to implement that strategy. Inconsistencies between mission, strategy and policy create obstacles to sustainability and success, because they impede revenue development and demotivate the staff. The work environment that rewards the creativity needed for basic science applications is not well suited to the repetitive, efficient production of radioisotopes, for example.

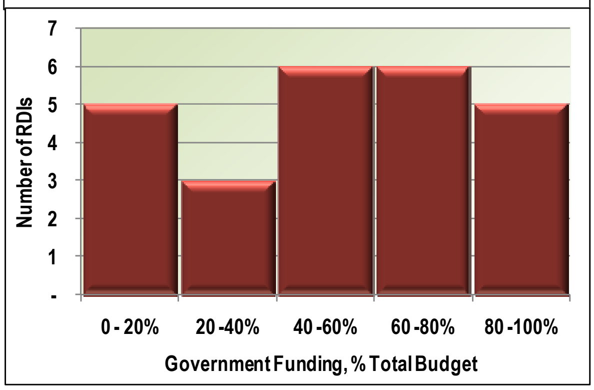
There are RDIs with refined management systems, but in general, RDI internal management is unsophisticated. Only one-third of the surveyed RDIs have either a Business Plan or similar strategic document. Systems for staff incentives are not well developed, and in several cases do not align staff rewards with the institute's objectives. Examples include institutes engaged in service or production activities that exclusively reward their staff on the basis of academic reputation and publications. This can threaten fiscal sustainability because it penalizes personnel that work to develop institute revenues instead of publishing scientific papers. In some cases, these policies are set at the national level and are outside the institutes' control, highlighting the need for dialogue between the institute management and their government policy makers RDIs that adopted improved management philosophies benefited from improvements in their financial and academic status.

Funding Trends

Significant changes have occurred during the past two decades, including accession to the EU of some Central and Eastern European countries and rapid GDP growth in several countries. Overall, the RDIs increased their revenues in line with the positive domestic economic climate, though this is not universally true. Some RDIs have been less successful, with revenues declining over the period, as shown in the figure at right.

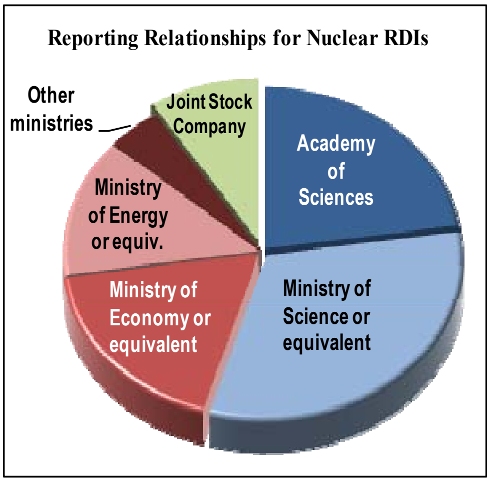


The RDIs' reliance on government funding varies significantly, ranging from near zero to almost the whole institute budget. Historically these government funds have been provided in the form of a direct subsidy, but there is an increasing emphasis on funding R&D through competitive grants. Many institutes are actively developing revenues from other sources, but for the majority, the government remains the institutes' most important sponsor and client.



In many cases, researchers doubt that 'new' revenue will benefit the RDI, expecting the government to reduce its funding as other revenues are developed. This perception forms a powerful internal barrier to development of alternative sources of funds, such that RDIs are more likely to develop non-government funding sources if it is clear that government funds will not be reduced as a consequence.

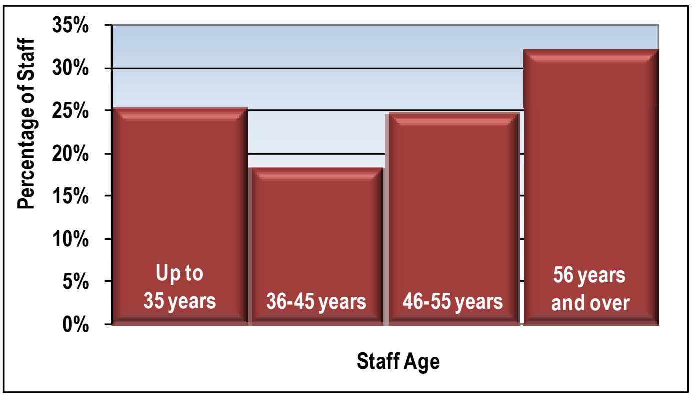
Reporting and Funding Relationships



Just over one half of the surveyed RDIs are strongly related with the bodies (Ministry of Science or equivalent, and the Academy of Sciences) that determine their country's S&T policies. Funding and reporting relationships are in conflict in some cases, making it difficult for the RDI to adapt to its funders' needs, and setting the stage for chronic funding deficits. Examples of conflicted reporting relationships include RDIs that are controlled by their Academy of Sciences, but funded by the Ministry of Economy to provide reactor or other support services. As a consequence staff promotion and reward policies can become disconnected from the institute's mission. Resolution of these conflicts will enable the RDI to better contribute to the countries S&T needs.

Human Resources

The age distribution of staff at the RDIs showed anomalies. Several RDIs have a deficit of experienced staff in the 36 to 55 age group and are facing problems with knowledge retention as the oldest staffs retires. In aggregate, there is a deficit of scientific staff in the 36 to 45 age group, reflecting difficulties in attracting and retaining talented staff in the last 10 to 20 years, but suggesting an increasing ability to attract new graduates.



Intellectual Property and Technology Transfer

Knowledge based societies need their RDIs to be an engine of GDP growth by creating and developing intellectual property, and stimulating innovation. However, this role is not uniformly recognized in the RDI funding systems, which often do little to reward RDIs for commercialising technology or for making expertise available through consultancy and services. RDI internal management systems also only weakly address this strategic role, with less than half of the RDIs having a policy for the protection and management of intellectual property, and almost none earning revenues from intellectual property rights. Few RDIs have skills in technology transfer.

Key success factors

There are several possible models for successful RDIs, and the key success factors for nuclear RDIs are similar to those for RDIs in other scientific disciplines. An overriding key for success is for the RDIs to align themselves, their policies, and their strategies to their capacities, their environment and the needs of their stakeholders.

RDIs exist within the environment created by their governments' regulations and policies, which can either help or hinder the institutes in their quest for sustainability. Thus, RDIs need to proactively manage their environment and nurture relationships with the government and other stakeholders.

The S&T environment is also increasingly international, so it is also essential that the RDIs develop peer group networks to supplement the RDIs capabilities, to provide international visibility and standing, and to ensure access to the major international programmes.

RDIs that participate in commercial markets, for either products or services, have a particular need for effective accounting systems and accounting policies that can realistically allocate costs to the various services and products and so make possible meaningful profitability assessments, as well as a purposeful business development function to build the customer base and business revenues. To succeed, these RDIs need to retain some part of the revenues gained in the commercial sector, and to have flexibility in staff recruitment and retention policies, so that they can meet the demands of the marketplace.

The way forward: Challenges and Opportunities

RDIs face significant challenges, with a recent history of reduced funding and staff retention difficulties in many cases. A particular challenge is the re-orientation of institutes to respond to the changes in S&T priorities, and in the structure of R&D funding. This requires new approaches, and application of new skills that several RDIs do not possess.

However, there are also many opportunities. The renaissance of nuclear electricity generation is creating a new demand for the skills, experience and capabilities of the RDIs. This includes training of professional staff, material investigations, development of the science and supporting technologies for new reactor systems.

Outside the nuclear energy sector, there are new opportunities in many fields. For example, expertise in nuclear physics and nuclear technologies must be combined with that from other scientific disciplines to address problems in agriculture, industry and medicine. The commitment of the European governments to substantially increase national R&D funding levels provides new vistas of opportunity for RDIs. Through careful adaptation, and with the support of their governments, the nuclear RDIs are poised on the threshold of a new and bright scientific future.

In order to fully benefit from these opportunities, an environment is needed in which basic and applied research can be closely integrated with development and commercialization of technological applications. This is the environment: (i) where excellent basic research is encouraged; (ii) where knowledge fosters innovation that assists the development; and (iii) where there is a high level of targeted research which leads to applications that are used for the economic, environmental or social goods.

Conclusions

The role of the nuclear RDI has changed from being a privileged and strategic research institution with one customer (the government) to becoming just one of many research institutions competing for priority and attention. Several nuclear RDIs are struggling to find their place in this world, with erosions of funding and status that has made it difficult to attract and retain talented staff. On the other hand, there are institutes that overcame a deep financial crisis and managed to complete the transition with great success.

There is not just one possible model for RDIs: there are several, all successful in their own way. The main key for success is to have high quality RDIs that align themselves, their internal policies, and their strategies to their capacities, the environment and the needs of their country. Successful RDIs have demonstrated the importance of institutional policies concerning key strategic elements such as incentives for staff, intellectual property ownership, benefit sharing and conflict of interest. Particularly crucial is to establish the right incentives in term of human resource policies, able to mobilize and motivate research staff in line with the institute's mission and the stakeholders' objectives.

Whatever the specific model, it is crucial that the institute take a proactive stance to shape its environment and to set strategy and action plans.

1. INTRODUCTION

1.1. BACKGROUND, TARGET AUDIENCE AND GOALS OF THE STUDY

The science and technology (S&T) sector is faced today with complex and diverse challenges. These challenges directly impact all Research and development institutes (RDIs), including nuclear RDIs.

In many countries, national science budgets are increasingly constrained. Consequently, RDIs are under pressure to reduce their dependence on central government funding and to compete to find alternative sources of revenue.

On the other hand, new opportunities have arisen as countries strive to become knowledge-based economies, and increase their focus and resources on the S&T sector to foster economic growth through innovation.

In this context, it is important for nuclear RDIs to be aware of the trends affecting the broader S&T sector, and to proactively respond to these trends when defining their vision and strategy. Nuclear RDIs that fail to align themselves with broader S&T trends risk falling behind the rest of the science and technology enterprise – in terms of management, structure, planning, funding and other aspects that could endanger their sustainability.

In 2004, the IAEA started a technical cooperation project to support RDIs working in nuclear power and non-power applications in Central and Eastern Europe**.** The challenge in this region is particularly severe. In earlier times, when the economy was centrally planned, RDIs grew accustomed to receiving funding and guidelines from their governments. In the transition to the market economy, the mechanisms used to fund RDIs are changing, and the responsibility for defining the institutes' role and strategy is transferring to the institutes themselves. While several RDIs have become very successful, others are struggling to adapt to the new environment. Some of the institutes have seen a sharp decline in funds, this has brought a range of negative consequences, not least the departure of some of their most talented scientists. The bottom line is that the long term viability of some nuclear RDIs is under threat, which in some cases could pose serious safety and security concerns.

The IAEA technical cooperation project is assisting institute managers and senior scientists in nuclear RDIs to improve their management practices and improve the access to national and international funding opportunities. An additional major objective of the project is to map the status of nuclear research institutes in Central and Eastern Europe. There is a widespread feeling within the nuclear community that some nuclear RDIs may be in financial distress but there is no current statistical data on this point. Two prior studies by the IAEA[1] in 1989 and the NEA/OECD[2] in 1996 reviewed the status of the RDIs from a global perspective, but these did not specifically address more detailed issues such as their financial performance.

The target audience for this report mirrors the major stakeholders of the project. Firstly, the managers of the nuclear RDIs who need benchmark indicators and examples of good practice. Secondly, government policymakers and members of the parliamentary committees for science and technology and energy planning who need information about the trends in the nuclear sector and the concrete of S&T policy on the RDIs. Finally, the target audience includes also the nuclear community and the international organizations that want general information on the status of nuclear R&D sector.

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[1] "Guidebook on Research and Development Support for Nuclear Power", Technical Reports Series No 298, IAEA, 1989

[2] Source: NEA, OECD: "Trends in Nuclear Research Institutes", January 1996

1.2. SCOPE OF THE STUDY, METHODOLOGY USED AND STRUCTURE OF THE REPORT

The report presents the results of a survey of the status of RDIs involved in nuclear science and technology in Central and Eastern Europe. These RDIs cover a broad spectrum of activities including basic scientific research, applications of nuclear science to medicine, agriculture and other fields, production of radioisotopes, and education, including, but not limited to, those RDIs with a focus on nuclear power applications.

The survey focused 25 institutes from 13 countries in Central and Eastern Europe plus Uzbekistan and Kazakhstan. The institutes from Kazakhstan and Uzbekistan were included because of the history and legacy they share with other institutes from the former Soviet Union. Russia was not included in this study, because the size and organization of the Russian nuclear research sector sets it apart from those of other countries in Central and Eastern Europe, and would be deserving of a full study in its own right. Chapter 3 briefly describes some recent initiatives in the Russian civil nuclear sector.

As can be seen in Table 1, the following countries provided data and inputs for the study: Albania, Bulgaria, Croatia, Czech Republic, Hungary, Kazakhstan, Lithuania, Montenegro, Poland, Romania, Slovenia, Slovakia, Serbia, Ukraine and Uzbekistan.

TABLE 1. COUNTRIES AND INSTITUTES INVOLVED IN THE PROJECT

Country	Institute	Institute Name and Internet Address
Albania	INP	Institute of Nuclear Physics, http://www.akad.edu.al/permbajtja/institute_of_nuclear_physics.htm
Bulgaria	INRNE	Institute for Nuclear Research and Nuclear Energy, http://www.inrne.bas.bg/main_bg.html
Croatia	RBI	Ruđer Bošković Institute http://www.irb.hr/en/
Czech Republic	UJV	Nuclear Research Institute; http://www.nri.cz/eng/
Hungary	AEKI	Hungarian Academy of Sciences KFKI Atomic Energy Research Institute, http://www.kfki.hu/~aekihp/
	VEIKI	VEIKI Institute for Electric Power Research, http://www.veiki.hu/english/index.html
Kazakhstan	IAE	Institute of Atomic Energy, http://www.nnc.kz/en/about/structure.html
	INP	Institute of Nuclear Physics, http://www.inp.kz/indexeng.php
	IRSE	Institute of Radiation Safety and Ecology, http://www.nnc.kz/en/about/structure.html
Lithuania	IP	Institute of Physics, http://www.fi.lt/fi/en
	LEI	Lithuanian Energy Institute, http://www.lei.lt/index.php?k=9
Montenegro	CETI	Centre for Ecotoxicological Research, http://www.ceti.cg.yu/index_en.html
Poland	IAE	Institute of Atomic Energy, http://www.cyf.gov.pl/index_ang.html
	ICHTJ	Institute of Nuclear Chemistry and Technology, http://www.ichtj.waw.pl/
	POLATOM	Institute of Atomic Energy, Radioisotope Centre, http://www.polatom.pl/
Romania	ICIT	Institute for Cryogenics and Isotope Technologies, http://www.icsi.ro/overview.html
	IFIN-HH	Horia Hulubei National Institute of Physics and Nuclear Engineering, http://www.nipne.ro/
	INR	Institute of Nuclear Research, http://www.nuclear.ro/
Slovenia	JSI	Jožef Stefan Institute, http://www.ijs.si/ijsw/JSI
Slovakia	VUJE	VUJE a.s., http://www.vuje.sk/en/
Serbia	VINCA	VINCA Institute of Nuclear Sciences, http://www.vin.bg.ac.yu/index_e.htm
Ukraine	INR	Institute of Nuclear Research , http://www.kinr.kiev.ua/
	KIPT	Kharkov Institute of Physics and Technology, http://www.kipt.kharkov.ua/.indexe.html
	INSC	International Nuclear Safety Center of Ukraine http://www.insc.gov.ua
Uzbekistan	INP	Institute of Nuclear Physics, www.inp.uz

The report is based on the data provided by the institutes themselves in response to a questionnaire supplemented by the results of several missions to the selected institutes over the period from 2004 to 2007. The questionnaire consisted of a self-assessment template that was sent to the selected institutes to gather information on legislation, institute policies and key performance indicators. Two rounds of such assessment surveys were carried out: first in the 2005, second, after reviewing the self-assessment template, in 2007.

The other major sources of information were the reports from missions conducted in 10 countries. These missions provided an opportunity to discuss and review in detail the data with the institutes' managers and senior scientists and to elaborate some conclusions on areas of concern and opportunity for nuclear RDIs.

The data collected was analysed by an expert group composed of IAEA staff and external experts in a systematic manner according to selected indicators. The report illustrates the links and relationships between those elements with the objective of identifying the main success factors. A first draft was prepared and reviewed by a working group of IAEA staff and external experts in March 2008. The final report was then presented and reviewed by the representatives of all the Member States participating in the project at the project final coordination meeting that took place in Czech Republic on September 3 to 5, 2008.

The report is structured around four main chapters. The present Chapter introduces the study and its scope and objectives. Chapter 2 provides a summary overview of the general trends in science and technology based on review of literature and contributions from leading organizations in the field such as the OECD, the World Bank, WIPO, UNESCO, and the European Commission.

Chapter 3 presents the data collected and identifies a series of key issues for nuclear RDIs sustainability based on the institutes survey data and discussions with managers of the institutes. It reviews the role, funding and human resources trends, and management practises of nuclear RDIs. It also highlights a series of lessons learned and good practices drown from concrete cases. Finally, Chapter 4 presents some considerations about the evolution of current trends and highlights some areas of concern and opportunity for nuclear RDIs.

Annex 1 provides a short description of each RDI, e.g., history, mission, major facilities, main R&D programmes. The Annex is designed to help readers better understand the general background of the participating RDIs and appreciate the variety of institute profile and characteristics.

Annex 2 provides the outline for the Self-assessment Template. The template requested an analysis of the institute and government policies and information on historical trends and current status of the institute mission, funding, human resources and major research facilities. This followed the approach for surveys on research and experimental development recommended by OECD[3].

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[3] *Frascati Manual – Proposed standard practice for surveys on research and experimental development, 2002, OECD.*

2. GENERAL TRENDS IN SCIENCE AND TECHNOLOGY

Several international organisations have reviewed the trends in S&T in the last 10 years and assessed the policies and choices that usually lead to a successful transition to a modern RDI. The Organisation of Economic Cooperation and Development (OECD), World Bank (WB), and United Nations Education, Science and Cultural Organisation (UNESCO) have produced reports that provide an overview of the issues facing all RDIs, including nuclear RDIs.

There are key trends and new ideas that have changed globally the way science is funded and organized. The main drivers of change include:

- Governments are introducing policies targeted at the 'knowledge economy' in which innovation and knowledge are replacing capital and labour as the primary wealth-creating assets [4], and are increasingly funding science to foster economic growth;
- Concepts such as open innovation are reshaping the way intellectual property (IP) is developed and transferred;
- The role of RDIs in society is changing;
- Scientific research has become much more interdisciplinary and international, reflecting a more interdependent and globalized world.

2.1. THE KNOWLEDGE ECONOMY

The transition to become a knowledge economy requires that the rules and practices that determined success in the industrial economy need to be rewritten. If know-how, expertise, and intellectual property are as critical to economic success as other economic resources such as capital, land, natural resources, or even manpower, then new policies must be introduced system-wide in order to protect and fully exploit these engines of wealth creation. This includes changes in public policies at the government level and the introduction of systems for knowledge management at the level of RDIs and companies.

Government investment in research and development (R&D) is an important indicator of the effort that countries are putting into achieving scientific and technological progress. However, in the most advanced economies, government contribution to the overall R&D funding is now being matched and exceeded by investment from industry, as can be seen in Figure 1.

[4] V.K. Goel, E. Koryukin, M. Bhatia, P. Agarwal Innovation Systems: World Bank Support of Science and Technology Development, World Bank Working Paper No. 32, 2004, p. 9.

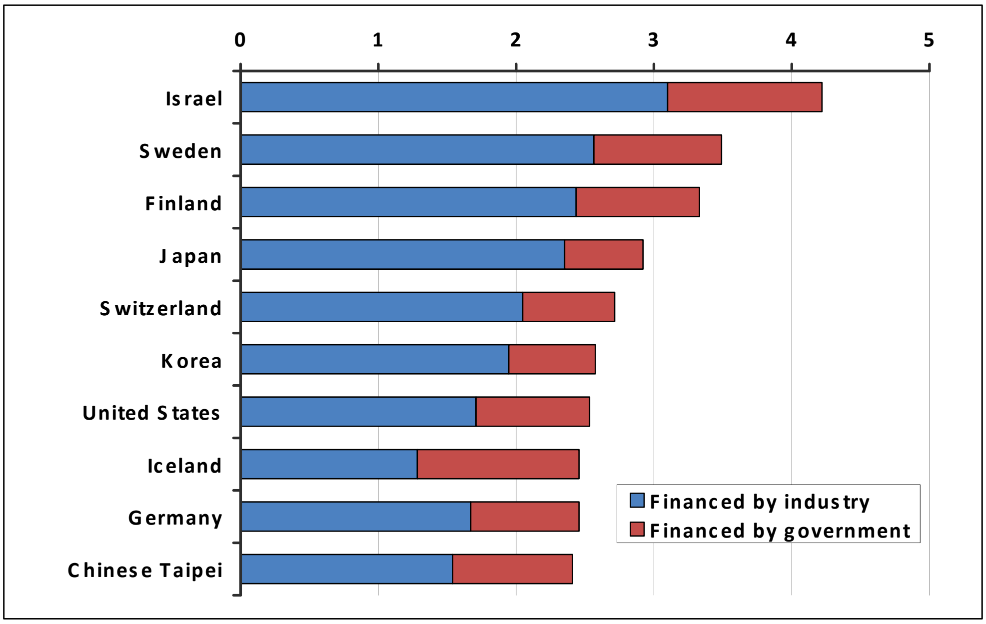

FIG. 1. Top Ten R&D Investors, Gross domestic expenditure on R&D as percentage of GDP, 2006.[5]

As Figure 2 shows, in Central and Eastern European countries there remains a much greater reliance on governmental funding of R&D, than for the countries shown in Figure 1, and overall R&D funding as a percentage of GDP remains well behind the levels of the world leaders: Israel, Sweden and Finland.

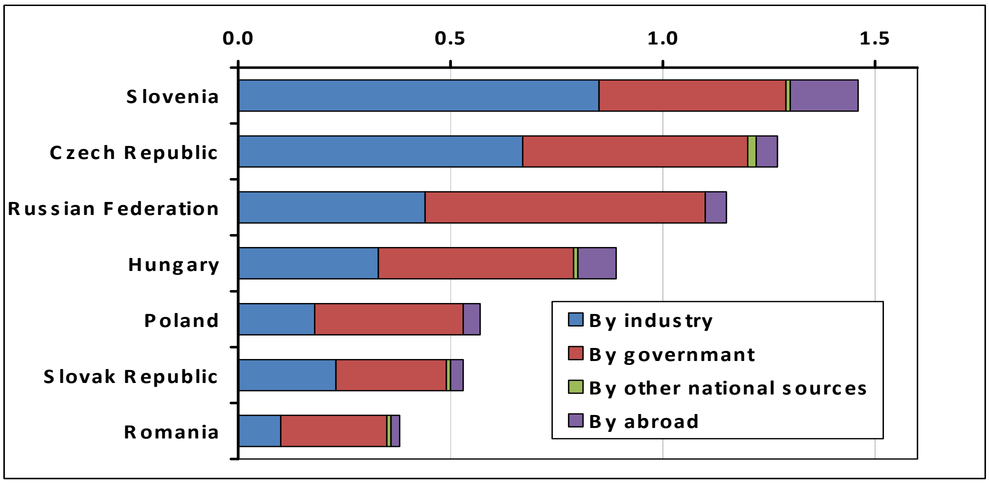

FIG. 2. Gross domestic expenditure on R&D as percentage of GDP in CEE countries, 2006.[5]

R&D spending increased in several Central and Eastern European countries in the period from 2000 to 2004. However if we compare the countries in Central and Eastern Europe (left side of Figure 3) with the most advanced knowledge economies (right side of Figure 3), it is clear that R&D funding is much lower not only as a percentage of GDP, but even more in absolute numbers since these countries have a lower GDP per capita.

[5] OECD, Science & Technology and Industry Outlook

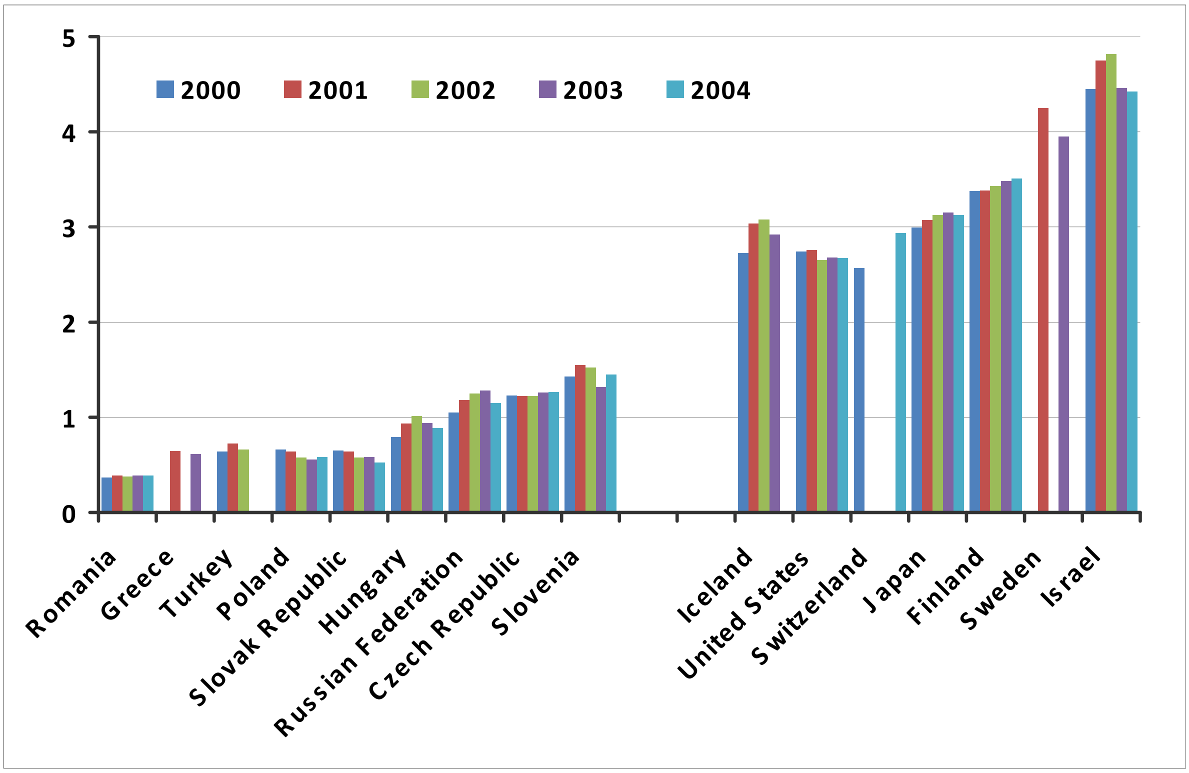

FIG. 3. Gross domestic expenditure on R&D from 2001 through 2006.[5]

In a knowledge economy, funding is only one aspect of the route to success. Increasing funding may directly result in the production of more knowledge, but this does not automatically translate into economic success. A key element, and probably the most difficult issue, in the knowledge economy is knowledge transfer, which requires effective mechanisms to transfer the knowledge produced from the research institutions to the end users, the society, and the economy as a whole.

Intellectual property policy seeks to balance two potentially conflicting public goals: (1) to provide an incentive to RDIs to create knowledge by giving creators property rights in the products of their creativity, and (2) to provide the greatest possible public access to the products of creativity, in order to create a competitive marketplace[6]. Many educational and public sector research organizations have developed processes and policies to discover, protect and exploit intellectual property rights (IPR), and to ensure that IP is successfully transferred to private corporations, or invested in new companies formed for the purposes of exploitation.

The concept of open innovation is gaining in importance for technology transfer. Open innovation[7] assumes that companies should not rely entirely on their own R&D, but should also license IP from, and license their own IP to, other organizations. This is particularly so for 'unused' IP which the company may possess, but for which it has no commercial application. This contrast with the historical closed innovation concept limits the use of internal knowledge within a company and makes little or no use of external knowledge. There is a trend for multinational companies to use open innovation concepts. For example, IBM has built an innovation network for semiconductor chip R&D[8]

[6] Chan, Thomas, Understanding Intellectual Property [http://montejade.org/images/mm/6/voices/Thomas%20Chan.pdf]

[7] See for example, http://www.openinnovation.eu/openinnovatie.php, or http://en.wikipedia.org/wiki/Open_innovation

[8] See http://www.businessweek.com/innovate/content/aug2007/id20070830_258824.htm

with nine partners, including one university research centre. Other multinationals such as Philips, Proctor & Gamble, Nokia, and others have also adopted the principles of open innovation.

Routes to commercialization of IP produced by research organizations include licensing, joint ventures, formation of new companies (spin offs) and agreements which include the payment of royalties.

RDIs engaged in fundamental research are unlikely to see huge benefits from IPR because their work is too far from the market. On the other hand RDIs that conduct more applied research may be able to benefit greatly from IP protection and exploitation, if appropriate routes to IP commercialization are put in place.

2.2. THE NEW GOVERNMENT ROLE

The change to market-led economic policies and the growth in importance of knowledge and innovation has changed governments' science policies. Previously governments funded nearly all scientific R&D as a public good in the universities and in government-owned RDIs.

Nowadays, most states are still willing to invest in fundamental research and even 'blue-sky' research as a public good. However, the investment is far more restricted in scope than previously, and a large part of funding is dedicated to applied research, where concrete results can be expected in a relatively short term. In an environment where governments foster knowledge as an engine of growth, it is expected that non-fundamental research will be transferred to companies and used to create economic development and new jobs.

States now concentrate their investment more to the beginning of the innovation process by increasing the research capacity of the national institutions. For applied research, governments are increasingly seeking to encourage industry to conduct or support R&D. The governments still have a role to perform in applied research by setting policies that promote and support entrepreneurship because so much innovation occurs in new companies. This governmental role includes providing technical assistance to new companies and entrepreneurs, designing programmes to improve access to capital, as well as ensuring the availability of technology transfer mechanisms such as licensing agreements, spin off companies, and technology parks.

In most developed countries venture capital has a major role in financing high-tech sectors; however venture capital markets are in their infant stage in most emerging countries.

In order to ensure the maximum return on R&D investment, several governments are concentrating their financial resources into centres of excellence. This is a mechanism to concentrate scarce resources into the institutes and sectors that have demonstrated that have the capacity to rise to the highest international standards.

The net result is that modern RDIs rely on both public and private funding, local and foreign, to finance research and other technical activities. In several countries where national budgets are increasingly constrained, the institutes are now under greater pressure to compete aggressively to find diverse sources of revenue. Public officials, policy makers, funding agencies and private sector executives now demand that R&D make a demonstrable difference to their sector and to achieve high performance before committing to continued support or funding for the Institutes.

2.3. CHANGING ROLE OF RDIS AND NEW SUCCESS CRITERIA

In an effort to better suit the requests coming from the government and the society at large, the role and mission of most of the RDIs have evolved with time. Funding institutions (whether the government or other bodies) expect to see a measurable return of the investment made. This trend towards more accountability involves all types of RDIs.

The focus of RDIs varies dramatically from institute to institute, and from country to country. Some RDIs are heavily involved in one single field, while others are interdisciplinary; some focus on basic research, whereas others are more involved with applied research and/or the development of new technologies, or are mainly providing services with only a small research component.

For RDIs involved with basic research, the measure of success is usually scientific excellence as quantified through reputation and academic outputs.

For RDIs involved in applied research it is expected that economically viable products or services will be produced in the short to medium term. The appropriate measures of success are therefore not the publication of academic papers, but rather the extent to which outside clients are using or paying for the research services, and the extent to which the knowledge created through research projects is contributing to the innovation 'pipeline' — (imagine successful products and services as the result of a pipeline in which basic research leads to applied R&D and then to precommercial development and finally a marketed good). Thus measures of success can include:

- Contracts from outside organizations;
- Licensing agreements and royalty payments;
- Revenue from services, and products (including consultancies);
- Spin off companies.

Some RDIs and universities have created an 'Office of Technology Transfer' dedicated to identifying research with commercial potential and defining strategies for its exploitation.

2.4. THE INTERNATIONAL DIMENSION OF R&D

Whereas in the past, science R&D was primarily a national agenda item, it has now assumed a more international dimension, reflecting a more interdependent and globalized world. R&D is not only of interest to individual countries but it must also respond to the needs of the broader society. A key feature of science nowadays is that no country can perform optimally in isolation. Science infrastructure is becoming more and more expensive and therefore countries feel the need to share infrastructure. Thus, although governments maintain national networks, they increasingly emphasize international cooperation. This trend is encouraged not only because infrastructure duplication is inefficient, but also because science benefits from an exchange of ideas and cooperation that crosses national borders.

A leading example of an international research centre is CERN in Switzerland. CERN offers world first class research facilities and a stimulating intellectual environment and it is open to the scientists from all the countries that contribute to its funding. Another, more recent, example is ANSTO's new regional neutron science facility at in Australia, which provides regional access to high-grade neutron irradiation and measurement equipment.

The EU-funded Enabling Grids for E-sciencE (EGEE) project is a recent example of infrastructure sharing. The project started in April 2004, with the objective to build a permanent European Grid infrastructure that could serve a broad spectrum of scientific applications reliably and continuously, and provide a round-the-clock computer calculation service to scientists throughout Europe. The work has been carried out by a collaboration led by CERN, involving 70 partners, encompassing major computer centres in Europe as well as leading American and Russian centres. By the end of 2005, the 800 scientists and engineers working on EGEE (from five different continents) were managing an infrastructure sharing the power and storage of more than 10,000 dedicated computers at over 200 sites. Scientists from six scientific fields — including physics, earth observation, climate prediction, petroleum exploration and drug discovery — use this infrastructure daily for their calculations. Between Oct 2004 and Oct 2005 two million activities were successfully run on this Grid.[9]

2.5. RESEARCH AS AN INTERDISCIPLINARY AND TRANSDISPLINARY EFFORT

RDIs are becoming increasingly aware of the benefits of an interdisciplinary approach to research. An interdisciplinary approach involves attacking a problem or issue from various angles, cutting across historical disciplines to form new methods for understanding the issue.

The complexity of the problems tackled by today's science requires the introduction of new research principles, such as the interdisciplinary approach. The need for interdisciplinary approach to scientific work arises in cases concerning solving problem as viewed from the perspective of the end user, for instance, environmental, energy and health care policy problems. A good example of the execution of this approach is the French Atomic Energy Commission (CEA)[10] which is combining short term industrial research and basic research to form a basis for sought after breakthroughs. Similarly, the new scientific centres formed in the USA, at Berkeley, Chicago, Harvard, Princeton and Stanford are no longer organised according to the traditional pattern of faculties or schools of physics, chemistry, or biology but rather according to an interdisciplinary perspective, which follows the actual developments of science. One example from Harvard is the 'Center for Imaging and Mesoscale Structures' that addresses a range of issues which could not be attributed to any particular discipline.[11]

2.6. RECENT INITIATIVES IN THE EUROPEAN UNION

In 2000, the EU decided to create the European Research Area (ERA), a unified area all across Europe that would:

- Enable researchers to move and interact seamlessly, benefit from world-class infrastructures and work with excellent networks of research institutions;
- Share, teach, value and use knowledge effectively for social, business and policy purposes;
- Optimise and open European, national and regional research programmes in order to support the best research throughout Europe and coordinate these programmes to address major challenges together;
- Develop strong links with partners around the world so that Europe benefits from the worldwide progress of knowledge, contributes to global development and takes a leading role in international initiatives to solve global issues.

Another objective of ERA is to inspire the best talents to enter research careers in Europe, convince industry to invest more in European research — contributing to the EU objective to devote 3% of GDP for research — and strongly contribute to the creation of sustainable growth and jobs.

Seven years after its creation, the ERA has become a central pillar of the EU 'Lisbon Strategy' for economic growth, together with the completion of the Single Market, the European 'broad-based innovation strategy' and the creation of a European Higher Education Area.

The Seventh Framework Programme (FP7) is the European Union's main instrument for funding research and promoting the European Research Area which constitutes the European single market for the Science & Technology sector. Over the period 2007 to 2013 it will bundle all research related EU initiatives together under a common roof and provide a total budget of 51 Billion Euros over the

[9] http://gridcafe.web.cern.ch/gridcafe/GridatCERN/egee.html

[10] http://www.cea.fr

[11] European Universities: Enhancing Europe's Research Base, Report by the Forum on University-based Research, EC DG Research, Science and Society, May 2005

seven years. In this way, it is expected to play a crucial role in reaching the goals for growth, competitiveness and employment.

Over 35 industrial sectors in Europe have prepared Technology Platforms as visions of what research needs to be done in their sectors, and guide the RDIs in defining research priorities, and to propose topics for coordination or funding at European level.

The Sustainable Nuclear Energy Technology Platform (SNE-TP) covers the research needed to provide safe, publicly acceptable, and sustainable options for nuclear power generation. It includes funding for work in the fields of nuclear safety, radiation protection, waste management, advising policy making and stakeholder bodies at governmental level, and providing information to the general public.[12] SNE-TP also promotes a coordinated training and educational system for developing nuclear competence in Europe; e.g. via the Euratom Framework Programme. The Platform is specifically focused on enhancing coordination between national and industrial programmes as well as constructing selected new state of the art facilities.

Other Technology Platforms may also be relevant to the nuclear science sectors, for example the Hydrogen and Fuel Cells Technology Platform and the future Geological Disposal Technology Platform.

In addition, the European Atomic Energy Community (EURATOM) has established a €2.7 billion programme for nuclear research and training activities in the areas of fusion energy research, safety performance and improved economics of nuclear fission, radiation protection, and medicine.

[12] Sustainable Nuclear Energy Technology Platform Vision Report (2007); http://publications.europa.eu

3. TRENDS OF NUCLEAR RDIS

3.1. HISTORICAL CONTEXT FOR NUCLEAR RDIS

3.1.1. Mission

Most nuclear RDIs in Central and Eastern Europe were established in the 1950s or early 1960s by national or subnational governments. In many cases they were established as part of the national academies of science. Their initial missions were to perform fundamental nuclear research, to develop indigenous expertise in nuclear science and technology, to educate and train specialized personnel for R&D services at nuclear RDIs and activities in industry, and to promote commercial applications of nuclear energy.[2] Some of the institutes were more oriented to basic research and the others to the development of technology and provision of support to industry and other strategic areas such as energy. The institute missions have changed over time, reflecting both changes in policy and society's attitude towards nuclear power. The following examples are given as illustration:

- The Institute for Nuclear Research (UJV, Rez; Czech Republic) was established in 1955 under the Czechoslovak Academy of Science. In 1972 it was transformed into a state supported organization under the Czechoslovak Atomic Energy Commission, and in 1992 it was transformed into a joint stock company driven mainly by industry oriented short term projects, mainly those of interest to its owners (Czech and Slovak Power Companies, Skoda Nuclear Machinery and local community);
- The Institute of Atomic Energy (IAE, Otwock-Świerk, Poland) emerged in 1983 as one of three independent research institutes in the field of nuclear energy formed on the basis of the Institute of Nuclear Research (INR founded in 1955). R&D Centre for Radioisotopes POLATOM joined the IAE structure on the January 01, 2007;
- RDIs in the republics of the former Yugoslavia, such as the Rudjer Boskovic Institute, Josef Stefan Institute and Vinca, were similarly formed at the beginning of 1950s as centres for the development of nuclear science and technology. However, starting in the 1960s, they increasingly evolved into interdisciplinary institutes, and today have lost their primarily nuclear character;
- The nuclear RDIs in the former Soviet Union (Ukraine, Kazakhstan, and Uzbekistan) were different, because they were established as a coordinated part of the overall Soviet Union nuclear program. The FSU nuclear programme was organised into two principal branches: (a) military (including the biggest RDI in the Soviet Union, the Kharkov Research Centre in Ukraine with six different institutes) and (b) civilian, with a mandate to promote commercial applications of nuclear science including nuclear power generation. The overall mission was similar to the RDIs described above, but with significant specializations at the different institutes, including research into military nuclear technology, space propulsion and associated science, nuclear fuel development, materials testing and nuclear physics research and isotope production.

The association of the early nuclear technology programmes with military research, and the potential dangers presented by nuclear technology resulted in a culture of privilege and secrecy at the institutes, aspects of which remain to this day.

3.1.2. Historical Importance of Government Funding

Government funding has been the dominant source of income for most nuclear RDIs since their creation, because their missions are predominantly government priorities. In part, this is because of the birth of nuclear energy and nuclear science from the weapons programmes, and because the development of nuclear science and nuclear energy production was (and still is) viewed in many countries as a strategic issue requiring direct government control.

This predominant role of the government in institute funding was not specific to the nuclear S&T sector, but was common to S&T funding generally. However, in the 1950s and 1960s, nuclear RDIs held a special position of importance with their governments, in comparison with other S&T sectors.

The confrontational environment of the cold war and with countries craving energy to foster their industrial development meant that nuclear expertise was associated with the weapons and energy programmes considered crucial to the national interest.

3.1.3. Transition to Market Economies

The structural changes caused major swings in the economic performance of most countries in Central and Eastern Europe. All of the surveyed RDIs have been affected by this economic instability, with research activity falling in bad times and increasing in good times. The nuclear RDIs were not special in this regard, but the effect was magnified because they not only had to contend with the market economy effect, but also they had to contend with the loss of their special position within government, a position taken over by IT, biotech, and nanotechnology.

In several countries the transition was very rapid and started some 15 to 18 years ago, while in most Central and Eastern European countries transition was more gradual and started earlier. However, for most of the countries, the 1990s were times of economic crisis, with perhaps the first 5 to 10 years being the greatest threat to survival. The reduction of government funding created many problems: scientists' morale declined dramatically together with the low salaries, nuclear science became, and still is, relatively unattractive to students, students were not motivated to study nuclear science and those who finished their studies were enticed abroad (the 'brain drain'), and the lack of funds for instruments and equipment created huge problems related to domestic experimental work.

In the former Czechoslovakia and Poland, governmental support was decreased because of constraints in state budgets during the transition to market economy. Institutes such as VUJE in Slovakia and REZ in the Czech Republic were privatized and focused their programmes more on applied research and profitable market oriented activities. In the Former Soviet Union (FSU), the nuclear RDIs found themselves in 'survival' mode because of the economic collapse associated with the end of the Soviet Union. Because of the former specializations at the various institutes, many of the RDIs in the FSU have inherited an 'unbalanced' portfolio of R&D skills and facilities. Old relationships between the RDIs have been broken and the RDIs now view each other more as competitors than collaborators, which hinder their ability to react effectively to the new environment requiring multiple skills to solve problems.

The economic and social changes that occurred during the last two decades in the countries of Eastern and Central Europe as they transitioned to market economies ushered in new R&D policies and strategies. The relationship between the R&D sector and government has changed, including the nuclear RDIs. In market economies, the successful transformation of research results and knowledge into commercially exploitable products or innovation is seen as important contributor to economic growth. Innovation is seen as an economic driving force and a key determinant of a country's ability to enter international markets and technology competitions. Issues such as the protection and exploitation of Intellectual Property Rights (IPR) play a fundamental role in these new economic processes, yet in almost all of the Central and Eastern European transition countries surveyed, IPR management is almost unknown and not used by the academic community in the universities and public RDIs. These institutions are now under great pressure to develop and adopt IPR policies and to increase their contribution to their societies.

3.1.4. Accession to the European Union

A number of countries in Central and Eastern Europe recently joined the European Union. R&D policy is a priority for the European Union, and lies at the heart of the Lisbon Strategy to boost employment and growth in Europe. The ambitious goal of the Lisbon Strategy is to increase investment in science and technology in EU to 3% of GDP by 2010, with two-thirds of funds coming from the private sector, to create a 'knowledge triangle' of research, education and innovation (see Figure 4) that will underpin the European economic and social model.

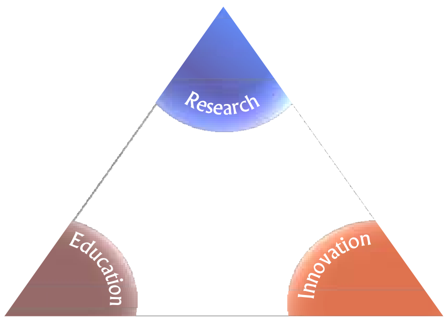

FIG. 4. Knowledge Management Triangle.

By comparison, funding for R&D in most European transition countries is only around 1% GDP, with about 90% provided by the governments. All the EU transition Member States and most non-EU transition Member States in the region are incorporating the recommendations of the EU Lisbon Strategy into their respective R&D policies and strategies. Consequently, there is a new emphasis on R&D with significantly increased funding being made available in many cases, and a push to involve commercial partners in the R&D sector. In addition, the EU's Seventh Framework Programme for Research (2007–2013) is an important source of funding for the region's RDIs, as it seeks both to consolidate the European Research Area (ERA) and to stimulate the national investments for R&D sector. However, the reduction of EU Commission FP6 and FP7 resources for nuclear fission R&D, compared to the previous framework programmes, has had a negative effect on nuclear R&D.

These environmental changes present challenges, but also hold the prospect of significant benefits for the RDIs through the increased focus on R&D and available funding. The nuclear RDIs in the survey are adapting to these new initiatives with differing levels of success.

3.1.5. Changes in Science Policy and the Reactions of Nuclear RDIs

In the past, nuclear R&D was primarily a national agenda item. It has now become a much more collaborative international activity, reflecting a more interdependent and globalized world. This is evidenced in the plans for new nuclear research facilities which have a strongly international emphasis, for example, the Jules Horowitz reactor project in France, and the regional neutron science facility at the OPAL reactor in Australia. Centres such as Halden in Norway, Petten in the Netherlands, and SCK in Belgium serve a strongly international customer base.

The designers and vendors of nuclear power stations have evolved from national enterprises, serving a national market, and requiring support from their national nuclear RDIs, to multinational companies with geographically diverse production operations, developing reactor systems for a worldwide market, and fed by technologies from multinational programmes such as GEN-IV, INPRO, and GNEP. This same globalization pervades all industrial sectors, and nuclear is not an exception.

The nuclear research community in Central and Eastern Europe is reacting to these changes, though not in a uniform way. There is considerable resistance to change. Many researchers agree with the statement that R&D has now become much more a collaborative international activity, reflecting the more interdependent and globalized world, and they are ready to join international collaborations and to participate in international projects. However, the survey showed that researchers often resist the shift from government to commercial funding of science because of what is perceived to be the "commercialization of knowledge". They emphasize the importance of basic science and the need for central government support, and almost refuse to work on other issues. Researchers that are accustomed to conducting fundamental research even question the value of applied research and especially technology transfer. In certain cases, the survey showed this resistance to change was sufficient to have blocked planned changes at both the institute and national levels.

The extent to which these changes are embraced or resisted is highly variable between countries, and between institutes within the larger countries, and even among the age groups and disciplines within a single institute. For example, it has been easier for scientists in institutes that already have research equipment for materials analysis or mass spectrometry to embrace opportunities to work in sectors other than reactor technology and nuclear power than for scientists that only have access to capabilities in the latter.

As a result of the changes in countries' R&D priorities, the need that led to the establishment of the many of the nuclear RDIs has been superseded**.** As a consequence, the role of the nuclear RDI has changed from being a privileged and strategic research institution with one customer (the government) to becoming just one of many research institutions competing for priority and attention, in a demand driven, rather than a supply driven, environment, and its status has changed from being protected to being exposed to overall R&D market forces.. For many of the nuclear RDIs, adapting to these changed circumstances is a significant challenge, as it requires a thorough revision of the mission, strategies, and policies at the institutes, and development of business skills that many institutes lack.

The reporting relationships for the nuclear RDIs are important to an RDI's ability to change, and its ability to influence changes. Figure 5 shows that only just over one half of the surveyed RDIs report to the bodies, (Ministry of Science or equivalent, and the Academy of Sciences), that have the responsibility and ability to define their country's S&T policies.

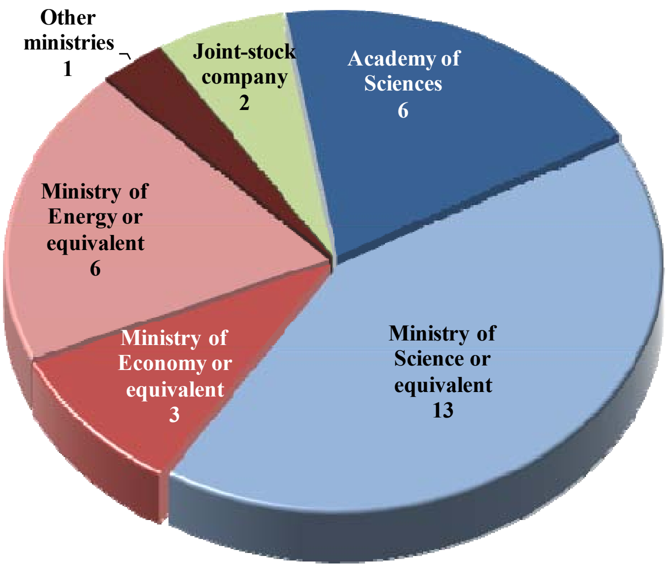

FIG. 5. Reporting Relationships for Nuclear RDIs.

The survey also showed that funding and reporting relationships have become disconnected in a number of cases making it difficult for the RDIs to meet the objectives of the funding organization. Examples include RDIs reporting to the Academy of Sciences with mandatory staff promotion policies based on publication of academic papers, but primarily funded by the Ministry of Economy for applied research or NPP support for which publication of papers is not directly relevant and is sometimes counterproductive. An illustrative example from the survey is given in Figure 6.

An institute in the survey is mainly oriented towards applied and engineering research with a greater than 70% focus on supporting the national nuclear power program through on NPP products, services and radioprotection, and receives the majority of funding from the government and the NPP operator for this purpose. For historical reasons, the institute is subordinated to a government company which sets the financial and staff management policies. Salaries are based on an inflexible industrial structure without scientific pay grades, salaries are lower than other national R&D institutes, and the institute is unable to incentivize its staff for excellence in NPP service provision, or for success in winning international research projects or commercial contracts. Experienced people are leaving, and the institute finds it hard to recruit talented staff. This lack of 'fit' between the institute mission and staff incentive system directly impacts the RDIs sustainability and the national capability to support its nuclear power programmes.

FIG. 6. Example of Reporting Relationship / Funding Conflict.

3.1.6. The case of civilian nuclear RDIs in the Russian Federation

Russia has an extensive history of nuclear R&D and has many RDIs. Some are part of Rosatom, which is responsible for nuclear energy in Russia, and others belong to the Ministry of Education. The Russia nuclear industry is in the process of restructuring to increase transparency and competitiveness of the Russian commercial nuclear sector. This includes changes to the funding and reporting relationships for the Russian RDIs that will require radical changes in the way they operate.

The restructuring is creating both opportunity and challenge for the Russian RDIs. Funding for nuclear R&D will be drawn from the profits of the new Atomenergoprom Company that will manage the nuclear civil power program, with reduced subsidies from the government. New initiatives are being launched, including the 'nuclear university' for which Rosatom is developing several training programmes and coordinating the roles of several institutes. This nuclear university will help Russia meet the human resources challenge to provide enough trained nuclear engineers for its planned rapid expansion of nuclear electricity generation.

3.2. THE CURRENT SITUATION: A SYSTEMATIC SURVEY OF NUCLEAR RDIS

As discussed above, 25 research institutes from 15 countries participated in this survey. Two rounds of self-assessment surveys were carried out: first in 2005, second, after reviewing the assessment template, in 2007. The outline of the self-assessment template is shown in the Annex 2. The information that was requested from each RDI was on past changes and current state of: mission of the research institute, financial resources, human resources and major research facilities. Other major sources of information were reports from IAEA missions conducted in the majority of the studied countries. The collected data were compiled and verified by the IAEA Secretariat, and then examined by the members of the expert group. Most of the expert group's work was based on these data.

The RDIs were asked to provide numbers of staff divided in the different qualifications and area of work for the time period between 2001 and 2006. Some RDIs provided very detailed data that included number of postdoctoral students and postdoctoral researchers. Three RDIs did not provide any data. In addition, the RDIs were asked to provide data about the number of scientists and engineers by age distribution. Two RDIs did not respond. The other 21 RDIs provided data about age distribution, with five including information for all staff age distribution.

The RDIs were asked to submit data about revenue trends (2001–2006) by source, including revenues from public sector, from private and international sources, revenues from intellectual property and other sources. All of the RDIs provided these data, but about one half of those provided incomplete or partial data. In addition, the comparison of information from the Assessment Templates with other data sources showed inconsistencies, and therefore the data non reliable could not be directly used in a quantitative analysis. In some cases the data were difficult to compare since they were given in local currency or partly in Euros and partly in local currency and so on. Therefore these data were critically analysed and compared with other data sources before their use.

About one third of all RDIs have not provided, or provided very little, data about their costs, performance indicators and organizational aspects. For one RDI the presented costs are equal to the reported total revenues. Another RDI simply stated the same proportion between the fixed and variable cost for each reported year. Eight RDIs did not provide any cost data. It was noted that many RDIs lack a robust accounting system, and that this is the primary reason for the lack of data about revenues and costs. In one case, financial data was not provided because it was considered to be confidential.

RDIs were asked to supply data on selected performance indicators (PI), for example how many applications had been submitted for national and international patents and the number of patents obtained, as well as the number of publications in indexed journals and the number of citations, for the period between 2001 and 2006.

Finally, the survey requested data about legislation, policy, planning, coordination and management, and business skills. While nine RDIs did not provide, or provided very little, data about their organizational aspects, the rest of the RDIs were able to fill all the information requested.

3.2.1. Roles and Types of Institutes

The information from both the self-assessment template and the other sources used in the preparation of this report showed the diversity of the institutes working in nuclear power and non-power application. As illustrated in Figure 7 the RDIs that participated in the survey are involved in a spectrum of activities from Basic Research, with its emphasis on the underlying science, to Applied Research, Development of new technologies, providing Services to other sectors, and Production and sale of products (for example radiopharmaceuticals), which have a progressively increasing emphasis on commercial applications.

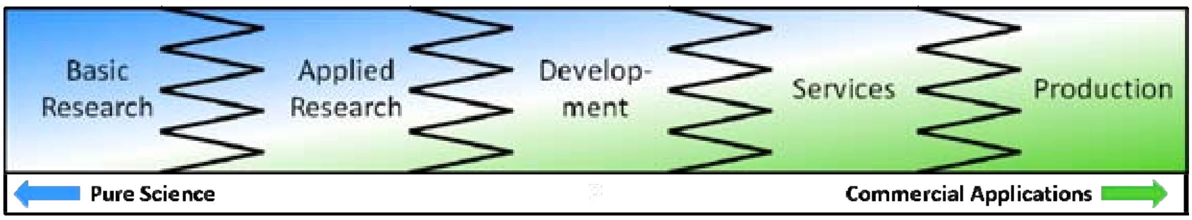

FIG. 7. The R&D Continuum.

Each of the RDI's surveyed had activities in more than one segment, and some had activities in all segments, as shown in Figure 8. However, even though some institutes had a broad scope of activity, they placed particular emphasis on certain activities, making it possible to categorize the institutes into two broad groups for the purpose of analysis, as shown in the right hand column of Figure 8.

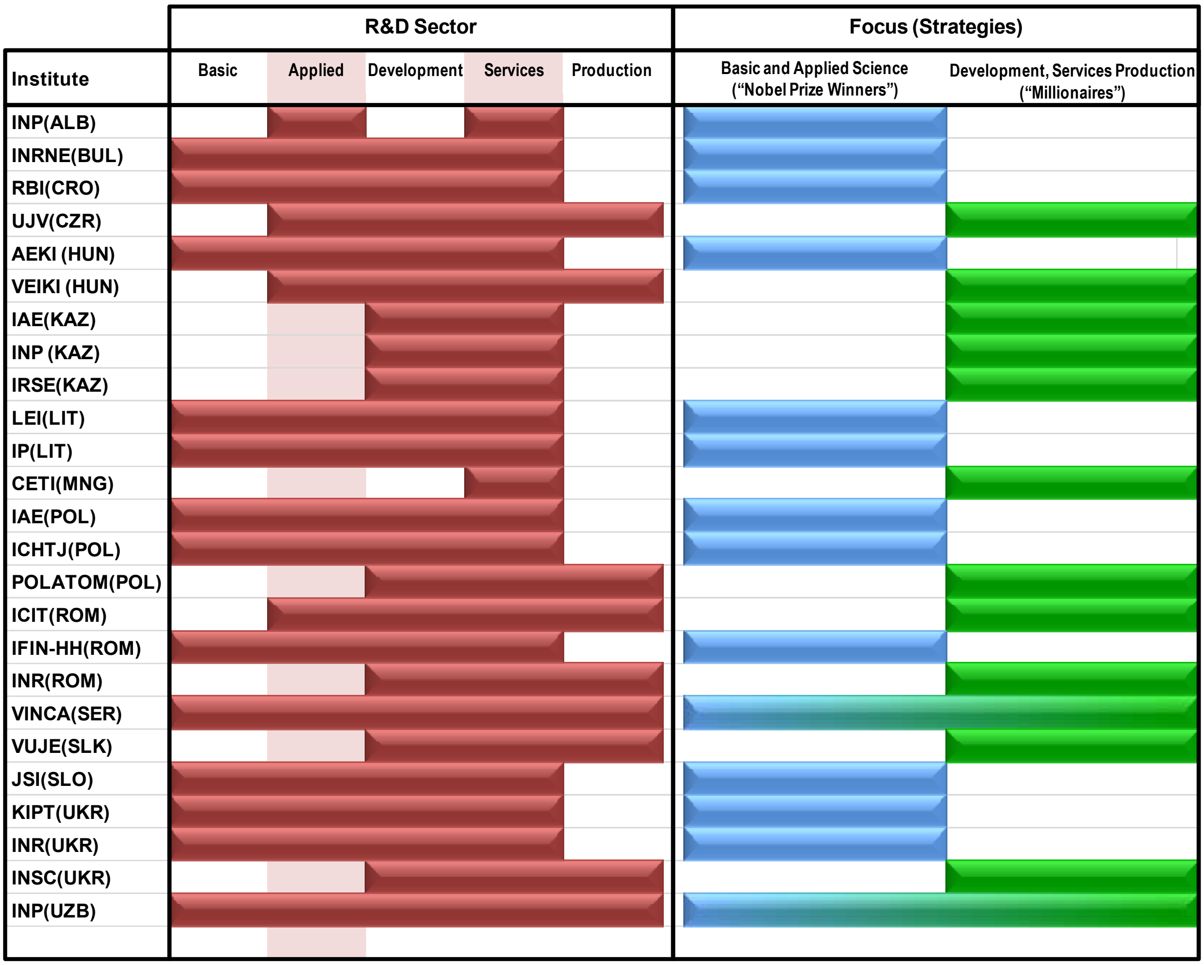

FIG. 8. RDI Positioning.

From Figure 8, we can see that about half of the surveyed RDIs are more oriented to basic and applied research while the other half is more oriented to development, services and production. The distinction is helpful to understand how effective is the RDI's internal organization and policies in fulfilling the institute mission. An institute with an academic focus has a differing set of priorities than one with a more commercial focus, and the most successful institutes have adapted their management and staff policies to match their mission and strategy. For ease of reference, we label the strategies here as 'Nobel Prize Winners' and 'Millionaires'. As is summarized in Table 2, the Nobel Prize Winners strategy is intended to create an environment for excellence in basic research, encouraging and rewarding creativity and making the academic standing of the institute the primary goal.

In contrast, the Millionaires strategy is focused on linkages to commercial markets, and rewards revenue generation, cost control and project skills, with financial success a primary institute goal. Key success factors (KSF) for RDIs vary and largely depend on their role and strategy. A number of possible KSFs and performance indicators for each of these two basic strategies are also listed in Table 3.

This is a simplified framework that divides RDIs in two categories. However, the reality is much more complex, and institute missions stretch across the R&D continuum. Some RDIs even have departments with different missions, some oriented more to the basic research side and the other to the development side.

TABLE 2. TWO BASIC RDI STRATEGIES AND POSSIBLE SUCCESS FACTORS

Basic Research

Public financing	**"Nobel Prize Winners"** - Critical mass of best researchers - Research infrastructure - Creative environment - Strong political support - Academic reputation		
		"Millionaires" - Link between technology and the market - Marketing skills - Flexibility - On time & on cost research	**Private financing**

Development

TABLE 3. PERFORMANCE OF RDIS AND POSSIBLE PERFORMANCE INDICATORS

Basic Research

Public financing	**"Nobel Prize Winners"** - Number of researchers - Number of post-docs - Number of government grants - Number of articles/citations - Employee satisfaction		
		"Millionaires" - Number of patents - Number of international projects - Number of industrial grants - Revenues per researcher - % projects on time & budget	**Private financing**

Development

In a report published in 1996 on Trends in Nuclear Research Institutes, the Nuclear Energy Agency (NEA)/OECD considered many of the issues discussed in this report. The NEA/OECD report focused mainly on trends and possible responses in major nuclear facilities in the energy field in developed countries. However, the same trends are now obvious in less developed countries and for all nuclear RDIs, both those strongly focused on the nuclear industry and those that are more cross-disciplinary.

The NEA/OECD report concluded that nuclear RDIs had three strategic choices if they were to have a viable future (the phrases in brackets and italics are explanatory additions used in this report):

- To continue to be research institutes dedicated to nuclear R&D (essentially nuclear power and reactor technologies);

- To expand their field of R&D into other energy (non-nuclear) energy technologies;
- To expand further into other fields of science and technology (such as medicine, agriculture, environment and industry).

The NEA/OECD report also made a number of key points in relation to making and implementing these choices:

- In making their choices, RDIs must recognise that they must service either a government need (choice a), a non-nuclear energy sector needs (choice b) or a need from a broad range of industries, regulatory authorities and society (choice c);
- Sources of revenue should be diversified;
- A greater emphasis on marketing activities was necessary to promote the benefits of nuclear capabilities in order to diversify revenue sources for example through contracts and commercial services;
- Management skills, particular in relation to outside organizations was of increasing importance;
- International cooperation and interdisciplinary approaches should be encouraged;
- The RDIs should consider internal restructuring, including restructuring their R&D programmes.

Comparing the 3 OECD strategic choices with the data collected in the present survey, the analysis shows that out of 25 surveyed RDIs:

- About 36% are focused on nuclear power R&D (mostly nuclear power and reactor technologies);
- About 8% are dealing with broad energy technologies (including nuclear);
- About 56% of the RDIs gradually expanded into other fields of science and technology. A few institutes even lost their primary nuclear character and became truly interdisciplinary institutions with a heavy involvement in environment, health and other sectors, a small fraction focused on nuclear non-power applications.

Besides activities in the R&D domain, a number of the surveyed RDIs have a role in education. About 74% of RDIs are involved in education (Figure 9). In particular, most of the RDIs reported that staff lectures at universities and PhD students perform research at RDIs. Most of the RDIs see their educational activities important because of keeping them in contact with new generation of scientists. It is also accepted way to provide a service to society even if not formally compensated (69% of RDIs noted that they are not formally compensated for their work in education).

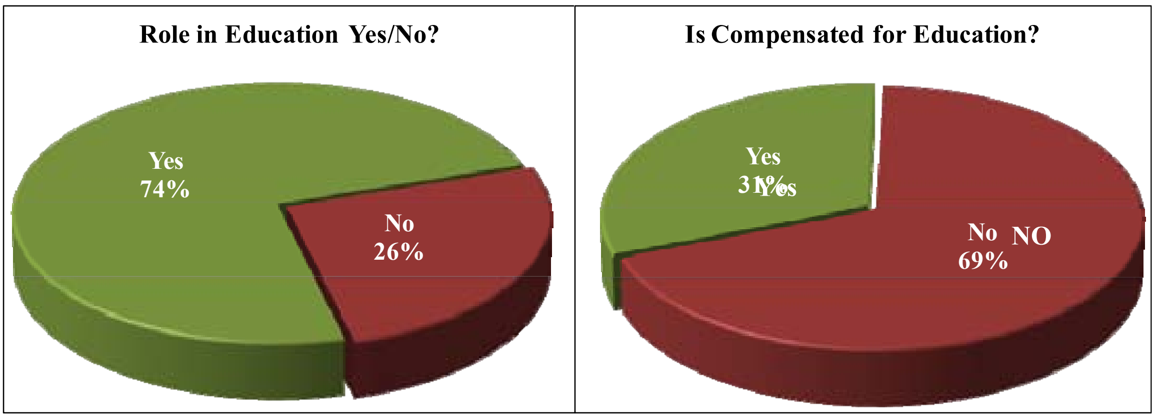

FIG. 9. RDI's role in education.

3.2.2. Infrastructure

Many of the surveyed RDIs operate complex facilities such as research reactors, radioactive waste repositories or treatment plants, accelerators, irradiation facilities and radioisotope production systems. For example, eleven have a research reactor facility that is either operating or being decommissioned and eleven of the surveyed RDIs are equipped with various accelerators, including cyclotrons electrostatic ion accelerators and electron accelerators. The majority of the surveyed RDIs that are not equipped with such complex equipment are in possession of various radiation detectors, alpha, beta and gamma spectrometers, X ray and mass spectrometers, thermo-luminescence detection systems, etc.

In general, running a complex facility such as a research reactor creates a financial burden on the institute. These RDIs need to have a mechanism for tracking and managing costs and revenues, to avoid unintentional impacts on other operations. For example, UJV in the Czech Republic has a special arrangement to track research reactor costs. We further examine this funding issue in Section 3.2.3.

In some cases, complex facilities such as research reactors are regarded as national infrastructure items that are of interest to other users and stakeholders and not only the institute. For example, the research reactor at INRE in Bulgaria was shut down some years ago, but now a new or reconstructed research reactor has been proposed to support Bulgaria's new NPP building program.

Running a research reactor or other complex infrastructure would be expected to require an increased technical staff. We analysed the relationship between numbers of technical staff and infrastructure later in the section on human resources.

3.2.3. Funding

For most of the RDIs in the study, obtaining adequate funding is a significant challenge. The surveyed RDI revenues are lower than those of institutes in Western Europe, and have been impacted by the shift in government funding priorities discussed in Section 3.1 above. Comparing Figure 10 and Figure 11, it can be seen that the RDIs with research reactors are among the least-well-compensated institutes, as measured by revenues per staff member. This reinforces the anecdotal evidence that the research reactors tend to be a burden on institute finances, rather than an asset that attracts funding from governmental or commercial sources.

Figure 10 and Figure 11 show the distribution of revenues per total staff for the RDIs surveyed, normalized using the purchasing power parity data published by the IMF[13]. The figures show data only for those RDIs which provided all the needed data, such as revenues and number of staff.

[13] International Monetary Fund "World Economic Outlook Database, April 2008 Edition" http://www.imf.org/external/pubs/ft/weo/2008/01/weodata/index.aspx

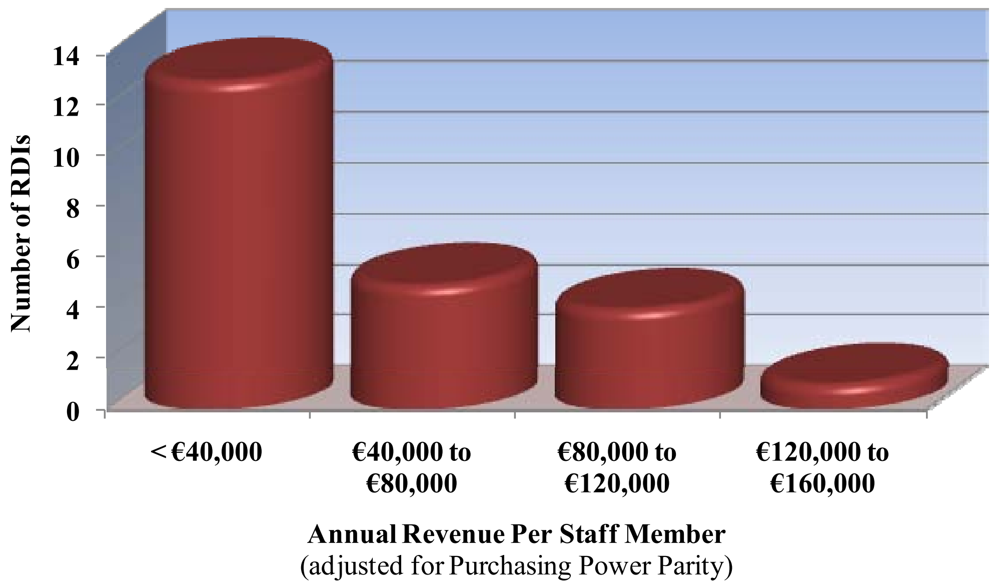

FIG. 10. Annual Revenues of All Nuclear RDIs.

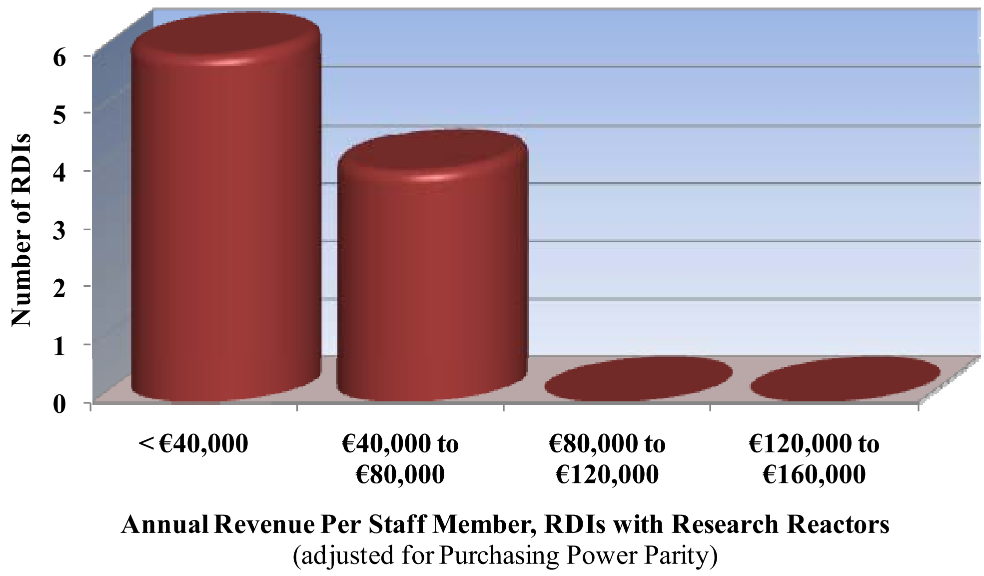

FIG. 11. Annual Revenues of Nuclear RDIs with Research Reactors.

Figure 12 shows that, in general, there is no correlation between the revenues per staff and the national GDP per capita (both normalised using purchasing power parity), with the possible exception of the RDIs located in countries with the lowest GDP per capita. RDIs in less wealthy countries are still capable of performing as well as those in more affluent countries, and RDIs in wealthy countries may underperform their peers.

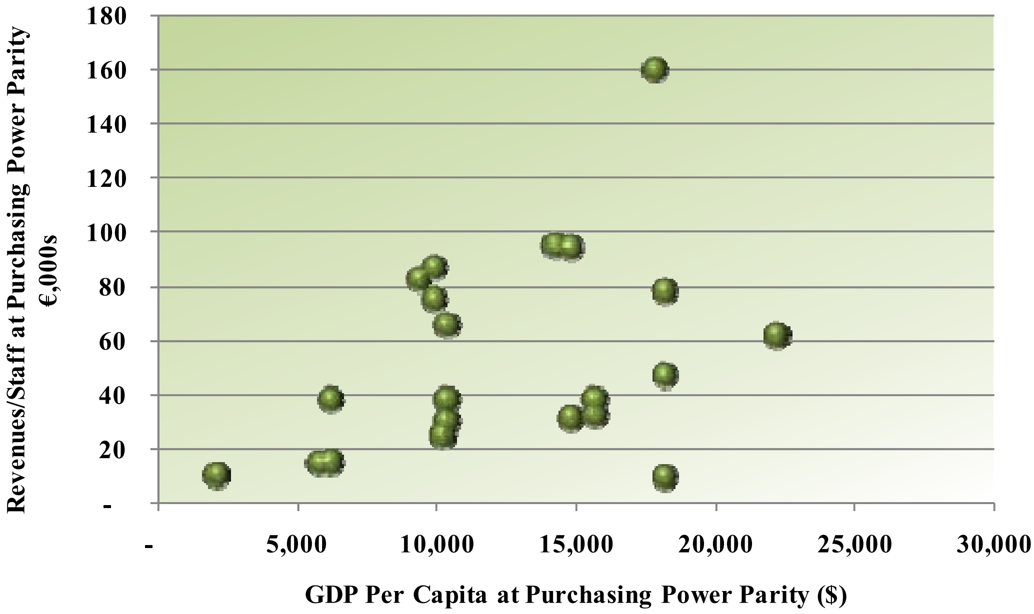

FIG. 12. Comparison of Revenues per Staff with Country GDP.

Significant changes have occurred during the last six years, including accession to the EU of some of the countries in Central and Eastern Europe, and rapid GDP growth in several countries. Overall, the RDIs increased their revenues in line with the positive domestic economic climate. This is not universally the case, however, and some RDIs have been less successful, with revenues declining over the period, as shown by Figure 13.

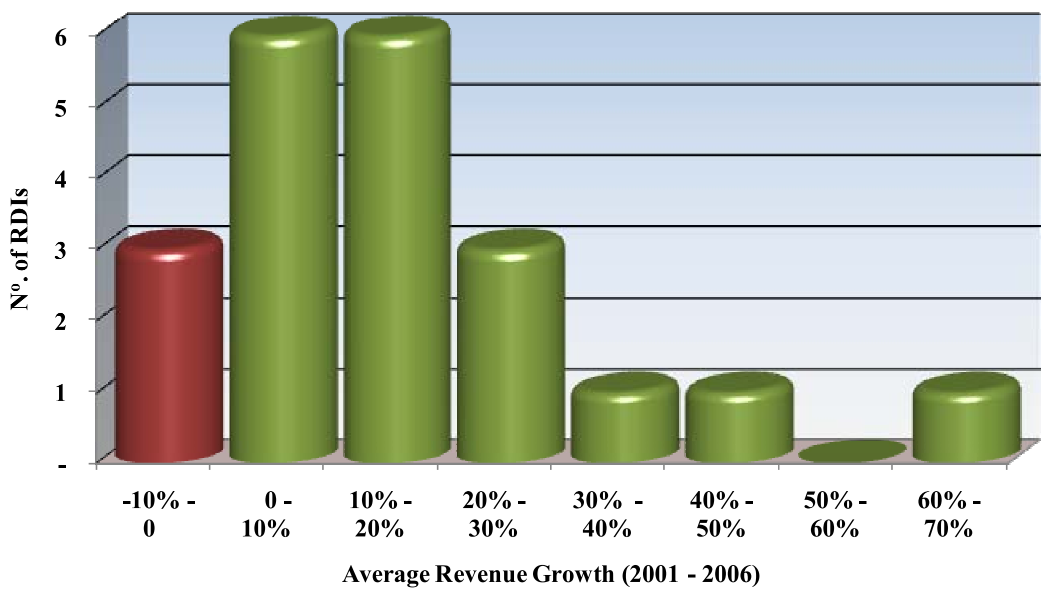

FIG. 13. Average Annual Revenue Growth at Surveyed RDIs.

Governmental Funding

Government funding is typically made available through a mixture of direct subsidies and projects awarded on a competitive basis. The governments in the Central and Eastern European countries are changing to project-based funding of R&D, and increasing their emphasis on funding RDIs through competitive grants. The intent is both to promote competitiveness and excellence, and to reduce the expectation of government subsidies.

Most of the RDIs surveyed are under increasing pressure to reduce their dependence on central government funds and to compete aggressively to find alternate sources of revenue. Public officials, policy makers, funding agencies and private sector executives now demand that R&D make a demonstrable difference to their sector and achieve high performance before committing to continued support or new funding for the institutes. The institutes have responded with determined efforts to increase their funds from other sources. The survey data show that the importance of direct government subsidies varies considerably between surveyed RDIs, from no subsidies at all, to up to 99% of the RDI's total public revenues. However, for the majority, the government remains the most important client and will probably continue to be for the foreseeable future, see Figure 14.

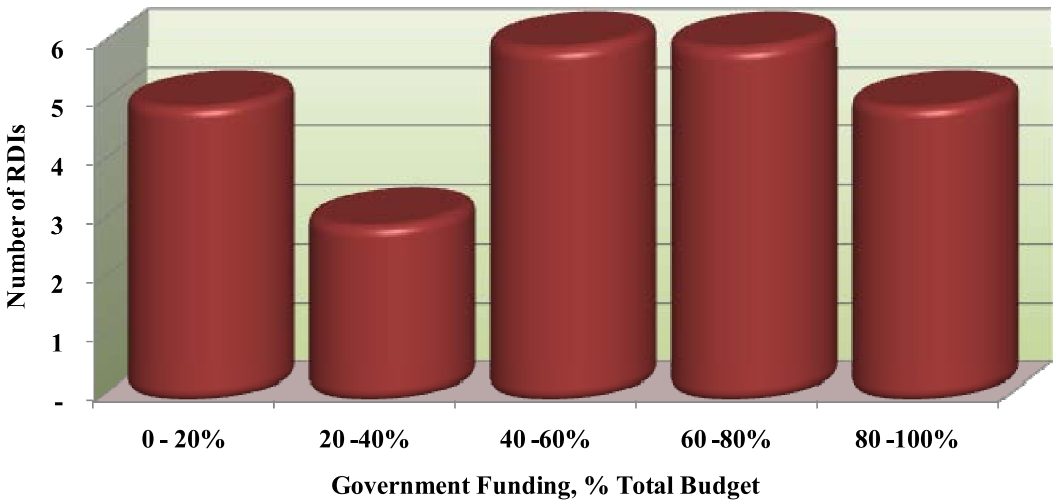

FIG. 14. Importance of Government Funding for Nuclear RDIs.

It is worth noting that, despite the encouragement for RDIs to seek sources of external funds, there is often a doubt amongst researchers that any 'new' revenue will benefit the RDI, because of a belief that the additional funds would be offset by a decrease in funding from government. This expectation forms a powerful internal barrier to development of alternative sources of funds, and is widespread, even though more than 90% of the surveyed RDIs have the ability to retain some portion of external revenues, see Figure 15, These RDI can use these additional funds to address institute priorities and many can transfer the additional funds from one year to the other).

For those RDIs with an emphasis on basic science, the 'Nobel Prize Winners' there is little correlation between the extent of government funding and the financial success of the institute as measured by the institute's revenues per staff, as shown in Figure 16. This implies that an RDI that is fulfilling its role within its government's strategy can expect to receive adequate funding, However, Figure 16 also shows that the revenues of RDIs that have a strong development or commercial focus, the 'Millionaires', there is a negative correlation with a heavy reliance on government funding. The three RDIs from the 'Millionaires' group that have the highest dependence on government funding have the lowest revenues per staff of their group, and are the least financially successful.

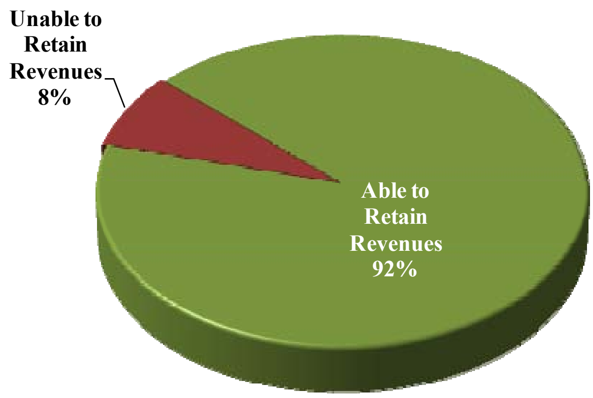

FIG. 15. Ability to Retain Revenues.

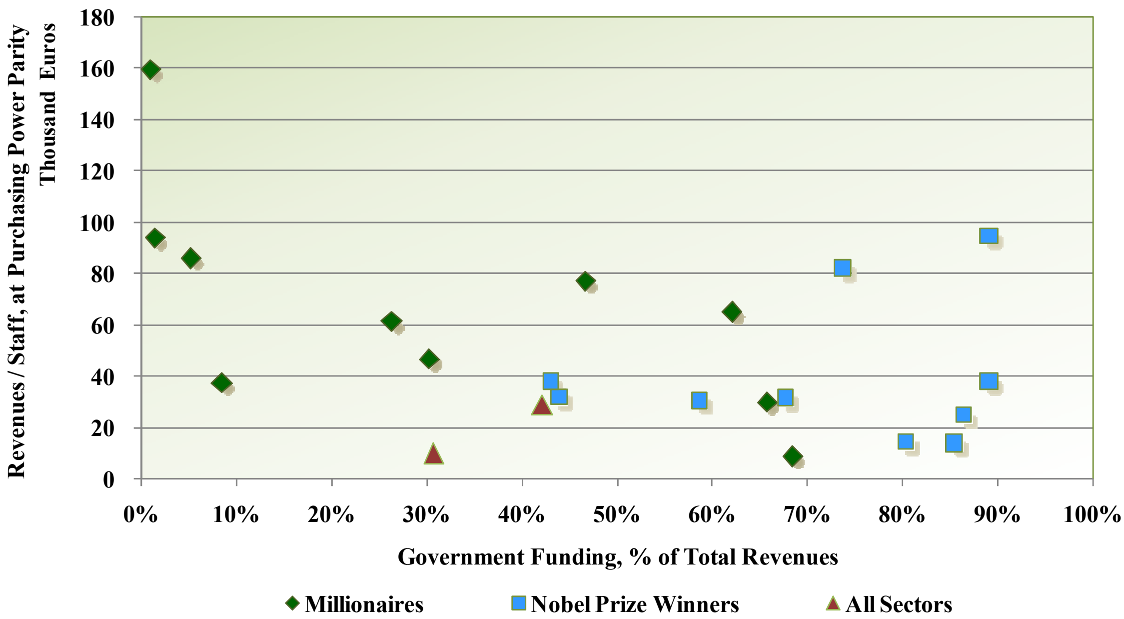

FIG. 16. Relationship between Proportion of Government Funding and RDI Revenues.

The dependence on government funding underscores another key issue: increased government funding should not be excluded from an RDI's thinking about 'new revenue sources'. Most discussion of additional funds with surveyed RDIs was focused on new external opportunities to develop revenues, for example from commercial opportunities, or from European Union grants. However, though these additional funds can make an important contribution to an RDI's finances, few nuclear RDI's have a realistic chance of generating enough non-government funding to fully support themselves.

Government support requires that the institute is recognized as an important contributor to the country's overall S&T objectives. The survey revealed a wide range of RDI involvement with the domestic government. Some RDIs were closely integrated into their governments science policies and programmes, other were largely isolated from the political sphere. The better integrated RDIs were more successful in obtaining government funding, implying that, for many RDIs, improving linkages to the government and relevance of the institute to government priorities and policies, should be an important part of the strategy to develop additional revenues.

International Funding

Several of the RDIs — particularly in the former Soviet Union — benefited significantly from the non-proliferation programmes sponsored by the US Department of Energy (DOE), the International Science and Technology Center (ISTC), the EC and others. Funding from these sources represented a large fraction of the RDI's income, and has been important to the development of the institutes. However, the non-proliferation programmes are finite in their scope and duration. In the longer term, those RDIs need to develop other, more sustainable sources of income.

The total FP7 budget is much bigger than FP5 or FP6, presenting opportunities for RDIs. However, the allocation for nuclear fission reactor, radiation protection and waste management R&D via Erratum has been reduced.

Only eleven RDIs provided separate data on funding from the European Commission and the data is summarized in Figure 17. The importance of funding from the EC varies from one RDI to another. For some RDIs it provides a vital source for funding, for others the financial importance has been reduced in the last few years (see Figure 18). For all RDIs it is an important opportunity to stay in the general trend of R&D, and to increase the institutes' international prestige and their reputation with their own governments. Several countries in Central and Eastern Europe joined the EU in 2004 and 2007. The RDIs in those countries, as well as others that are still outside the EU have been given the opportunity to participate in the European Research Programmes. Over time, one would expect the RDIs in Central and Eastern Europe to match the level of participation of RDIs from older EU members. However revenues from European Programmes are still very low in most of the RDIs surveyed.

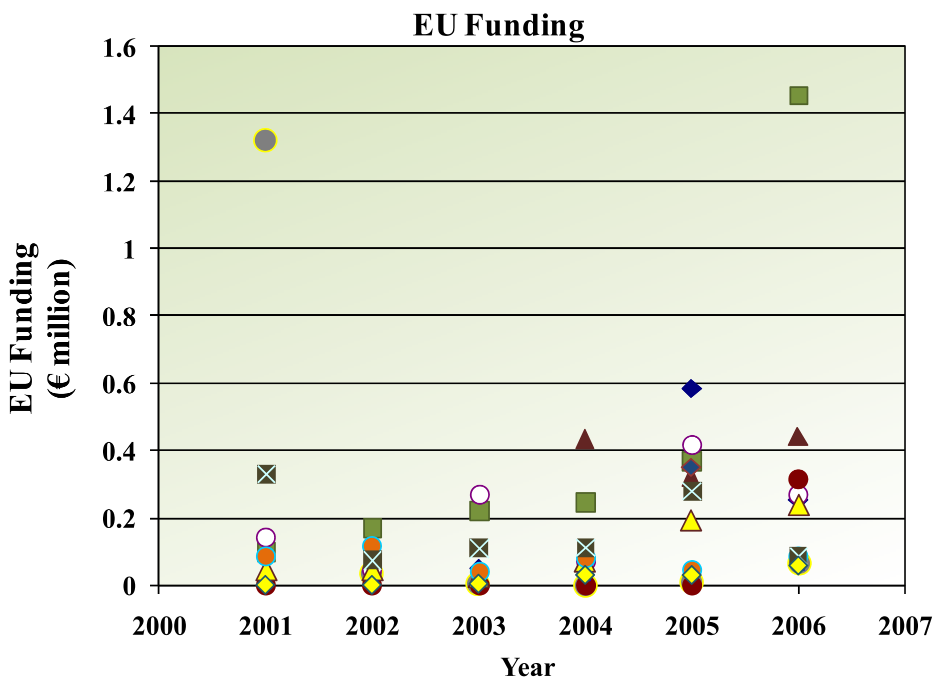

FIG. 17. RDI funding from the European Commission Projects.

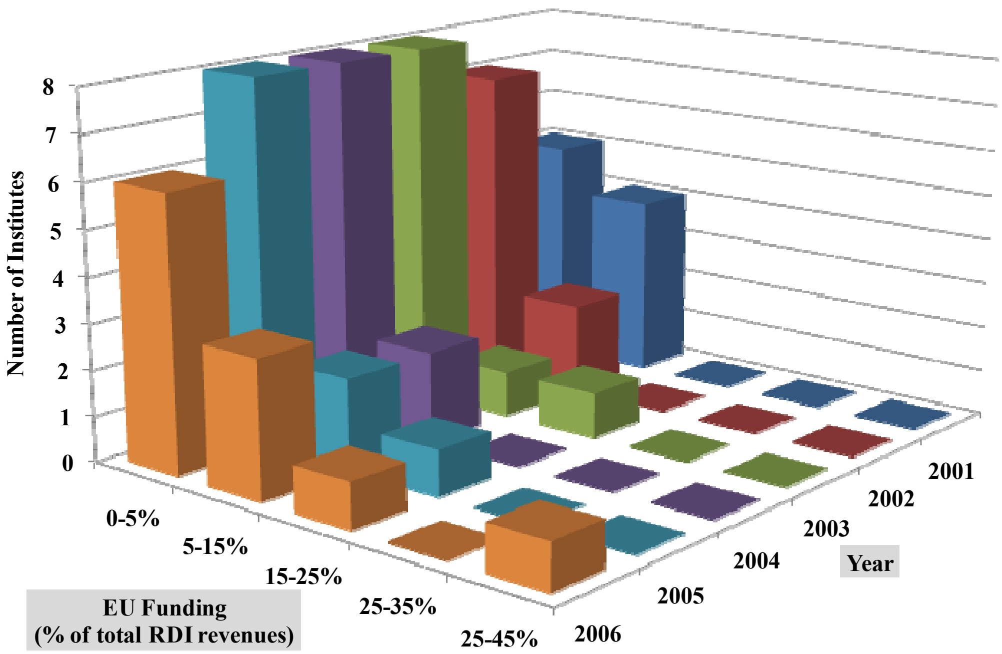

FIG. 18. RDI funding from the European Commission Projects in percent of total revenues.

The survey noted that success in European Research funding competitions requires a proficiency in proposal writing that takes time to be fully developed, and observed that many RDIs lacked incentives for the scientists to develop and pursue research proposals. The survey found that most RDIs from Central and Eastern Europe have established themselves as minor partners in collaborative EU projects. Thus, one way to increase the benefits from the EU programme is to become project coordinators with a leading role in such projects. Countries that have taken specific action to increase their access to European funding have been generally successful.

For RDI's located within the EU, the EU Structural Funds present another very important option to increase funding and to strengthen their capacities for research or innovation.

Funds from Exploitation of Intellectual Property Rights

Only one of the RDIs surveyed reported appreciable revenues from IPR licensing, and as discussed further in Section 3.2.5 below, only just over one-third of the RDIs have a formal policy on the management of IPR, see Figure 19.

Several of the RDIs surveyed were exploring ways to commercialize technology developed at the institutes. These included establishing technology parks in which RDI staff and local companies could take benefit of RDI experience and facilities for an interim period while technologies were commercialized.

Between 2001 and 2006 seven RDIs obtained national patents, and three RDIs obtained international patents. Only one RDI regularly files for, and obtains, national and international patents in any significant number, even though it doesn't gain any revenues from its patent rights. Only two RDIs obtain revenues from their patent rights, and these revenues are relatively small.

FIG. 19. IPR Policy.

Note that even though patent protection is an important part of IP management, it is only one aspect, and not necessarily the most important one for nuclear RDIs. Other aspects of IP management, including negotiating and implementing confidentiality agreements to protect both the institute's own IP, and that of its partners, are also important. For example, in many cases the RDIs are contracted to do R&D and the funders retain any IP rights that result. The financial benefit of such IP management aspects cannot be separately quantified, though they are important to the overall ability of the institute to secure relevant work.

Commercial Revenues

The survey showed that many RDIs have developed commercial revenues from services such as radiation protection consultancy, radiation and environmental monitoring for NPPs, utilities and to regulatory authorities, and radiation sterilization, as well as products such as radiopharmaceuticals and industrial radioisotopes.

Most NPP-related services are provided to NPPs in the RDI's own country, though there are examples of RDIs providing such services internationally. Just over half of the RDIs surveyed were located in a country with at least one NPP, ten of those RDIs reported NPP-related income. Of those RDIs, the NPP provided a majority of the institute's revenues in only one case. For the majority of the RDIs, the direct revenues from NPPs provided only a small proportion of the institutes' overall funding, as shown by Figure 20. This observation raises some interesting questions. For example, what level of funding for NPP services is included within government subsidies, or could RDIs play a greater role as a source of expertise for the NPP operators?

A few RDIs still perform some commercial activities which are not related to their core mission, for example: telecommunication services, running cafeterias, water pipelines, and farming. These activities appear to be a legacy of the past, or a response to the economic collapse of the 1990s, and are generally being phased out.

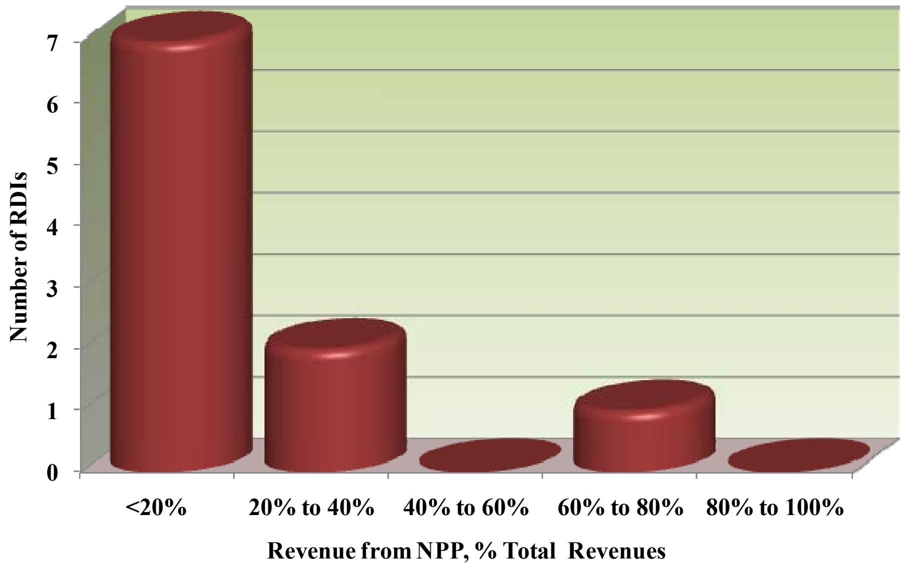

FIG. 20. Funding Derived From NPP (RDIs in Countries with NPPs).

3.2.4. Human Resources

Human resources data were provided by almost all of the institutes surveyed. Only three RDIs did not provide statistics about staff qualifications and area of work for the period 2001 to 2006. Figure 21 shows the percentage of Scientific/Engineering, Technical and Administrative staff employed in the surveyed RDIs in 2006. Scientific/Engineering staff includes researchers (including fellows), postdoctoral students, PhD and MSc students.

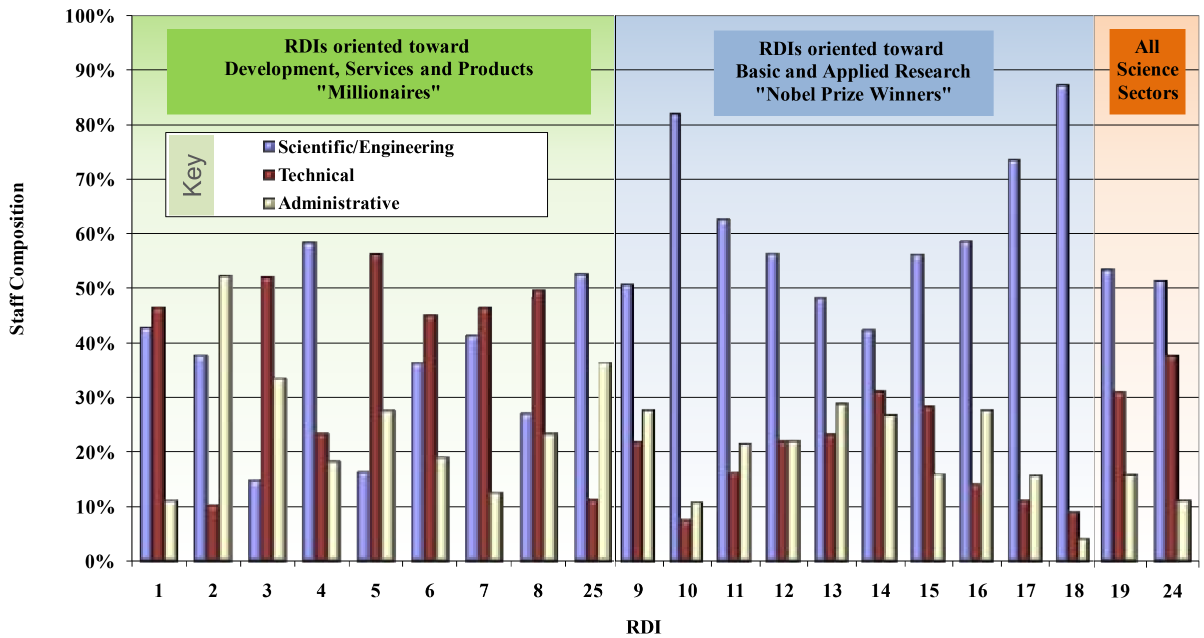

FIG. 21. Percentage of Scientific/Engineering, Technical and Administrative Staff within surveyed RDIs.

As one would expect, the figure shows that RDIs in the 'Nobel Prize Winner' group tend to have a higher proportion of Scientific/Engineering staff then the 'Millionaires' group, whereas those in the 'Millionaires' group have a higher proportion of technical staff. Scientific/engineering staff comprise between 15% and 52% of the total staff for the RDIs in the 'Millionaires' group, while for the 'Nobel Prize Winners' group the percentage ranges from just under 40% to almost 90%. The majority of RDIs from the 'Millionaires' group has more than 30% technical staff, while the 'Nobel Prize Winners' group has less than 30% technical staff.

The figure shows that there is not a significant difference in percentage of administrative staff between the two groups of RDIs. The percentage of administrative staff for most RDIs varies between 10 and 30%. In fact, one RDI has only about 5% administrative staff, six RDIs have between 10 and 20%, nine RDIs have between 20 and 30%, one RDI has a bit above 30% and the other one even more than 50% of administrative staff.

Figure 22 also shows the percentage of Scientific/Engineering, Technical and Administrative staff employed in the surveyed RDIs in 2006, but with the RDIs grouped into those with research reactors and those without. The figure shows the human resource implications of operating a research reactor on human resources. The data show that the percentage of technical staff is not correlated with the operation of a research reactor. It is the RDI mission that determines the make-up of the staff. RDIs number 10, 17 and 18, for example, operate research reactors, but have the lowest ratio of technical staff to scientists and engineers of all of the RDIs. These institutes are focused more on basic and applied research as can be seen in Figure 21. In contrast RDI 5 has the highest proportion of technical staff of all of the institutes, even though it does not operate a research reactor. This institute is oriented toward development services and products.

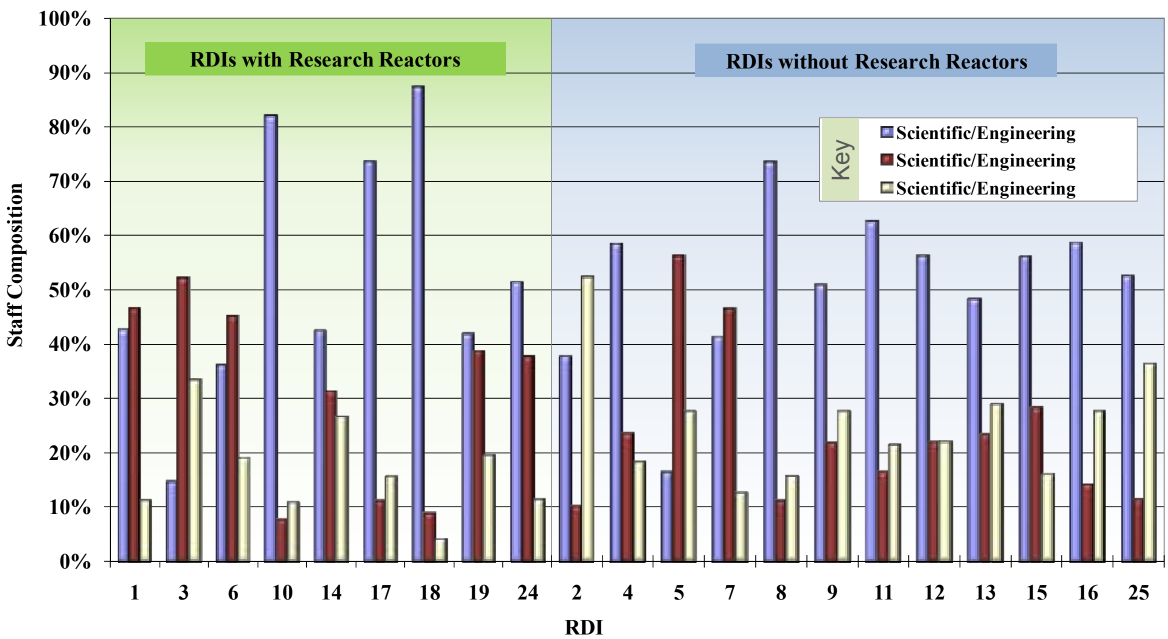

FIG. 22. Percentage of Scientific/Engineering, Technical and Administrative Staff.

Figure 23 shows staff distribution by age in 2006. Some RDIs show a bimodal staff distribution with majority of staff above 56 years old and a significant number of staff below 35 years old, while the staff aged between 35 and 55 is relatively small. This pattern suggests that the institute had difficulty attracting and retaining talented staff in the last 10–15 years. Although current recruitment appears strong, the deficit in experience in the 45–55 year age range may present challenges with knowledge and skills retention as the oldest staff retire. Other RDIs have even more challenging staff age distribution with the majority of their staff more 45 years old.

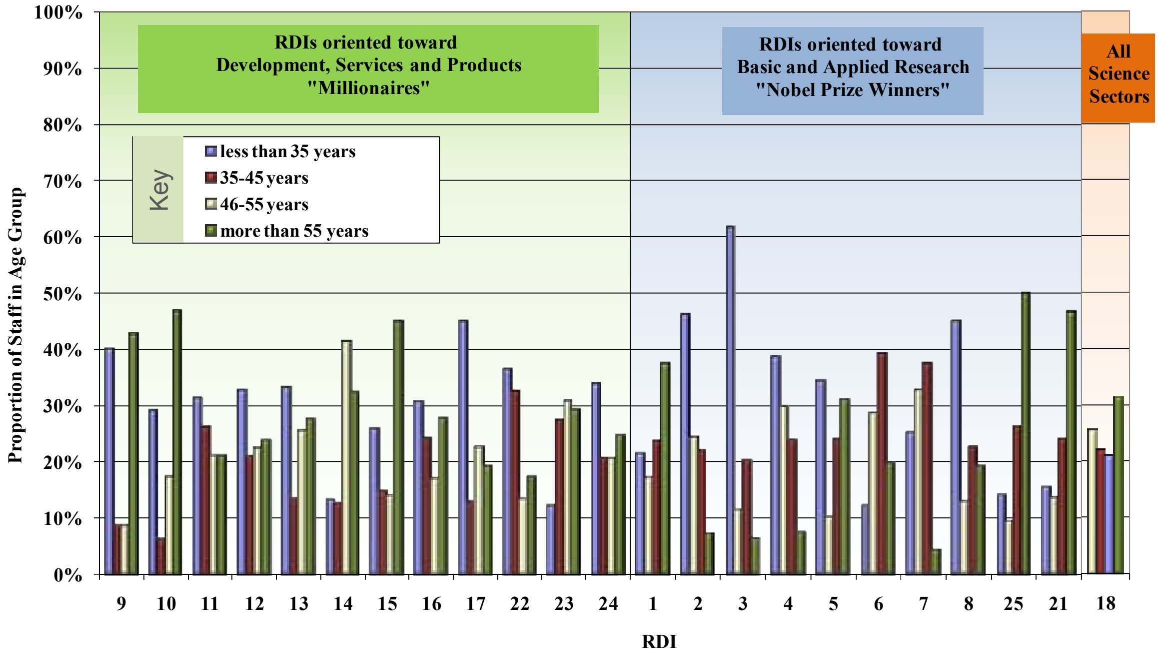

FIG. 23. Staff Distribution by Age.

Figure 24 shows total number of staff for all the RDIs which provided data, together with the breakdown by category: Scientific/Engineering staff, Technical staff and Administrative staff. These numbers provide an indication of primary nuclear R&D capability in the surveyed geographical area. The institutes surveyed include the major facilities in countries representing over 90% of the population and of the economic activity of Eastern Europe excluding the Russian Federation (RDIs in the Russian Federation were outside the scope of this survey, as noted in Section 1.2) though it should be noted that the survey did not cover all nuclear RDIs and University departments in the sampled countries.

Figure 24 b) shows the overall age distribution of the RDI staff, aggregated over all RDIs which provided data. The overall lack of staff in the 36 to 45 years age range testifies to the economic difficulties of the nineties, and the institutes' inability to attract new expert staff. The increased proportion of staff below 35 years of age reinforces the observations elsewhere in the survey that the situation is now improving at many institutes, as the overall economic situations improve. The high preponderance of staff aged over 56 years warns of upcoming difficulties in knowledge retention in the nuclear R&D sector.

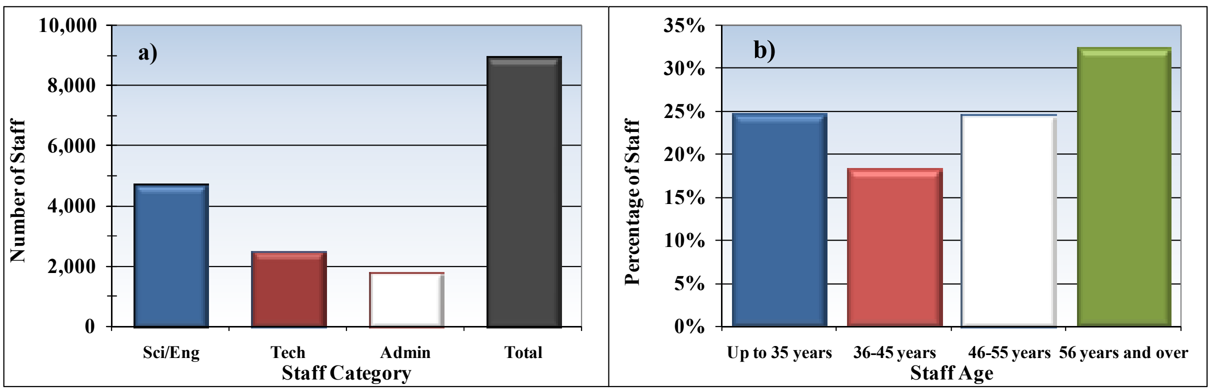

FIG. 24. Aggregated Staff Age Data.

3.2.5. Policies and Performance Indicators

Policies and performance indicators are indispensable tools for motivating institute staff and management and bringing their actions into line with the institute interest. There is a widespread feeling that the difficult financial situation confronting many nuclear RDIs is exacerbated by a mismatch, or lack of fit, between the organization of science funding at the government level, the institutes' missions, and the policies and performance indicators used by the institutes to monitor and assess their own activities. Thus the study included an initial assessment of RDI

The survey showed that in several cases the performance indicators in use by the institutes are not well developed. For example, as shown in Figure 25, just over half of the surveyed RDIs have a staff incentives policy, meaning that they have a formal policy in place to reward staff members that achieve good results. However, in several cases these policies do not align staff and institute objectives. Examples of this mismatch include:

- Academic reputation remains the prime objective and the recognised pathway to promotion for scientists, even for institutes that are engaged in service or production activities. This is mainly a legacy of the past and was acknowledged by many institute managers and government policy makers to be a direct hindrance to institute sustainability because it penalizes staff members that develop institute revenues instead of publishing scientific papers.
- In some cases, staff recruitment, promotion and reward policies are outside the direct control of the institute and are rigidly set by national legislation or policy.

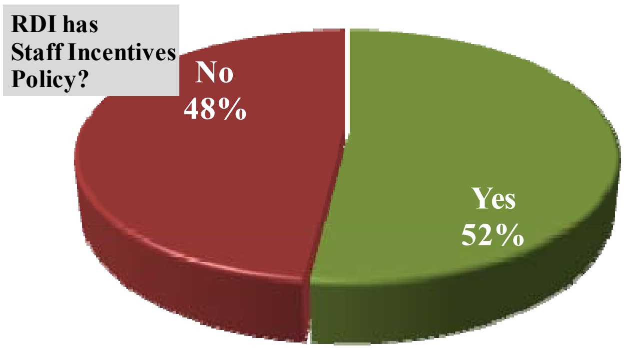

FIG. 25. Staff Incentives Policies.

Figure 26 compares the revenues of the RDIs which have a staff incentives policy in place with those without such a policy. The figure shows that those RDIs with the policy in place tend to have better revenues per staff (are more successful) than the others.

As discussed in Section 3.2.3, almost two-thirds of the RDIs have an IPR policy (see Figure 19) although at the time of the survey only two institutes generated even minor revenues from IPR. Survey data show that few RDIs make efforts to protect their intellectual properties through patents.

Often, the way the RDIs are funded does little to reward them for transferring technology or for providing consultancy, services and products. Consequently, little consideration is given to how the results of R&D are to be transferred out of the laboratory and into practical use within society. This limits the relevance of the institute with respect to government sponsorship, and it impedes generation of revenues from IPR, because there is often no clear pathway between the RDIs and the potential end users of their technology.

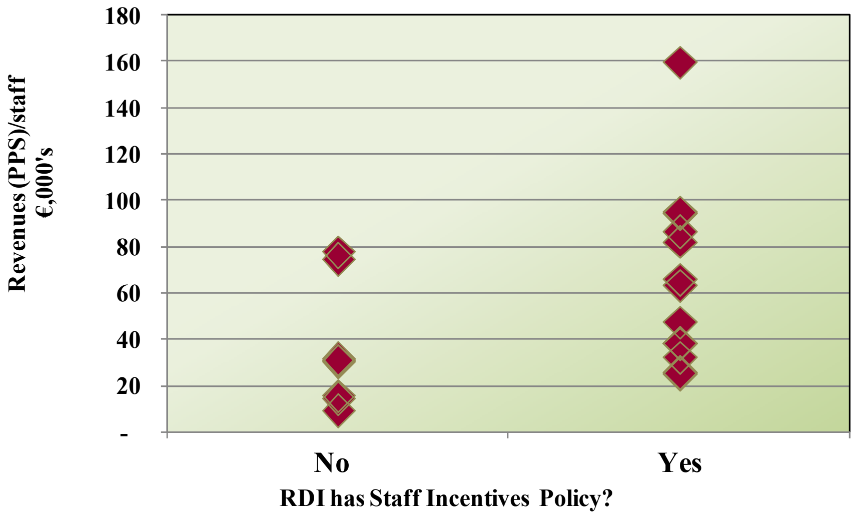

FIG. 26. RDI's Revenue versus Staff Incentives Policy.

Several of the RDIs that took part in the survey reported that they lacked the skills needed to commercialise technology or to manage the process of technology transfer and the effective and efficient provision of services and products. In addition, there were reports of RDIs being impeded in this respect by tensions and mutual suspicion between staff focused on commercialization of technology and those focused upon basic science.

A minority of the surveyed RDIs had a formal strategic or business plan to guide their activities. Figure 27 shows that about only one-third of the surveyed RDIs have a formal business plan in place.

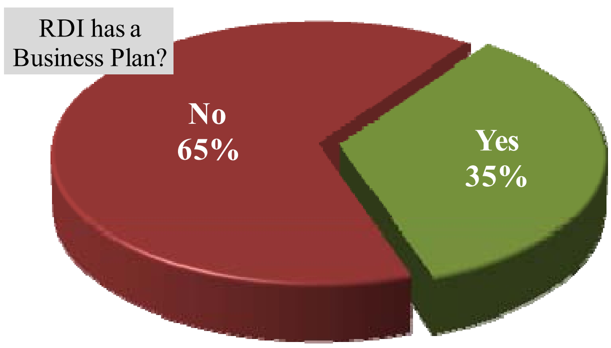

FIG. 27. Use of Business Plans.

Alternative performance indicators

The managers of several RDIs mentioned that they had or were in the process of considering the inclusion of alternative performance indicators within the promotion system, although these were not in place at the time of the survey. These alternative performance indicators include statistics from contracts or projects with the public and private sectors, statistics from educational contracts, and patents. The intent of these proposed performance measures is to encourage researchers to obtain more applied research work and thus earn more revenues for the institutes.

An institute focusing on expanding its participation in competitively tendered projects established a staff promotion and reward policy that not only includes the number of publications in appropriate journals, but also rewards staff based on the number of patents obtained and R&D projects won. Staff working on successful R&D projects are able to substantially increase their salaries. Institute revenues grew by a factor of four over the four years following introduction of the new rewards policies.

FIG. 28. Example of Successful Alignment of Internal Policies and Mission.

The survey found that performance indicators that are realistic and carefully tuned to the RDI's strategic plan can be effective in encouraging the development of revenue-generating business. As an example, an institute seeking a greater international role can reward staff for increased participation in international projects.

However, there is also evidence that if the RDI lacks the necessary management systems to execute the new work, or if it is otherwise constrained in managing different types of work, such performance indicators can create damaging frustration. For example, in Croatia and other countries in the region, the government policies define the promotion criteria for all scientific staff employed in all public R&D institutions, including Universities. State-recognized scientific grades can be obtained only by satisfying the government criteria. Scientists in the natural sciences, including the majority of nuclear physicists, are assessed for promotion only on the number and quality of publications. The RDIs have to use the government based criteria, though they may add their additional criteria of their own to the government ones. Thus, incentivising staff at the institute level to focus on revenue generation rather than publishing papers may jeopardise their long term careers.

3.2.6. Key Success Factors

The survey looked at legislation, institute policies and key performance indicators of the surveyed institutes, and held discussions with the key government decision makers as well as the directors of the RDIs, with the objective of identifying the main success factors.

Although the report focuses on the policies and skills at the institute level, RDIs exist within the environment created by their governments' regulations and policies, which either enable or hinder the RDIs. In order for nuclear RDIs to prosper they need suitable government policies, for example, policies that support the retention of revenues from non-governmental sources, and the institute's autonomy in staff recruitment and incentive policies.

This work showed that there is not only one possible model for a successful RDI, but several. However, it also showed that key success factors do not vary significantly between nuclear RDIs and RDIs involved in other disciplines. The main keys for success are for the RDIs to:

1. Align their mission, policies, and strategies to the environment and the needs of their stakeholders.
2. Take a proactive stance to shape a favourable environment and set their strategy and action plans. This requires developing relationships with the government and the other stakeholders.
3. Prepare strategic plans to prioritize activities and investments. This includes developing a clear understanding of the institute mission, capabilities and unique strengths. A successful strategy builds on the RDI's capabilities, and includes realistically achievable objectives, with supporting action plans and staff incentive policies. For example, the plan may focus on the development of commercial applications and revenues, or it could ensure that the RDI remains

indispensable to its government's plans for development of science and technology, nuclear medicine, or industry. It is not 'one size fits all'.

4. Develop alliances with strategic partners and participate in international and national networks with other nuclear RDIs to build the institute's international reputation and enable access to international funding.

For those RDI's that are planning to market products and services commercially, there are many aspects to be taken into account. The most important, and the most neglected, is to have an accounting system that can realistically allocate costs to the various services and products. If an RDI lacks such systems, two self-defeating behaviours can result:

(i) Over allocation of unavoidable costs to new product and services, making them apparently 'unprofitable' and unsustainable; and

(ii) Pricing products and services below sustainable levels. In other words, below the cost of replacement fuel, routine maintenance and safety work, etc. This is a detriment not only to the RDI in question, but also to everyone else in the market, because of the impact on overall market prices.

In addition, as for any commercial business, it is important to have a marketing function integrated with the activities of each of the institutes departments, and business development and marketing skills.

4. THE WAY AHEAD: CHALLENGES AND OPPORTUNITIES

"What physics was to the 20th century, biology will be to the 21st."[14] However, far being passé, nuclear science is at the threshold of a new era. After years of struggle and reduced funding, a new age is dawning for the nuclear RDIs. The world is preparing for a renaissance of nuclear power generation which will require a new generation of nuclear reactors, matched to a new generation of proliferation resistant fuel cycles and radioactive waste management strategies.

Nuclear science is also finding new applications; in medicines to treat cancer and other diseases; in equipment and techniques that can see into the core of our being and precisely target disease or injury; in agriculture to help improve productivity; in industry, to improve efficiency and safety. These new applications present significant possibilities for scientific advance, opportunities for research that can attract the brightest intellects, and that will be directly relevant to the governments and commercial interests that will fund the work.

Thus, for the RDIs there is a new world of opportunities, but there are also new challenges. Many of the new applications and technologies are interdisciplinary and require a close integration of different scientific fields. The old specializations that grew from the original mission of the RDI may not be well matched to the opportunities, and, thus, the RDIs require new conceptual and organizational approaches if they are to succeed. The funding of research is changing from subsidy to the competitive tender, and the scope of study is shifting from national to international, requiring the RDIs to develop skills in teaming and proposal writing, and, in many cases, to take the lead in defining how best to participate in the major projects. There is also strong competition to attract young scientists, who can choose between careers in a number of vibrant and dynamic scientific fields.

By understanding and managing the opportunities and challenges the nuclear RDIs have the possibility to move into a secure and invigorating future.

4.1. CHALLENGES

4.1.1. Strategy as a 'Fit' between the Institute Environment, Mission and Policies

One of the major challenges facing the nuclear RDIs is maintaining the fit between the institute's mission as perceived by its stakeholders, its strategy as defined by the institute management and the policies on staff incentives, control of IPR, etc, needed to implement that strategy. Inconsistencies between mission, strategy and policy create obstacles to sustainability and success, because they impede revenue development and demotivate the staff.

An RDI must develop an understanding of the priorities and needs of its major stakeholders if it is to preserve their interest and support. Only through a close dialogue can the RDI ensure that its work and capabilities are appreciated by the stakeholders. Though this may seem obvious, the surveys revealed significant gaps in these understandings in practice. For example, the role of the government as a client of the RDI, and the RDI's role in proactively maximising the benefit it provides to the government were not strongly developed in several cases.

The RDI must define its vision based on its understanding of the stakeholders' needs, and structure its organization accordingly. The strategic plan of the RDI should explicitly acknowledge what is to be done to support existing stakeholders, as well as reaching out to new stakeholders and clients. Performance indicators should be established to measure and guide progress against the strategic plan.

[14] The Economist, June 14, 2007 "Biology's Big Bang"

Governments and other stakeholders need to recognize that the RDIs cannot succeed if they are shackled by obsolete bureaucratic rules for operating budgets and staff resources. RDIs need to have the flexibility to establish internal structures for management control, financial and staff motivation.

Balancing Commerce and Science

One of the most common ways to increase self-generated revenues is through commercial activities in applied R&D, technical services, or products such as isotopes for medicine and industry. However, this requires the solution of organizational issues that several of the surveyed RDIs do not, or cannot, address.

The ability to retain, and later spend, self-generated revenues is clearly an essential incentive to develop new funding sources. In some extreme (but fortunately declining) cases, all commercial revenues are transferred to the government and cannot be retained or used by the RDI. Most RDIs surveyed reported that they can retain a portion of the new funding, yet there are often barriers to staff recruitment, and limited discretion at the institute level to increase salaries or to invest in additional equipment or facilities. These restrictions make it difficult for the RDI to support new activities with adequate resources and are clearly an obstacle to maintaining or increasing self-generated revenues. Governments and RDIs should negotiate realistic total budgets, to include both government and the non-government revenues, and set appropriate targets for both scientific outcomes and revenues.

Managing the different, and often conflicting, requirements of commercial or service work, and scientific research can present significant challenges to the RDIs. Success in the production of radioisotopes or radiopharmaceuticals, for example, requires consistent, cost-efficient delivery according to standardized procedures, whereas scientific research thrives on creativity. Thus, differing reward systems and promotion criteria are required in the two areas, presenting a difficult challenge for an institute hoping for success in both. There are examples of effective management of this aspect of the research/commerce conflict, though the survey confirmed that it is easier to be successful with a specialized approach.

An additional challenge is the management of staff expectations and attitudes to ensure that the staffs are aligned with the RDI mission. The surveys revealed a concern amongst institute scientists that an increased focus on ‘commercial’ activities would reduce the RDI’s commitment to basic research, and yet be ultimately fruitless because the additional revenues would be offset eventually by reductions in government support. This stands in contrast to the view that working closely with end-users can invigorate programmes of work in basic science by stimulating additional ideas and themes for R&D, and that success in basic research can underpin an institute’s technical and commercial standing. For example, UJV in the Czech Republic mentioned that their research work is very important for their sustainability and essential to their ability to obtain future revenues.

Modern ideas on how R&D is transferred from the laboratory into the marketplace show the importance of working closely with end users for technology forecasting. Rather than considering technology transfer as a sequence of separate phases (Linear Model, Figure 29a), the modern approach (Evolutionary Model, Figure 29b) emphasizes that the different phases are interconnected and that a feedback mechanism operates. The end users identify the problem while researchers develop possible solutions. The closer relationship with the end-user provides hints at where their interest is shifting, stimulates new research and forecasts the future demand that will drive tomorrow’s technology. The example provided by the CEA (see Figure 30) shows how the fundamental and applied research can be closely integrated with development and commercialization of technological applications.

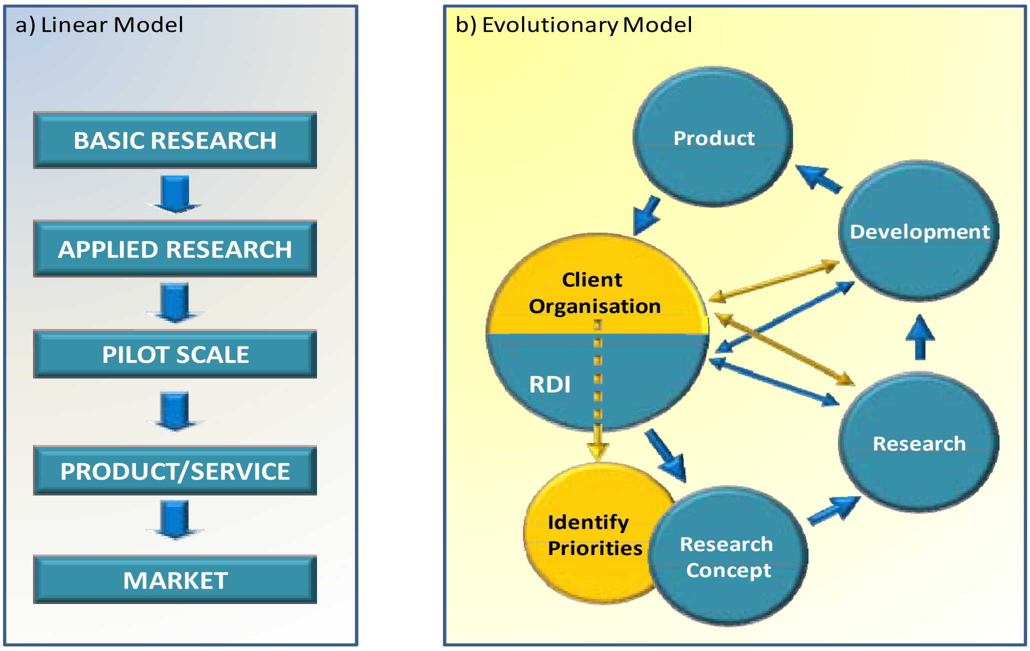

FIG. 29. Models of Technology Transfer.

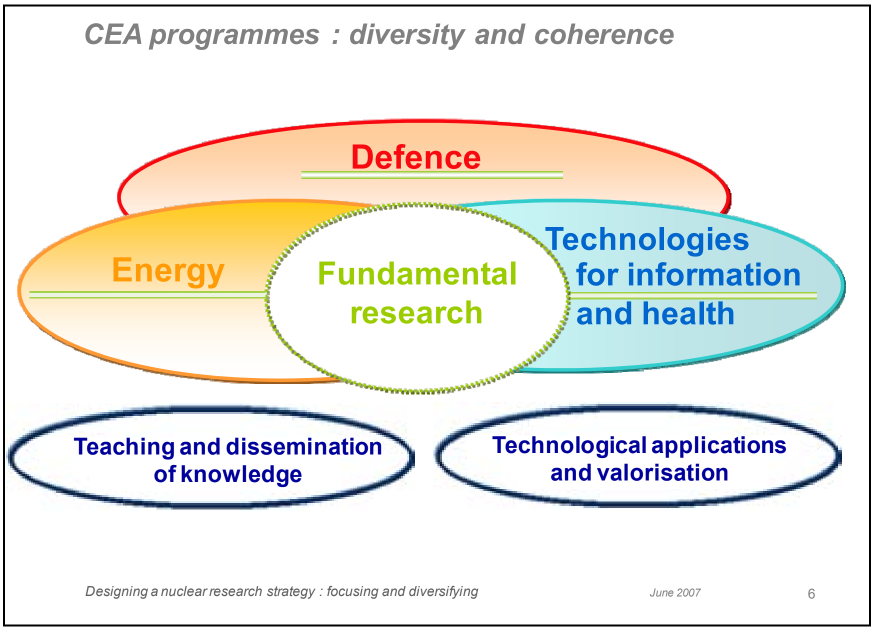

FIG. 30. CEA Model of Integration of Fundamental and Applied Research.[15]

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[15] Presented by CEA to the Symposium on Science and Technology and Nuclear Research in the 21^{st} Century: Strategies for Research Institutes in a Changing Paradigm of Science Policy and Funding, 4 and 5 June 2007, Vienna.

Requirement for an Interdisciplinary Approach

Applications of nuclear S&T in other scientific fields are increasing and there is a shift toward interdisciplinary approaches to tackle the most important research topics. Therefore, in addition to geographic globalization, we are also seeing an internal ‘globalization’ within the scientific world.

The RDIs have historically been organized according to the different scientific disciplines (such as nuclear physics and nuclear chemistry). However, many opportunities for scientific research require a project or solution-oriented approach, for which expertise from multiple specialities or disciplines must be combined. Examples of such interdisciplinary applications include the development of sophisticated imaging devices for medicine and security applications, which marry nuclear science, mathematics and computer technology with truly remarkable results; and the push into nanotechnologies in which scientific disciplines converge to open new chapters in nuclear science.

In response many R&D organizations are moving from rigid divisional structures based on disciplines to flexible structures able to combine specialists from different disciplines according to the specific project needs. This is a challenge to some RDIs because it requires more sophisticated management techniques and rewards policies than are currently in place.

Performance Indicators

Performance indicators that are well tailored to the strategic plan are effective tools to monitor and guide an RDI’s activities. They can provide information not only on how well an institute is performing, but also provide insight how to enhance performance. Appropriately selected performance indicators can also align the staff’s incentives with the institute mission and strategy, to ensure that all employees are contributing effectively. There is a considerable body of published information on the selection and use of performance measures, so this issue is not considered only in summary here.

The possible performance indicators include measurements of financial and managerial performance, as well as measures of staff performance. Examples of such indicators include the turnover rate of scientific or professional staff, attraction and retention rate of young scientists, market share and revenues for products and services, the number of scientific or commercial proposals submitted, and so on.

The survey revealed a significant tendency amongst the institutes to focus narrowly on the number of scientific publications when reviewing staff or institute performance, even when the institute’s mission is applied research or services, and the publication of papers is largely unimportant to the institutes’ customers and stakeholders. Many of these institutes reported difficulties in maintaining stakeholder support, and of obtaining adequate revenues.

The most successful RDIs also monitor their standing within their national and international environment. Potential measures include stakeholder satisfaction, the extent of RDI participation in government policy drafting forums, recognition by international R&D community, and the number of active external partnerships with other RDIs or commercial companies, academic and technical awards. The international recognition of the institute can be measured by, for example, the number of invited speakers at major conferences, or guest professorships, or the participation rate in international projects.

4.1.2. Human Resources

A number of human resource challenges confront the Central and Eastern European RDIs. The RDIs in the survey have an imbalanced age distribution of staff, and the survey revealed an overall deficit of skilled staff in the 35–45 age range. As the older staffs retire, the institutes will face significant issues with retention of institute knowledge and succession policy. In addition, many RDIs are struggling to attract new graduates, or to retain experienced staff because of the low salaries that they are able (or allowed) to pay. It is clear that if the RDIs are to maintain the calibre of their scientific teams, they need the flexibility to recruit staff at appropriate salary levels and to establish systems to properly reward their staffs' achievements. This will require coordinated action both from the government and from the institutes.

Attracting scientific talent to the nuclear RDIs has also been hampered by the tarnishing of nuclear power's image by the legacy of reactor accidents and the environmental contamination at some nuclear processing sites. Although it is difficult and slow to change the perceptions of nuclear science, the nuclear RDIs themselves have an important role as ambassadors for nuclear science, and should be active in helping reshape the image of nuclear science and technology in order to make a career in nuclear science more attractive.

4.1.3. International Perspective

Nuclear science is becoming increasingly international. Many of the new challenges for nuclear science can only be addressed at global level, for example, the development of new reactor technologies and spent fuel management. The large, well-funded research and development framework programmes of the European Union, NATO's programme Science for Peace, U.S. National Science Foundation (NSF), U.S. National Institutes of Health (NIH) and IAEA Technical Cooperation usually require grant applicants to collaborate with international or national partners. This globalisation of nuclear research presents RDIs with the opportunity to participate in larger scientific programmes and gain international recognition prestige, as well as benefit from the international funding.

On the other hand, this globalisation presents challenges for the nuclear RDIs. The institutes need the governments' financial support and concurrence if they are to take their place in the international research infrastructure, yet governments tend to be more focused on domestic priorities with relatively short timescales, than international concepts with often decades-long objectives. The challenge for the RDI is to expand its vision beyond the national perspective in order to define its role within these programmes, to take the lead in visualizing how the programmes could benefit its own country, and to decide how best to present the associated proposals for funding and programme to the political decision makers.

Some RDIs have an additional barrier to programme participation in that their researchers lack the international contacts needed to build a consortium and prepare a project proposal. For these RDIs, establishing and developing relationships and working arrangements with other RDIs is a priority.

4.2. OPPORTUNITIES

As noted at the beginning of this section, there are many new and expanding opportunities for the nuclear RDIs. The need for nuclear expertise and services is growing strongly and diversifying into many other sectors. The RDIs in some of the Central and Eastern Europe countries are benefiting from a recent surge in government funding, as governments increase the total R&D spend as a percentage of GDP, and as the GDP itself increases, or as their governments prepare the infrastructure for the expansion of nuclear power generation.

At the international level, there are significant international research programmes that can support nuclear R&D in European countries. These programs are likely to expand further as the global community seeks to meet its energy requirements while reducing its emissions of greenhouse gases.

In addition, there are structural and conceptual changes in the management and application of science which could provide benefits to the RDIs. For example, the establishment of Technical and Scientific Support Organisations (TSO) to advise governments and regulatory bodies, the open innovation concept for technology transfer, and the importance of a strong national science base to benefit from global innovation.

4.2.1. International Initiatives

There are a number of large international programmes to promote nuclear R&D, as discussed in Section 2. These provide many opportunities for European RDIs to stay at the forefront of research, to increase their international reputation and visibility, as well as obtain research funding.

The European FP7 research grants are mainly structured around international project teams. In order to become a partner in an FP7 programme, RDIs need an international reputation and visibility, and recognized state of the art expertise and equipment. To facilitate this, nuclear RDIs and their staff participate in relevant research networks and research associations. For example, the COST[16] network of 20,0000 researchers with annual meetings to share activities and plan future cooperation, and the EARTO[17] association which represents over 300 of the top research centres in Europe.

The Sustainable Nuclear Energy Technology Platform seeks to network existing RDIs and construct new facilities to be operated as 'European user facilities to create a modern research infrastructure and to attract a new generation of scientists and engineers. RDIs should communicate with the governing board of the Sustainable Nuclear Energy Technology Platform to optimise their involvement.

4.2.2. Trends in Science Management

The Technical and Scientific Support Organizations (TSO)

The rapid developments in the peaceful uses of nuclear energy are changing the way nuclear enterprises are organized and operated in many countries. There is a need for high-quality, independent, technical and scientific expertise to support the various industry organizations, including the vendors, operators, and regulators, to ensure that high safety standards are maintained. The industry has recently begun to define the concept of the TSO as the provider of that expertise.

As yet the concept of the TSO is not fully defined, and alternative descriptions, and even acronyms, are being discussed. As the current custodians of much of the independent nuclear expertise, the RDIs could play an influential role in the evolution of the TSO concept and in the provision of TSO services. The RDIs' work in nuclear research may be presented as an advantage for the TSO role because it helps to maintain state of the art capabilities. The nuclear industry's search for TSO expertise thus creates opportunities for expert and well-connected RDIs.

In 2007, the IAEA held the first International Conference specifically addressing the role TSOs can play and the challenges they face[18], and the fledgling European TSO network[19] is seeking to define how safety related TSOs can best support the regulators. There is a consensus that a TSO should be independent and impartial, and this raises issues that should be carefully considered by the RDI management in constructing or defending its role as a TSO. There are potential clashes between commercial activities and TSO services, and in particular in doing work for both the regulators and the industry that is being regulated.

To be successful in the TSO role, the RDIs need to demonstrate and market their abilities, skills and competences and have adequate resources to provide credible technical and scientific expertise to their stakeholders. They should also have sufficient independence to resist external pressures from regulatory bodies, industrial organisations or other stakeholders.

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[16] See http://www.cost.esf.org/index.php

[17] See http://www.earto.eu/

[18] See http://www-pub.iaea.org/MTCD/meetings/Announcements.asp?ConfID=142

[19] See http://www.eurosafe-forum.org/tso.html

Open Innovation

Many companies have concluded that succeeding in the 21st century requires teaming with other companies and organizations, including public and private R&D institutions or even individual researchers, to create innovation networks based on the guiding principles known as 'Open Innovation'. Contrary to the 'closed' innovation principles by which a company may profit from R&D only if it makes its own R&D, the open innovation principle states that external R&D can create significant value using its internal R&D as a means to claim some portion of that value. R&D process is thereby treated as an open system.

Nuclear RDIs should actively investigate possibilities to become partners in such innovation networks. It is likely that major multinationals in nuclear energy and other nuclear related technology sectors will take advantage of the open innovation principles, thus increasing possibilities for nuclear RDIs to be involved in creating new products and services as partners in innovation networks.

4.2.3. The Nuclear Renaissance

For the first time since the 1980s there is an increase in the interest in nuclear power. The threat of global warming, the high price of fossil fuel and the potential geopolitical problems challenging the security of fuel supplies have spurred the re-evaluation of energy policies at both the national and international level. The updated energy policies of many countries foresee the increasing use of nuclear energy in the 21st century for electricity generation as well as hydrogen production, desalination, and oil sands recovery, for example. In the electricity sector, the number of reactors under construction, planned, or proposed is increasing rapidly (see Figure 31). In Europe new NPPs are to be built or completed in Bulgaria, Finland, France, Romania and Slovakia, and lifetime extension and power increase work on existing NPPs is being undertaken in several other European countries.

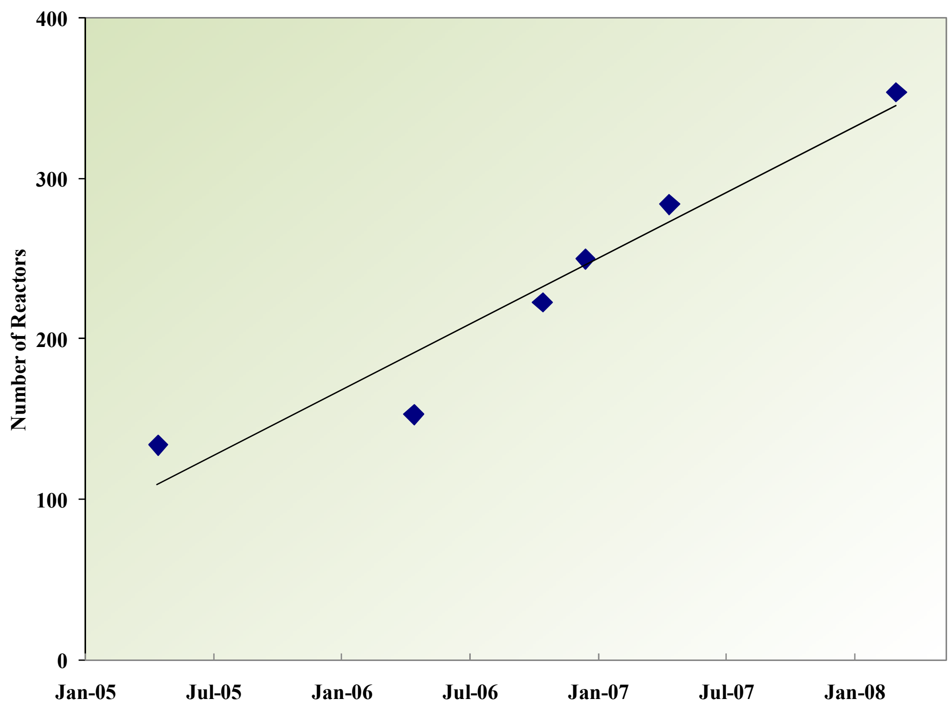

FIG. 31. Reactors under Construction, Planned or Proposed.[20]

[20] Data Source World Nuclear Association

This renaissance of nuclear power generation is therefore creating a demand for RDI services, to help with the development of reactor technologies, waste management issues, safety assessments and for training and education of nuclear engineers and facility operators.

The structure of R&D on reactor designs is complex. The reactor vendors undertake the bulk of the development for near-to-market reactor designs in conjunction with selected RDIs. Development of the longer term reactor technologies, such as high temperature gas reactors or fast reactors, or new applications of nuclear energy, such as hydrogen generation and desalination, is the subject of several international programmes, with many opportunities for the wider RDI community. For NPP construction and operation, both the reactor vendor and the local plant operator will require well-qualified scientific and technical support which could be provided by the local RDIs. In addition, the national safety authorities in each country will require TSO support as discussed in Section 4.2.2.

In addition, there is R&D work required in the nuclear fuel cycle and radioactive waste management. The U.S. has initiated work on proliferation-resistant nuclear fuel cycles through its Global Nuclear Energy Partnership (GNEP), and the EU has created a number of Technology Platforms as discussed in Section 4.2.1, which provide fertile ground for participation by the nuclear RDIs.

4.2.4. Interdisciplinary Research and Development

The trend in S&T is to a greater focus on interdisciplinary and applied R&D and ensuring research reaches into the wider community (see Section 4.1.1). The future for interdisciplinary R&D, where nuclear expertise is applied to other sectors, is potentially very strong. The last 20 years has demonstrated the ability of nuclear techniques to diversify and contribute to advances in many areas. One of the most successful diversifications has been in the area of diagnostic and therapeutic nuclear medicine, which has required integration between nuclear physics and other technologies and sciences such as electronics and medicine.

There is a conceptual shift from a focus on scientific disciplines to a focus on the solution of problems or market needs. This requires identifying the various scientific disciplines, experience, and facilities that will be needed to solve the problem, and then acquiring and combining those capabilities from within the RDI and its collaborators or partners.

The opportunities for nuclear and radiation technologies to help solve problems in the interdisciplinary areas of medicine, industry, development of advanced materials, nanotechnology, agriculture, environmental and resource management are huge. There are already many success stories from nuclear RDIs which are available through the IAEA publications.[21]

To realise its full potential the RDI must take action to increase its understanding of the clients' problems to which it may contribute, and base future interdisciplinary research and applied development programmes on those collaborator/client needs rather than on protecting existing technical capabilities.

4.3. RESEARCH REACTOR COALITIONS

To play a role in the further development of peaceful uses of nuclear energy, the RDIs that operate research reactors need to be financially sound, with adequate income for safe and secure facility operations and maintenance, including planning for eventual fuel removal decommissioning. However, in the context of changing, and usually declining governmental financial support, research reactors are increasingly challenged to generate income to offset operational costs. Reactors operating at low utilization levels have difficulty providing the service availability and reliability demanded by

[21] For example, IAEA Bulletin Vol. 43 No. 3 (2001) and IAEA Bulletin Vol. 42 No. 1 (2000).

many potential users and customers, and difficulty making the case for additional governmental support, both of which create a significant obstacle to increasing reactor utilization.

In common with the situation at the nuclear RDIs generally, the institutes with research reactors have limited access to potential customers for their services and are not familiar with the business planning concepts needed to secure additional commercial revenues or international programme funding. The RDI community possesses the expertise to address these concerns, however, this knowledge is not uniformly available, and parochial attitudes and competitive behaviour restrict the information sharing, dissemination of best practices, and mutual support that could help to correct the problem. Some successful research reactor RDIs would need to share workload in order to increase flexibility or to maximise revenues.

The IAEA has initiated a programme to help foster coalitions between institutes to share best practices, improve information availability to members, as well as improve market analysis and support for strategic and business planning. The IAEA's role serves as a catalyst and a facilitator of ideas and proposals, to support institutes by organizing meetings and providing training. Coalitions can take different forms according to the needs and capabilities of their members, from simple arrangements to share best practise, to highly organized structures to provide joint marketing of services. Coalitions are expected to facilitate access by non-reactor owning countries/members, with financial subscriptions paid in return for access to reactor services.

Participation in research reactor coalitions is another strategic avenue available to the nuclear RDIs to enhance the quality of services offered to their shareholders, and to help improve sustainability.

5. CONCLUSIONS

Major forces are driving changes in Science & Technology, and the way it is funded and managed. In the last two decades, structural changes have caused major swings in the economic performance of most Central and Eastern European countries and RDIs have been affected by this economic instability. Public officials, policy makers, funding agencies and private sector executives now demand R&D work to make a demonstrable difference to their sector and to achieve high performance before committing continued support or funding for the Institutes. As a result, the funding mechanism is moving from subsidy to competition.

The second major driver of change comes from the fact that science has become more and more a regional and global endeavour. Nowadays no country can perform optimally in isolation. Science infrastructure is more and more expensive and countries feel the need to share infrastructure. This trend is encouraged not only because infrastructure duplication is inefficient, but also because science by nature requires an exchange of ideas and cooperation that crosses borders. Lessons learned from other S&T sectors are to a great extent applicable to a nuclear sector.

Nuclear RDIs in Central and Eastern Europe range from RDIs fully devoted to nuclear power R&D to interdisciplinary RDIs using nuclear techniques in different fields, such as human health, environment, and cultural heritage, and from those involved in basic research, to those focusing on products and services.

The role of the nuclear RDI has changed from being a privileged and strategic research institution with one customer (the government) to becoming just one of many research institutions competing for priority and attention, and its status has changed from being protected to being exposed to overall R&D market, from a supply driven to a demand driven environment. Several nuclear RDIs are struggling to find their place in this world, with erosions of funding and status that has made it difficult to attract and retain talented staff. For these institutes still in transition life is neither easy nor smooth, and it is understandable that institute scientists and managers may feel discouraged.

On the other hand, there are institutes that overcame a deep financial crisis and managed to complete the transition with great success, becoming a source of pride for their countries. Defining the way forward requires RDIs to build a strong link with the end users and the continuous engagement of all stakeholders, since their needs are the best indicators for new R&D trends.

There is not just one possible model for RDIs: there are several, all successful in their own way. The main key for success is to have high quality RDIs that align themselves, their internal policies, and their strategies to their capacities, the environment and the needs of their country. Successful RDIs have demonstrated the importance of institutional policies concerning key strategic elements such as incentives for staff, intellectual property ownership, benefit sharing and conflict of interest. Particularly crucial is to establish the right incentives in term of human resource policies, able to mobilize and motivate research staff in line with the institute's mission and the stakeholders' objectives.

Whatever the specific model, it is crucial that the institute take a proactive stance to shape its environment and to set strategy and action plans. RDIs exist within the environment created by their governments' regulations and policies, which either enable or hinder the RDIs. There are large, well-funded international R&D programmes which present RDIs with the opportunity to gain knowledge, international recognition and prestige, as well as the benefit from the international funding. Establishing and developing selected partnerships and collaborations is a priority for RDIs and requires a conscious effort, careful strategies and political will.

While some lessons apply to most of the institutes, each institute and country needs to recognize its own specific abilities and constraints to plan its way forward.

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LIST OF ABBREVIATIONS

ANSTO	Australian Nuclear Science and Technology Organisation, operator of the OPAL research reactor in Australia, http://www.ansto.gov.au/
CERN	European Organization for Nuclear Research, http://public.web.cern.ch/Public/Welcome.html
DOE	United States Department of Energy, http://www.energy.gov/
EGEE	Enabling Grid for eScience, http://public.eu-egee.org/
ERA	European Research Area, http://ec.europa.eu/research/era/index_en.html
EU	European Union
EURATOM	European Atomic Energy Community, http://ec.europa.eu/euratom/index_en.html
FSU	Former Soviet Union
GDP	Gross domestic product
GEN-IV	Generation IV International Forum, international collaborative effort to develop next generation nuclear energy systems. http://www.gen-4.org/
GNEP	The Global Nuclear Energy Partnership, a U.S. led programme to develop proliferation-resistant spent fuel recycling technologies. http://www.gnep.energy.gov/
HR	Human Resources
IAEA	International Atomic Energy Agency, http://www.iaea.org/
INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles, an IAEA led programme to support the safe, sustainable, economic and proliferation-resistant use of nuclear technology to meet the global energy needs of the 21st century.
IP	Intellectual Property
ISTC	International Science and Technology Center. http://www.istc.ru/
MURR	University of Missouri Research Reactor Center, http://www.murr.missouri.edu/
NATO	North Atlantic Treaty Organization, http://www.nato.int/
NEA	Nuclear Energy Agency of the OECD, http://www.nea.fr/
NIH	National Institute of Health
NPP	Nuclear Power Plant
NSF	National Science Foundation
OECD	Organisation for Economic Cooperation and Development, http://www.oecd.org/
PI	Performance Indicator
R&D	Research & Development
RDI	Research & Development Institute
S&T	Science & Technology
SME	Small and Medium-size Enterprise
SCK	Belgian Nuclear Research Centre, http://www.sckcen.be/
TSO	Technical and Scientific Support Organizations.

GLOSSARY

Intellectual property (IP)	— Refers to creations of the mind: inventions, literary and artistic works, and symbols, names, images, and designs used in commerce. Intellectual property is divided into two categories: Industrial property, which includes inventions (patents), trademarks, industrial designs, and geographic indications of source; and Copyright, which includes literary and artistic works such as novels, poems and plays, films, musical works, artistic works such as drawings, paintings, photographs and sculptures, and architectural designs.
Intellectual property rights (IPR)	— The legal rights which result from intellectual activity in the industrial, scientific, literary and artistic fields. Countries have laws to protect intellectual property for two main reasons. One is to give statutory expression to the moral and economic rights of creators in their creations and the rights of the public in access to those creations. The second is to promote, as a deliberate act of Government policy, creativity and the dissemination and application of its results and to encourage fair trading which would contribute to economic and social development.
Technology transfer (TOT)	— Is important for economic development. It can be defined as transfer of new technologies from universities and research institutions to parties capable of commercialization, or in the sense of transfer of technologies across international borders, generally from developed to developing countries. Generally TOT consists of knowledge or IP rights that are: • licensed in the form of intellectual property, • the subject of formal consulting or training agreements, • communicated in the work place or research settings, • diffused by publication or other means.
Licensing	— Licensing is the practice of leasing a legally protected property (such as a trademarked or copyrighted name, logo, likeness, character, phrase or design) to another party in conjunction with a product, service or promotion. It is based on a contractual agreement between the owner of the property (or its agent) known as the licensor; and a licensee — normally a *manufacturer* or *retailer*. It grants the licensee permission to use the property subject to specific terms and conditions, which may include the purpose of use, a defined territory and a defined time period. In exchange for this usage, the licensor receives financial remuneration — normally in the form of a guaranteed fee and/or royalty on a percentage of sales.
Spin off	— Is the process when a division of a company or organization becomes an independent business. The 'spin-off' company takes assets, intellectual property, technology, and/or existing products from the parent organization. Many times the management team of the new company are from the same parent organization. In most cases, the parent company or organization offers support doing one or more of the following: • investing equity in the new firm, • being the first customer of the spin-off (helps to create cash flow), • providing incubation space (desk, chairs, phones, internet access, etc.) or • providing services such as legal, finance, technology, etc.

Centres of excellence	- States increase research capacity in a number of ways. The most common is a mechanism called centres of excellence. These are programmes that support highly targeted investments in applied research, often with industry partners, that focus on technology strengths of importance to the state's economy. In practically all areas and disciplines, Europe has public or private centres where science and technology (S&T) is performed at a very high, world-class level. Such 'centres of excellence' may be recognised because they comprise and attract excellent researchers and developers, earning a reputation as a significant resource for the progress of science and technology and the spread of innovation. Examples from the USA, such as Stanford University (which produced Silicon Valley), the MIT (with 'Route 128' spin-offs), or Princeton University, suffice to demonstrate the role that centres of excellence can play. An outstanding European example is CERN.
Technology parks	- Technology parks provide the launch pad that start-up companies need when they are *spin off* from a university or company. Park-provided training in such areas as intellectual property law and business planning help the fledgling businesses to succeed. Universities, in turn, benefit by exposure to the business world, and the connection to the cutting-edge research being conducted outside their walls in industry. What all technology parks have in common is that they are, at heart, knowledge partnerships that foster innovation.
Venture capital	- Venture capital is a type of private equity capital typically provided by professional, outside investors to new, growth businesses. Generally made as cash in exchange for shares in the invested company, venture capital investments are usually high risk, but offer the potential for above-average returns. A venture capital fund is a pooled investment vehicle (often a limited partnership) that primarily invests the financial capital of third-party investors in enterprises that are too risky for the standard capital markets or bank loans. Venture capital can also include managerial and technical expertise. Most venture capital comes from a group of wealthy investors, investment banks and other financial institutions that pool such investments or partnerships. This form of raising capital is popular among new companies, or ventures, with limited operating history, which cannot raise funds through a debt issue. The downside for entrepreneurs is that venture capitalists usually get a say in company decisions, in addition to a portion of the equity.

Useful links: www.wipo.int
www.lesi.org
http://ec.europa.eu/research/era/index_en.html
http://www.ipr-helpdesk.org/controlador/principal?seccion=principal&len=en

ANNEX I

SUMMARY DESCRIPTION OF EACH RDI

ALBANIA

Institute of Nuclear Physics

Address:	P.O. Box 85, Tirana, Albania
Telephone:	+355 4 376341
Fax:	+355 4 362596
URL/E-mail:	inp@albaniaonline.net
Background:	Institute of Nuclear Physics (INP) has been founded in 1970 under the auspices of the Tirana University and since 1973 INP was included in the Scientific Institutes Network of the Academy of Sciences of Albania. The principal aim of INP is the performance of applied research activity and the dissemination of scientific knowledge's in the field of Nuclear and Atomic Physics, Radiochemistry and Radiation Protection. The main financial support of the Institute is provided by state budged. The other sources of financing are the national and regional projects and the project with international organisations (IAEA, UNDP, CERN, etc.). In April 2008 the institute was incorporated into the University system and renamed Centre of Applied Nuclear Physics. The number of staff was 53 in 2007 and after the restructuring was reduced to 25.
Subordination:	Academy of Sciences
Key research areas:	Applied research using nuclear & atomic physics methods in Medicine & Public Health, Environment and its protection, Agriculture and biology, Industry (heavy and light), Geology (general, petroleum and gas), Hydrology & Hydrogeology, and Agriculture.
Major research facilities:	- SSD, α,β,γ and mass spectrometry, XRF, spectrofluorometry, Atomic Absorption, Mössbauer spectrometry, Raman spectrometry - Van de Graaff electron accelerator and Neutron generator - Radiochemistry/Radiopharmaceuticals, ^{14}C counting, Tritium counting

BULGARIA

INRNE: Institute for Nuclear Research and Nuclear Energy

Address:	72 Tzarigradsko chaussee, Blvd, BG 1784 Sofia, Bulgaria
Telephone:	+359 2 9795 000
Fax:	+359 2 975 36 19
URL/E-mail:	http://www.inrne.bas.bg/main.html
Background:	INRNE was founded in 1972 to carry out the main part of activities of the former Institute of Physics with Atomic Research Centre. INRNE is the leading Bulgarian Institute for fundamental and applied researches in the field of elementary particles and nuclear physics, high energy physics and nuclear energy, radiochemistry, radioactive wastes treatment, monitoring of the environment, nuclear instruments development, etc. Total number of staff in 2006 was about 600.
Subordination:	Academy of Sciences
Key research areas:	Fundamental and applied research in the field of elementary particle physics, nuclear physics, high energy physics, nuclear energy and nuclear electronics
Major research facilities:	- Nuclear Reactor - Ion Implantator - Basic Environmental Observatory

CROATIA

Rudjer Boskovic Institute

Address:	Rudjer Boskovic Institute, Bijenicka cesta 54, HR-10000 Zagreb, Croatia
Telephone:	+385 1 456 11 11

E-mail: info@irb.hr
URL: http://www.irb.hr/
Background: The Ruđer Bošković Institute (RBI) is the largest Croatian research centre in sciences and science applications. In the multi-disciplinary environment of the Institute more than 500 academic staff and graduate students work on problems in experimental and theoretical physics, chemistry and physics of materials, organic and physical chemistry, biochemistry, molecular biology and medicine, environmental and marine research, electronics, informatics and computer science. Within Croatia, the RBI is a national institution dedicated to research, higher education and provision of support to the academic community, to state and local governments and to technology-based industry. Total number of staff in 2006 was 825. About 20% of Scientific/Engineering staff is involved in nuclear research and applications.
Subordination: Ministry of Education, Science, Technology and Sports
Key research areas: - Broad spectrum of basic and applied research in the fields of natural sciences and technology, including experimental and theoretical physics, chemistry and physics of materials, organic and physical chemistry, biochemistry, molecular biology and medicine, environmental and marine research, electronics, informatics and computer science.
Major research facilities: Major nuclear and related facilities include:
- Two electrostatic Tandem accelerators (1MV Tandetron accelerator and 6MV EN Tandem) equipped with ion microprobe and another 7 end stations used for analysis and modification of materials and research in nuclear physics.
- 14 MeV neutron generator
- Cobalt-60 irradiation facility and small electron accelerator
- alpha, beta, gamma spectrometers, XRF, large liquid scintillation detector, mass spectrometer, electron microscope, Moessbauer and Raman spectrometers
- Cyclotron for PET radiopharmaceuticals production (under installation)

CZECH REPUBLIC

Nuclear Research Institute UJV

Address: Husinec, Rez 130, 250 68 Rez, Czech Republic
Telephone: +420 266 172 111
Fax: +420 266 172 111
URL/E-mail: http://www.nri.cz
Background: The present Nuclear Research Institute REZ plc (UJV) is the immediate successor of the Nuclear Research Institute which was founded as a part of R&D base for the Czechoslovak nuclear programme within the Czechoslovak Academy of Sciences in 1955. The total number of staff in 2006 was 986.
Subordination: Joint-stock company
Key research areas: - Theoretical, experimental and operational reactor physics, including reactor safety, technology, reliability and risk analyses, thermal–hydraulic analyses, diagnostic and measurement, radiation research and technology, ...
- Radioactive waste management, treatment, characterization, ...
- Irradiation research, research and production of radiopharmaceuticals
- Physical and chemical analytical research
- Nuclear facilities and power plant's design, environmental impact assessment of nuclear installations
Major research facilities: - Experimental research reactor LVR-15 (10 MWt), reactors loops
- Irradiation facilities, hot cell laboratories, semi hot cell laboratories
- Metalurgical laboratory, radiation chemistry laboratory
- Light water critical assembly LR-0
- Waste treatment and characterisation
- Spent fuel storage
- Fluorine chemistry
- Physical and chemical analytical laboratories
- Cyclotron and laboratories for PET radiopharmaceuticals
- Radiopharmaceutical research and production laboratories
- Biological testing laboratory

HUNGARY

Atomic Energy Research Institute (AEKI)

Address: Konkoly Thege út 29-33, 1121 Budapest, Hungary
Telephone: +36 1 392 2222
Fax: +36 1 395 9293
URL/E-mail: http://www.kfki.hu/~aekihp/index.html
Background: AEKI is a research institute of the Hungarian Academy of Sciences mainly active in the field of basic and applied research related to nuclear energy. Practical applications are essential as well. The activities of the institute started in the fifties, that time AEKI was part of the Central Research Institute for Physics (KFKI). AEKI became independent on January 1, 1992. Experimental work has always been emphasized. Experiments were performed from the fifties to the eighties on several critical assemblies. Experiments on a thermohydraulic loop started in the seventies and are still running. Small scale experiments on severe accidents are running since the early nineties.
The total number of staff in 2006 was 189.
Subordination: Academy of Sciences
Key research areas: Reactor physics, thermal hydraulics, fuel behaviour studies, material sciences, related aspects of informatics (simulators, core monitoring, etc), health physics, environmental investigations, nuclear electronics and chemistry.
Major research facilities: The institute operates the 10 MW Budapest Research Reactor, providing the scientific community of Europe (see Budapest Neutron Centre for details) with research possibility for neutron physics and applications and Hungary with radioactive isotopes, mainly used by medical applications. The research reactor is improved by the liquid hydrogen type cold neutron source that was commissioned in 2000.

Institute for Electric Power Research (VEIKI)

Address: Gellérthegy u. 17, 1016 Budapest, Hungary
Telephone: +36 1 457-8273
Fax: +36 1 457-8274
URL/E-mail: http://www.veiki.hu/english/index.html / i.kromer@veiki.hu
Background: The VEIKI Institute for Electric Power Research was established in 1964 by merging of the Electrotechnical institute (VILLENKI) and the Heat-engineering (HÖKI) Institute founded both in 1949. Since the 1st of January 1993 it has been functioning as a public limited company owned 100% by the Hungarian state.

During the last decades the Institute took part almost in every important development and investment project of the national energy system. It took an active part among others in the domestic power-plant building and refurbishing programs, in the national and international electric system development works, in carrying out system control tasks and regional tele-mechanical as well as control-engineering tasks.

In addition to these, it played an important role also in many power engineering developments of the manufacturing industry. It held a leading position in the domestic introduction and spreading of the industrial application of control and information technology, as well as in effecting engineering tasks serving the realization and safe operation of the nuclear power plants. The total number of staff in 2006 was 80.
Subordination: The Minister of Economy and Transport
Key research areas: probabilistic analyses of safety related operational events, modelling of physical and chemical processes during severe accidents, power engineering, combustion- and control engineering, automation of the power systems, improvement of information and control technology applied in industrial environment

Major research facilities:

KAZAKHSTAN

IAE: Institute of Atomic Energy

Address:	10 Krasnoarmeiskaya St., VKO, Kurchatov, 071100, Kazakhstan
Telephone:	8 72251 2-35-49
Fax:	8 72251 2-31-25
URL:	pjatova@nnc.kz
Background:	During the Soviet era, the Baykal-1 reactor complex was a branch of Luch Scientific Production Association set up to test fuel elements of experimental nuclear rocket engines and fuel assemblies. Nuclear projects have accounted for no more than half of the activities at the test site since 1980. The Soviet nuclear rocket engine program ended in the late 1980s. In 1992 IAE was established on the base of Luch Scientific Production Association. The total number of staff in 2004 was 843.
Subordination:	National Nuclear Center
Key research areas:	R&D activities to support the Kazakhstan Nuclear Power Development Program, feasibility studies for nuclear power plant construction in certain regions, thermonuclear and nuclear power safety, space power reactor facilities, solid-state radiation physics, and reactor material testing.
Major research facilities:	▪ Baykal-1 Research Reactor Complex ▪ IVG-1M Research Reactor ▪ RA Research Reactor (non-operational) ▪ IGR Research Reactor Complex

INP: Institute of Nuclear Physics

Address:	1 ulitsa Ibragimova, Almaty, Kazakhstan 480082
Telephone:	+327 2 546467
Fax:	+327 2 5465172
URL:	http://www.inp.kz/
Background:	The Institute of Nuclear Physics of the Republic of Kazakhstan was established in 1957 to conduct research in the field of nuclear and solid-state physics. Total number of staff in 2004 was 736.
Subordination:	National Nuclear Center
Key research areas:	- Basic research on solid-state nuclear physics and radiation material science, development of nuclear-physical study methods, radioecological studies, and training in science and technology - Nuclear technology development - Reactor safety research - Radiation materials studies - Solid-state radioactive physics research - Electron beam research - Monitoring of radiation levels in Kazakhstan - Nuclear physics applications in the fields of geology, industry, agriculture, and medicine - Isotope production for medical and industrial use; and analyses of radioactive cargo seized by Kazakhstani customs.
Major research facilities:	- Research reactor WWR-K - Isochronous cyclotron - Research cyclotron - Electrostatic tandem accelerator UKP-2-1 - The electron accelerator ELV-4.

IRSE: Institute of Nuclear Safety and Ecology

Address:	2 Krasnoarmeiskaya str., 490021, Kurchatov, Kazakhstan
Telephone:	+7 3225 12 32 71
Fax:	+7 3225 12 34 13
URL:	irbe@nnc.kz
Background:	IRSE was established on the basis of research sub-units of Military Unit 52605 and NNC radioecological subdivisions in 1993. The total number of staff in 2004 was 135.

Subordination:	National Nuclear Center
Key research areas:	Radioecology and radiation monitoring of national regions where nuclear tests have been conducted or nuclear facilities are available, decontamination of radioactively contaminated areas, and study of medical and biological aspects of radiation impact on the environment.
Major research facilities:	Radiation monitoring equipment.

LITHUANIA

Institute of Physics

Address:	Savanoriu ave. 231 LT-02300, Vilnius, Lithuania
Telephone:	+370 5 2661640
Fax:	+370 5 260 23 17
URL:	http://www.fi.lt/
Background:	Institute of Physics is a state scientific research institute of Lithuania. It joins scientists and laboratories for basic and applied research in chemical physics and biophysics, modern laser spectroscopy and nonlinear optics, nuclear physics, physics of atmosphere and some other related areas of physics. In addition to the scientific research, the Institute is engaged in the educational activities via tight connection links with several universities of Lithuania. Total number of staff in 2006 was 169.
Subordination:	Ministry of Education and Science
Key research areas:	- Processes in atmosphere and hydrosphere, investigations of atmospheric pollution regularities, background and anthropogenic pollution monitoring; - Dynamic processes in proteins, polymers and organized molecular structures; - Development and application of nuclear spectroscopy methods, investigation of environment radionuclides and radioecological monitoring; - Development and application of nonlinear optics and spectroscopy, laser construction and application, investigations of megasystem evolution.
Major research facilities:	- Alpha, beta and gamma-spectrometry, High Resolution mass spectrometry, Mössbauer spectrometry - Liquid scintillation counter - Tandetron accelerator, model 4110A, General Ionex Corp.

Lithuanian Energy Institute

Address:	Breslaujos str. 3, LT-44403 Kaunas
Telephone:	+370 37 401801
Fax:	+370 37 351271
URL:	http://www.lei.lt
Background:	In 1948 the Lithuanian Academy of Sciences established the Institute of Technical Sciences. This institution, which was comprised of 5 subdivisions (Energy, Metals technology, Textile technology, Construction and engineering constructions, Technical physics), analysed the issues of rational water energy and fuel consumption, metals industry rationalization and its work processes automation as well as typical projects of industry and dwelling construction. Throughout its history institute undergone several restructurings and finally in 1992 it was renamed to Lithuanian Energy Institute. Total number of staff in 2006 was 303.
Subordination:	Ministry of Science and Education
Key research areas:	- Applied nuclear physics - Nuclear and radiation protection - Environment radioactivity - Environment physics
Major research facilities:	Nuclear and related facilities include: - Scanning electron microscope - Atomic force microscope - Chromatograph-mass spectrometer

MONTENEGRO

CETI: Centre for Ecotoxicological Research of Montenegro

Address:	81000 Podgorica; Radomira Ivanovića br. 2
Telephone:	+381 81 658-090
Fax:	+381 81 658-092
URL:	http://www.ceti.cg.yu/index_en.html
Background:	CETI was founded 1996's in accordance with the Government policy, for the purpose to unite the problems of protecting the vital environment and organise the monitoring of the all segments of environment of the Republic (air, waters, soils, waste, radioactivity, human and animal food), as well as to concentrate the expensive instrumental equipment that is indispensable for the toxicant diagnosis in other institutions in Montenegro. The total number of staff in 2006 was 67.
Subordination:	Ministry of Tourism and Environment Protection
Key research areas:	- Ecotoxicological research of all the vital environment segments. - Research of ionising and non-ionizing radioactivity and climate variations in the environment and working places.
Major research facilities:	Gamma spectrometers, TLD, Dosimeters, Alpha – Beta counter, Radon measurements equipment, analytical chemistry instruments.

POLAND

INCT: Institute of Nuclear Chemistry and Technology

Address:	ul. Dorodna 16, Warszawa, woj.mazowieckie, Polska
Telephone:	+482 2 504 1220
Fax:	+482 2 811 1917
URL:	http://www.ichtj.waw.pl/
Background:	Institute of Nuclear Chemistry and Technology was established in 1983. It had been formerly operating since 1955 as the Chemistry Division of the former Institute of Nuclear Research. The Institute has an interdisciplinary character. The results INCT works have been implemented in various branches of national economy, particularly in industry, medicine, environmental protection and agriculture. Since the early sixties, the Institute has played a leading role in developing and implementing nuclear technologies, methods and instruments in the country. Nowadays with its nine electron accelerators in operation and with the staff experienced in the field of electron beam application, the Institute is one of the most advanced centers of science and technology in this domain. The total number of staff in 2006 was 241.
Subordination:	
Key research areas:	- Radiation chemistry and technology, Radioanalytical techniques - Application of nuclear methods in material and process engineering - Design and production of instruments based on nuclear techniques - Environmental research
Major research facilities:	- Electron accelerators - Mining radiometer - Portable radon concentration gauge and set for long term radon concentration monitoring - Sulphuric acid and airborne dust concentration gauges - X-ray fluorescence analyzer - Dose reader, activity and dose rate gauge, gamma counter, field and industrial radiometer.

IAE: Institute of Atomic Energy

Address:	05-400 Otwock-Świerk, Poland
Telephone:	+482 2 718 00 01
Fax:	+482 2 779 38 88
URL:	http://www.cyf.gov.pl
Background:	Institute of Atomic Energy, Institute for Nuclear Problems and Institute of Nuclear Chemistry and Technology emerged on January 1, 1983, from dissolved Institute for Nuclear Studies. The total number of staff in 2006 was 286.
Subordination:	Ministry of Economy through the Ministry of Science (Committee for Scientific Research)
Key research areas:	- Physics and technology of nuclear reactors. - Condensed matter physics and material engineering. - Application of nuclear techniques in environment and health protection, ecology, nuclear safety, health physics and nuclear spent fuel management. - Institute operates the only Polish research nuclear reactor MARIA that is employed in production of radioactive, isotopes, modification of materials with nuclear radiation and studies with neutron beams.
Major research facilities:	MARIA high flux multipurpose research reactor of 30 MW power

Polatom

Address:	05-400 Otwock-Swierk, Poland
Telephone:	+48 22 718 07 21
Fax:	+48 22 718 03 50
URL:	http://www.polatom.pl
Background:	History of the POLATOM's activity begins in 1950-ties and was connected with the Institute of Nuclear Research. In 1990 the Radioisotope Centre POLATOM was created. In February, 2005 the limited liability company POLATOM Spółka z o.o. was separated to deal with manufacturing and commercial activity. The total number of staff in 2006 was 178.
Subordination:	Ministry of Economy
Key research areas:	- Radiopharmaceuticals for therapy of thyroid and bone diseases. - Kits for technetium labelling used for diagnostics and for examinations in oncology. - Sealed radiation sources for intraocular tumours brachytherapy. - Accessories necessary in nuclear medicine centres activity. - Wide range of radiochemicals. - Sealed radiation sources for gamma radiography and industrial process control. - Standard solutions and sources for electronic measurement devices calibration.
Major research facilities:	- Hot-cells, glove boxes and other radiation protection equipment. - Clean rooms for pharmaceutical manufacture. - HPLC with UV, gamma and beta radioactivity detectors, FPLC, semi-preparative HPLC. - Thin layer chromatography, electrophoresis and column chromatography methods with appropriate radioactivity scanners. - Spectrophotometers, gamma- and LSC spectrometers. - ICP-Optical Emission Spectrometer.

ROMANIA

IFIN-HH: Horia Hulubei National Institute of Physics and Nuclear Engineering

Address:	Str. Atomistilor no.407, P.O.BOX MG-6, Bucharest - Magurele, Romania
Telephone:	+4021 404 23 00
Fax:	+4021 457 44 40
URL:	http://www.nipne.ro
Background:	IFIN-HH is committed to the development of the knowledge in physics, especially of the sub-atomic one, and growing of the nuclear domain impact in society, through advanced research and the most professional services. We believe that our first-rate results in some of the most exciting areas of the physics can be a genuine source of

wisdom for our community and an inspiring model of excellent inquiry for our youths. The total number of staff in 2006 was 772.

Subordination: National Authority for Scientific Research.

Key research areas:
- Nuclear Physics and astrophysics
- Particle physics and field theory
- Atomic physics and condensed matter physics
- Mathematical physics and information physics
- Life and environmental physics
- Advanced detection systems
- Nuclear safety, radiation protection and radioactive products
- Radioecology and nuclear biomedicine
- Nuclear techniques and applications

Major research facilities:
- Multi-purpose gamma-Co-60 technological irradiation- IRASM- max. capacity 2 MCi, in present- 150 kCi;
- Radioactive Waste Treatment Plant- institutional radioactive waste
- National Repository of Radioactive Waste- low and intermediate radioactivity levels
- Van der Graaff-Tandem Accelerator of heavy ions
- Cyclotron Accelerator
- Nuclear Research Reactor VVR-S, permanent shut-down (1997), preparatory activities for decommissioning
- Radioisotopes Production Center
- Spent Nuclear Fuel Deposit- wet storage assemblies in ponds
- Certified Laboratories

INR: Institute for Nuclear Research

Address: Str. Campului No.1, POB 78, Postal Code 115400, Romania

Telephone: +40 248 213400

Fax: +40 248 262449

URL: http://www.nuclear.ro, http://www.scn.ro

Background: Established in 1971 and known for several years as 'Institute for Nuclear Technologies' (ITN-1971), 'Institute for Nuclear Power Rectors' (IRNE-1977), presently 'The Institute for Nuclear Research' (ICN-1990) becomes, in 1998, SCN - Pitesti subsidiary of the Romanian Authority for Nuclear Activities (RAAN). The institute always had and still has as a main task to sustain research and other activities related to the peaceful utilization of nuclear energy. During the last decade, the research activity of the Institute mainly concerned the applicative studies for Cernavoda Nuclear Power Plant. The total number of staff in 2006 was 658.

Subordination: Ministry of Economy and Finances

Key research areas:
- Reactor Physics and Nuclear Safety;
- Irradiation tests;
- Post- Irradiation Examination of Materials and Nuclear Fuel;
- Irradiation technologies and radioisotopes;
- Nuclear materials and Corrosion;
- Evaluation of nuclear fuel performances;
- Out-of-pile testing;
- Characteristics and Treatment of Radioactive Wastes;
- Electronics, instrumentation and control;
- Tests and qualifications for nuclear equipment and instrumentation;
- Radiation protection, Environmental protection and civil protection;
- Design of Nuclear equipments;
- Nuclear Prototypes;
- Technological transfer;
- Quality Technical Testing;
- Metrology & IT;
- Quality Management.

Major research facilities:
- Research reactors (Material Testing) - Steady State Reactor TRIGA SSR (14MW), and Annular Core Pulsing Reactor TRIGA ACPR;
- Post-Irradiation Examination Laboratory;

- High-Activity Irradiation Gamma Station;
- Laboratory devices used to manufacture experimental elements for advanced nuclear fuel;
- Devices used for testing and analysis: nuclear fuel, materials and equipments used in nuclear and non-nuclear areas;
- Stands for testing the fuelling machine;
- Loops for thermo-hydraulic testing at high pressure and high temperature;
- Equipment for conditioning and treatment of radioactive waste.

ICIT: National R&D Institute for Cryogenics and Isotopic Technologies

Address:	ICSI Rm.Valcea, Uzinei Street no.4, Code:240050
Telephone:	0040-050-732744
Fax:	0040-050-73274
URL:	http://www.icsi.ro
Background:	ICIT history can be traced back to 1970 when a Factory 'G' was established at Rm. Valcea as an industrial pilot plant to elaborate a technology to produce heavy water. After 1990 Factory 'G' was transformed into the research institute (ICIT). Special attention was given to the research of cryogenic processes and to the development of the specific equipments and technologies for separation of hydrogen isotopes. Today ICIT R&D activities spread across nuclear and non-nuclear areas, including tritium and heavy water; nuclear fusion; cryogenic R&D; hydrogen and fuel cells; environment and quality of life. The total number of staff in 2006 was 209. About 50% of scientific/engineering staff is involved in nuclear research and applications.
Subordination:	National Authority for Scientific Research
Key research areas:	- Physical and isotopic technologies; - Processes and equipments at low temperature; - Isotopic analysis, pure gas, gas mixtures and water solutions elements; - Separation of hydrogen isotopes; - Cryogenics technologies and equipments;
Major research facilities:	In addition to non-nuclear, the following nuclear or related facilities are available: - Gas chromatograph-mass spectrometer - equipment for deuterium analysis, isotopic control of heavy water, production and certification of deuterium depleted water and heavy water standards on all research domain.

SERBIA

Institute of Nuclear Sciences 'Vinca'

Address:	P.0. Box 522, 11001 Belgrade, Serbia
Telephone:	+381 11 2458 222
Fax:	+381 11 244 0871
URL:	http://www.vin.bg.ac.yu/
Background:	Since its foundation in 1948 the basic and applied research activities of the Institute have dealt with the peaceful uses of nuclear energy. They have gradually been complemented by re search concerning classical aspects of physics, chemistry, biology, power engineering, environmental protection, electronics, etc. The last decade, heavily affected by the disintegration of the country, has, to a great extent, been devoted to preservation of the Institute's research potentials and to maintaining existing connections with the world of science. The total number of staff in 2005 was 787.
Subordination:	Ministry of Science and Environmental Protection
Key research areas:	In the area of nuclear and related R&D: - Elementary particle physics, nuclear physics, atomic and molecular physics, solid-state physics, plasma physics, and theoretical physics. - Radiation chemistry, physical chemistry, analytical chemistry, inorganic chemistry, kinetics and thermodynamics, radio isotopes (organic and inorganic radio pharmaceuticals, industrial radioisotopes, sealed radiographic therapeutic sources).

	- Nuclear energy, reactor physics, neutron physics, nuclear safety, nuclear facilities and environment, fast reactor physics, radiation protection, fusion and accelerators. - Radiation safety and protection, dosimetry, radioactive waste treatment, environmental monitoring, radiation medicine, decontamination.
Major research facilities:	- 2 research nuclear reactors (RA and RB) - Radioactive waste storage - Irradiation facility - TESLA accelerator (under construction). - Van de Graaff accelerator and ion implanter.

SLOVAKIA

Vuje

Address:	Okružná 5, 918 64 Trnava, Slovakia
Telephone:	+ 421 – 33 – 599 11 11
Fax:	+ 421 – 33 – 599 12 00
URL:	http://www.vuje.sk
Background:	VUJE was established in 1977 as a state research institute; in 1994, it was transformed into a joint stock company whose shares are owned by company employees and former employees. The change from the state-owned company into a 100% private company meant also a change in company operations, i.e. a change from an originally research organisation into an engineering company that presently implements large projects mainly in the field of nuclear power generation. Participation of industry RDIs in government supported research programmes in the Slovakia is strongly restricted, because the conditions are tailored for participation of the public academic institutions. At the time of writing this report, there is no government supported research programme for nuclear energy. The current scope of company operations is wide and it includes all activities related to the preparation, implementation, operation and termination of operation mainly of energy installations. As a matter of course, the qualification of VUJE personnel corresponds to the highly specialised company operations and more than 50% out of the total number of employees have a university education. Annual incomes of the company for the past 5 years did not fall below EUR 50 mill. The total number of staff in 2006 was 655.
Subordination:	Joint Stock Company
Key research areas:	- Performs analyses of thermal-hydraulic transients and accidents, probabilistic safety assessments, and core neutronic calculations, analyses of beyond design-basis accidents and accidents with severe core damage, by means of advanced computer codes. - VUJE develops concept issues of nuclear safety, carries out analyses of safety related events in plant operation. It develops drafts of safety rules and guidelines for the Nuclear Regulatory Authority (UJD) of the Slovakia. - Carries out nuclear power plant commissioning and provides scientific background for reliable and safe operation of nuclear power plants. It participates on safety upgrading of nuclear units and prepares basic materials for the Nuclear Regulatory Authority for the execution of inspection activities. - Develops and applies methods of personal dosimetry for nuclear power plant personnel and methods for the evaluation of radiation situation in plant areas. It develops methods and monitors leaks from primary into secondary systems via steam generators. It monitors selectively noble gases and carbon C-14 in plant discharges. It provides control and tests of the efficiency of filtration stations for the absorption of aerosols and iodine in plant ventilation systems. It analyzes and evaluates the efficiency of the safety assurance system for the radiation protection of personnel and the application of ALARA principles during the operation and decommissioning of nuclear installations and during manipulations with radioactive waste, and proposes measures for improvement.
Major research facilities:	Specialized development workshops, several certified laboratories and radioactive waste treatment facilities in the phase of decommissioning.

SLOVENIA

Jozef Stefan Institute

Address:	J. Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia
Telephone:	+386 1 477 39 00
Fax:	+386 1 251 93 85
URL:	http://www.ijs.si/
Background:	The Jožef Stefan Institute is the leading Slovenian research organisation. It is responsible for a broad spectrum of basic and applied research in the fields of natural sciences and technology. The Institute was founded in 1949 at a time when scientific research was expanding rapidly throughout the world. Initially established as an institute for Physics within the Slovenian Academy of Sciences and Arts, it is today involved in a wide variety of fields of both scientific and economic interest. After close to 60 years of scientific achievement, the Institute has become part of the image of Slovenia. Total number of staff in 2006 was 818. About 20% of Scientific/Engineering staff is involved in nuclear research and applications.
Subordination:	Ministry of Higher Education, Science and Technology
Key research areas:	- Broad spectrum of basic and applied research in the fields of natural sciences and technology - Research in physics, chemistry and biochemistry, electronics and information science, nuclear technology, energy utilization and environmental science
Major research facilities:	- TRIGA MkII reactor and - 2MV Tandetron accelerator. The reactor is used mainly for training and research in Neutron Activation Analysis (NAA). The Tandetron has several beam lines and the potential to conduct a range of high-end nuclear analytical techniques.

UKRAINE

INR: Institute for Nuclear Research

URL:	http://www.kinr.kiev.ua/
Background:	The Institute for Nuclear Research (INR) of the National Academy of Sciences of Ukraine (NASU) was founded in 1970 on the base of nuclear-oriented scientific departments in the Institute of Physics.
Subordination:	National Academy of Science of Ukraine
Key research areas:	Nuclear physics of low and intermediate energies; nuclear power; solid state radiation physics and radiation; material science; plasma physics; radiobiology and radioecology; applied research
Major research facilities:	- Isochronous Cyclotron U-240 - Electrostatic Accelerator - Cyclotron U-120 - WWR-M Research Reactor

KIPT: Kharkov Institute of Physics and Technology

Address:	1, Akademicheskaya St., Kharkov, 61108, Ukraine
Telephone:	+38 (057) 335-35-30
Fax:	+38 (057) 335-16-88
URL:	http://www.kipt.kharkov.ua/.indexe.html
Background:	Kharkov Institute of Physics and Technology (the KIPT, earlier referred to as Ukrainian Institute of Physics and Technology), being one of oldest and largest centers of physical science in Ukraine, was created in 1928 for the purpose of developing urgent lines of research (at that time - nuclear physics and solid-state physics). By the decree of the President of Ukraine in 1993 the Institute was given the status of the first in Ukraine National Science Center (the NSC KIPT). Significant part of research in the NSC KIPT is executed within the framework of international agreements, on contracts with foreign organizations and companies. The total number of staff in 2006 was about 2500.
Subordination:	National Academy of Science of Ukraine

Key research areas:	- Solid-state Physics. Physics of radiation effects and radiation materials science. Technologies of materials. - Plasma Physics and controlled fusion. - Nuclear physics, physics of electromagnetic interactions, physics and engineering of electron accelerators. - Plasma electronics and physics of high-current beams. Physics and engineering of heavy charged particle accelerators. New methods of acceleration. - Theoretical physics.
Major research facilities:	Main facilities in the institute are 42 accelerators and special laboratories for material research including the laboratory for nuclear fuel cycle research.

INSC: International Nuclear Safety Center

Address:	Bldg. 208, 9700 S. Cass Ave, Argonne, IL, 60439, USA
Telephone:	+1 (630) 252 6690
Fax:	+1 (630) 252 5167
URL:	http://www.insc.gov.ua/nindex.html
Background:	International Nuclear Safety Centers (INSCs) have been established in several countries to promote the open exchange of nuclear safety information, to cooperate in the development of technologies associated with nuclear power engineering, and to be international centers for the collection of important information on nuclear safety and technical improvements in nuclear technology.
Subordination:	The Center reports to University's Rector
Key research areas:	- Radiation safety - Development of technologies associated with nuclear power engineering
Major research facilities:	

UZBEKISTAN

INP: Institute of Nuclear Physics

Address:	
Telephone:	
Fax:	
URL:	
Background:	INP is located in a remote, wooded area approximately 30 kilometres from the capitol city of Tashkent. Founded in 1956 as part of the Uzbekistan Academy of Science, the INP has a staff of 220 people that monitor the operations of a 10 megawatt research reactor. Often described as the largest facility of its kind in Central Asia, the INP has an ambitious program to become the primary nuclear research and isotope production facility for the region. Today, the facility maintains fresh and irradiated nuclear fuel storage facilities to support continued reactor operations. The main objective of physical protection upgrades at INP is to protect the reactor complex which consists of three contiguous buildings; the Administration Building which contains the reactor control room, the Reactor Building which houses the research reactor and the spent fuel storage pool, and two-story addition. The total number of staff in 2005 was 591.
Subordination:	Academy of Sciences of Uzbekistan
Key research areas:	- Radioisotopes, radioisotope devices (level meter, density meter); - Sterilization of medical instruments; labelled compounds; - Sample irradiation - Analytical services - Radiation measurement, radiation safety
Major research facilities:	▪ Nuclear 10-MW reactor WWR-SM, ▪ Gamma - irradiation facility, ▪ U-150 and U-115 cyclotrons, ▪ Neutron generator.

ANNEX II

SURVEY TEMPLATE

SUSTAINABILITY SURVEY

The Sustainability Survey has been elaborated to help survey the baseline status and progress of the Institute towards producing self-generated revenues and becoming sustainable.

Section I	Requests general information about the Institute as well as staff composition.
Section II	Requests basic Institute data, such as revenue and cost structure, and performance indicators. The **ANNEX presents some guidelines and an example** for answering this section.
Section III	Concentrates on the criteria to measure progress towards self-reliance and sustainability and is divided in three sub-sections: Policy, Planning and Coordination and Management Business Skills.
Section IV	Requests to identify the barriers for the RDI in generating revenue. The barriers are segmented in 3 columns, external, institutional and market.

COUNTRY:

INSTITUTE:

DATE OF SURVEY:

I. BASIC INFORMATION ABOUT THE INSTITUTE:

1. Is it a Government Institution or an Independent Institution supported by government funds?

2. Which Authority does the Institute report to? (e.g. Ministry of Science and Technology through the Academy of Sciences or Ministry of Energy)

3. What are the Nuclear Research Areas of the Institute? (LIST)
   If there is a Research Reactor, please indicate its use (e.g. Decommissioning)

4. Which are the main Institute's facilities and equipment? (LIST)

5. What are the Main Nuclear Services and Products available to the market (and which are the main customers for each)? (LIST)
   The main commercial activities and opportunities include –

NUMBER OF STAFF	2001	2002	2003	2004	2005	2006
Scientists/Engineers						
Researchers (including fellows)						
Post-doctoral students						
PhD and MSc students						
Technician/Technical Staff						
Administration & Service						
TOTAL						
What is the **% of Scientists/Engineers** involved in **nuclear research and applications**?						

NUMBER OF SCIENTISTS & ENGINEERS BY AGE DISTRIBUTION						
AGE DISTRIBUTION	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
35< (below)						
35-45						
46-55						
56> (above)						

II. REVENUE, COST DATA AND PERFORMANCE INDICATORS

Please indicate ALL Revenue Sources and add lines if necessary
Please indicate whether the revenue is associated with a state subsidy, research grant, provision of services, or product if possible
Note that state subsidy is only an option in 1. Total Revenue from Public Sector
Please make sure that the Total Revenue is the sum of ALL the Revenue Sources combined

REVENUE TREND BY SOURCES *(Please specify currency used)*		**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1. Total Revenue from Public Sector *(Title of Ministry, Academy of Science and/or Government Agency)*	**subsidy** research services product						
2. Total Revenue from Private Sector *(Title of Company)*	research services product						
3. Total Revenue from Intl. Sources *(Title of Intl. org e.g. IAEA, EU, US DOE)*	research services product						
4. Other Sources *(Title of NPP and/or Research Institutes etc.)*	research services product						
5. Patents / Intellectual property							

TOTAL REVENUE						
Comments:						

TOTAL REVENUE TREND (from 1990-2006)																
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006

COST STRUCTURE	2001	2002	2003	2004	2005	2006
Total Costs (National Currency)						
Fixed Costs (% of total)						
Variable Costs (% of total)						

PERFORMANCE INDICATORS			2001	2002	2003	2004	2005	2006
Number of Patents	National	Filed						
		Obtained						
	International	Filed						
		Obtained						
Number of Articles (journals with impact)								
Number of Citations								

III. SCIENCE AND TECHNOLOGY POLICIES

INSTRUCTIONS: Please answer the following questions by explaining in detail

LEGISLATION AND POLICY	**Comment**
Is the **State Budget** based on negotiated objectives?	
Is the **State Budget** based on Assessment of costs?	
Does the Institute have a role in **education**? - If YES, does the Institute receive any financial or other compensation for training students	
Do government rules facilitate self-generation of revenue? (Please answer the following)	
Does the Institute retain (part) of self-generated revenue?	
Can the Institute work with the private sector?	
Can the Institute charge for products and services?	
Can the Institute undertake joint ventures?	
Does the Institute have a policy on **intellectual property**? - If YES, can you earn revenues from patenting?	
How does the Institute **cost and price** its services and products?	
Does the Institute **human resource policy** provide incentives in the form of staff recruitment / retention / remuneration? - If YES, is the policy based on publications and/or products and contracts?	
PLANNING AND COORDINATION	
Does the Institute have a **strategic plan** with mission and vision?	
Does the Institute focus mostly **on basic research, applied research** and/or **services and products**?	
Does the Institute have **partnership agreements** with other RDIs? (joint research and infrastructure sharing)	
Does the Institute have a **business plan** for key technologies with revenue potential?	
Does the Institute have an Office/Unit for **business development or marketing**?	
Does the Institute have **promotional/marketing activities** (i.e. Advertising)?	
Does the Institute have a **website**? (Please indicate)	
Does the Institute hold any **seminars and demonstrations for potential users** of your products/services	
Does the Institute have a **multi-disciplinary team approach** to projects?	
Does the Institute have a **Quality management system** in place (i.e. ISO, …)?	
Does the Institute have a project-based financial and staff **management system** in operation. (Technical databank in operation)	
MANAGEMENT BUSINESS SKILLS	
Do the institute managers and senior scientists have any management training? - If YES, what kind of management training?	

IV. BARRIERS FOR INCREASING SELF-GENERATED REVENUE FROM PRODUCTS AND SERVICES

INSTRUCTIONS: Circle the factors you consider as barriers for increasing the self-generated revenue of the institute

EXTERNAL	INSTITUTIONAL	MARKET
- Bad economic situation in the country - Rigid Legal Framework Other: _____________	- Lack of qualified personnel - Lack of infrastructure. - Lack of IT - Institutional/Organizational rigidities - Lack of incentives for market behaviour (e.g. promotion based on academic research) - Other: _____________	- Lack of information on market potential - Lack of appropriate finance for developing new products. e.g. Venture Capital - Lack of customer responsiveness to new services & products - Other: _____________

Please use additional pages if necessary

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