Research infrastructures in Hungary

About the Hungarian participation in the European research infrastructure large projects that are, where appropriate, included in the Roadmap of the European Strategy Forum on Research Infrastructures and the development of the national research infrastructures

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NEMZETI INNOVÁCIÓS HIVATAL

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1. Introduction

The aim of the document introducing the situation and vision of the Hungarian research infrastructures is to present to the European Union how Hungary plans the issue of one of the particularly important RDI resources, namely the research infrastructures (RI).

The international competitiveness of a country's scientific community is increasingly influenced by the state and quality of its research infrastructures (RI). The development of research infrastructures is also a headline target in the strategic plans of the EU.

The role of research infrastructures is very significant in RDI. In addition to being the essential base for basic researches and frontier researches, they have a significant role in shaping the society and economy.

One of the direct impacts on the economy is when an undertaking uses a research infrastructure for its RDI activities and so develops a product. The undertaking can use its own infrastructure or use an external infrastructure. A similar – but already indirect – impact is when a Hungarian undertaking becomes a supplier of a large foreign infrastructure through some high-tech device – this is directly utilised by Hungary in many cases by the so-called in-kind supplies if the access costs to certain large foreign infrastructures are reduced thereby to a fraction.

In the social sense, it is known that the networking, i.e., the lack of relations with diverse market actors is a general problem in Hungary, which, in many cases, is not a result of the lack of available resources but rather the low level of trust between the economic actors.

Research infrastructures can be exemplary in this regard since they are all part of operating research networks or heading in this direction – establishing a real national innovation system, which supports the economy, on the basis (and through the strengthening) of this network is of critical importance to Hungary.

At the same time, it must be understood that certain changes do not leave research infrastructures unaffected; they also operate in a changing context. The traditional approach for research infrastructures focusing on possessing the own “inside fence” devices and equipment has been significantly transformed by the development of the information and communication technologies. The access to networks with fast and large data transfer capacities and huge databases expanding in a continuous and planned way in international cooperation is increasingly becoming a basic condition of modern scientific activity.

Hungary is significantly behind in this respect. If Hungary does not keep pace with the most developed countries then the scientific position reflected in the intellectual power of education and scientific community, exceeding the size and economic strength of the country may be quickly lost.

One of the most efficient method of using the significant financial resources of the European Union available between 2014 and 2020 may be the development of the research infrastructure. Without radical modernisation, it cannot be expected that the Hungarian scientific and technical development maintains its current position in the international field and it can be even less expected that the country improves its performance at an international level. The general decline in research quality will also result in the decreasing personal participation of the Hungarian researchers in the international decision-preparing and decision-making processes. A current significant qualitative jump may trigger effects lasting for several years; the further continuous development may be also successful for decades.

We will present the vision for national RIs in the document and, related to it, we try to present in detail the situation of the Hungarian RI and the process, in the framework of which the Hungarian RIs have been assessed within the National Research Infrastructure Survey and Roadmap project. The most important international trends and international comparative data will be presented; and the current situation and trends influencing the development of the Hungarian RI will be presented on the basis of the much more detailed Hungarian time-series.

In addition to the situation analysis, the vision and governance structure of the RIs will also be presented, and we make a proposal to an indicator supporting the long-term monitoring of the area.

We note that this document should be regarded as a supplement to the S3 material so we will make references to the S3 document on several occasions – which is quite evident if we take into account that the research infrastructures are particularly important elements of the National Innovation System, but they are far not the only elements.

2. Vision

On the one hand, the research infrastructures either reach or exceed the European standard of scientific excellence by their activities; on the other hand, they advance the RDI processes, as well as the national and international networking of economic actors by their active participation.

The research infrastructures must play several roles at the same time:

- ✓ They shall conduct scientific activities that put them at the forefront of the European science.
- ✓ They shall support networking between the economic and higher education-academic sectors so as the economic actors may operate in the markets of their products more efficiently, i.e., directly use the infrastructure for applied researches.
- ✓ They shall assist the national economic actors in becoming high-tech suppliers to foreign and national research infrastructures through in-kind contributions (in-kind supply).

3. Situation of the Hungarian research infrastructures and its directions of development

The concept of the infrastructure serving the R&D activities has fundamentally changed in the last decades owing to the accelerated technical progress in the one hand and the internal processes of science on the other hand (the research infrastructure hereinafter referred to as "RI"). While RI primarily meant equipment and instruments in the past, the concept has significantly widened by now: it already involves databases, gene banks, systems for the transmission and processing of data and digitizers, also including the human resource necessary for their operation.

The analysis exploring the situation of the Hungarian RI is based partly on the available domestic and international statistical data, and partly on the data of the RI register created and operated by the NEKIFUT project. The connection to the international research infrastructures is also discussed here, as we will see that the development directions of the Hungarian research infrastructures and international connections are inseparable from each other.

In accordance with the EPD process, the NEKIFUT database was open to all organisations with a research infrastructure for registration and data supply. The submitted applications (more than 400) were evaluated by the representatives of the given discipline on the basis of certain methodology along the three main disciplines (physical sciences, natural sciences and social sciences). Nearly 100 researchers, most of whom are working in the academic sector, participated in the evaluation work. Their work has resulted in a database, which has determined the infrastructures of extreme importance for Hungary in each discipline.

In addition to the NEKIFUT database, we relied on the data available from the KSH to demonstrate the situation; however, the data sets of the NEKIFUT enable a deeper understanding of the infrastructures and the making of the resulting conclusions.

3.1. General introduction of the research infrastructure

Consultation with the professional community is an essential element of the methodology applied by the NEKIFUT. As a result of an application process, the project decided on granting the strategic research infrastructure (SRI) and the registered research infrastructure (RRI) titles in 2009/2010 and in 2013/2014. The individual decisions, which had been adopted with the involvement of a large number of experts, were taken into account by the NEKIFUT working groups when making proposals, which were adopted by the Steering Board. This process enabled to gain more general experience which also highlights certain factors of the status of the domestic research infrastructure which cannot be grasped by means of statistical data.

We can conclude that there are still strong efforts for the exclusive use of the infrastructures and that the degree of openness is insufficient, which hamper the provision of the research infrastructures for the research community.

The first line of the Hungarian researchers have been continuously striving to gain access to the leading-edge research infrastructures abroad. On the other hand, several international-level research infrastructures were established in Hungary over the past 10 years by using domestic and, mainly, EU grants awarded in tenders. These are typically operating in the institutes of the HAS or universities and mostly rely on the resources of large enterprises, i.e.,, multinational companies.

It is a non-negligible experience of the past 25 years that the utilisation rate (contracting in time and actual accounting) of the sources in the case of the tenders supporting the purchase of instruments, equipment and devices for R&D purposes was very good – almost 100%.

Examining the impacts of the earlier RI development tenders, it can be concluded that the significant developments of public research organisations have contributed to maintaining and, in some cases, strengthening their international rank. All of this has had a positive impact on their international tendering ability and the quality and quantity of PhD training as well. On the other hand, it is an important experience that using the new devices requires extra costs (maintenance, operation, auxiliary materials, service, etc.), the cover of which is not guaranteed. All this can/may result in a significant reduction in the effectiveness of the investment.

Generally, [1] the following conclusions apply to the public financed research organisations:

- Several decades of gap should be made up in terms of infrastructure development. The size of this gap increases intensely due to the rapid technological change.
- The public research organisations are not able to prevent the accelerating obsolescence of the assets, as they do not have the possibility to create a depreciation fund for the renewal of the instrumentation.
- As regards RI utilisation, the business sector is positioned more favourable than the public sectors.
- The use of RI for research service purposes in the public sectors should be improved, and also the use of the devices for educational purposes in higher education should be strengthened.

The low degree of coordination in the use of domestic state (central budget) financing sources and uncertainty of access to these sources in time[2] may have caused unused parallel capacities and

[1] The evaluation covered the tender of the KMÜFA (Central Technical Development Fund) between 1999 and 2003, the tenders of the OTKA (National Scientific Research Fund) between 2001 and 2003, and the GVOP (Economic and Competitiveness Operational Programme) tenders in 2004-2005.

[2] Sources for the domestic development of the research infrastructure have been primarily provided by the so-called instrumentation tenders, which in most cases are not sufficient to fund large investments.

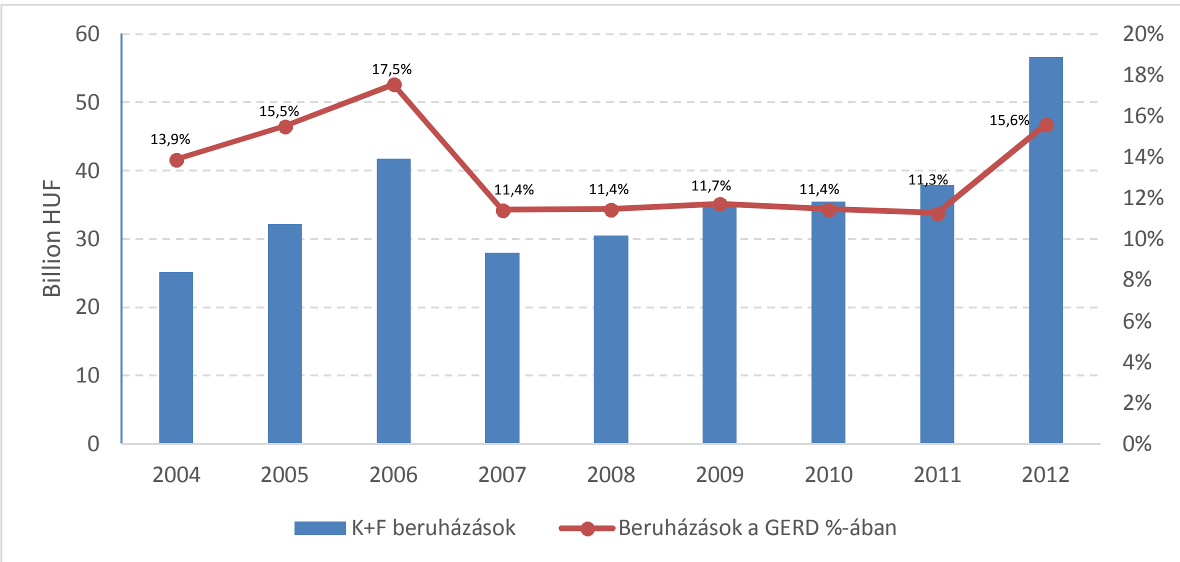
prevented the establishment of important and necessary infrastructure. The domestic decision-making system could hardly manage the efforts to reach an international infrastructure which, due to their volume, does not require a decision-making process different from the average (for example, a government decision or any other individual corporate decision is not required), but cannot be realised without active government participation.

3.2. R&D investment in numbers

The total domestic R&D investment increased from HUF 25 bn to almost HUF 57 bn in nominal value during the period from 2004 to 2012. Intense growth had been observed in the beginning of the period (60% growth in less than 2 years; the HUF 41.7 bn value was reached already by 2006), which was followed by a significant decline and then slow growth. The current status was reached in 2012, as a result of abrupt increase. At current prices, more than twice as much was spent on R&D investment in 2012 than in 2004.

The view of the total R&D expenditure is more nuanced. There was clear growth at the beginning of the analysed period (jump from 13.9% in 2004 to 17.5% in 2006, which was the peak of the period). The ratio practically stagnated between 2007 and 2011 (ranged from 11.4% to 11.7%), and was followed by a more than 4% jump in 2012. The question is whether the growth in 2012 was a unique swing, or the first year of a new trend.

Figure 1: Value of (HUF bn) and share (%) of R&D investments from the total domestic R&D expenditure, 2004-2012

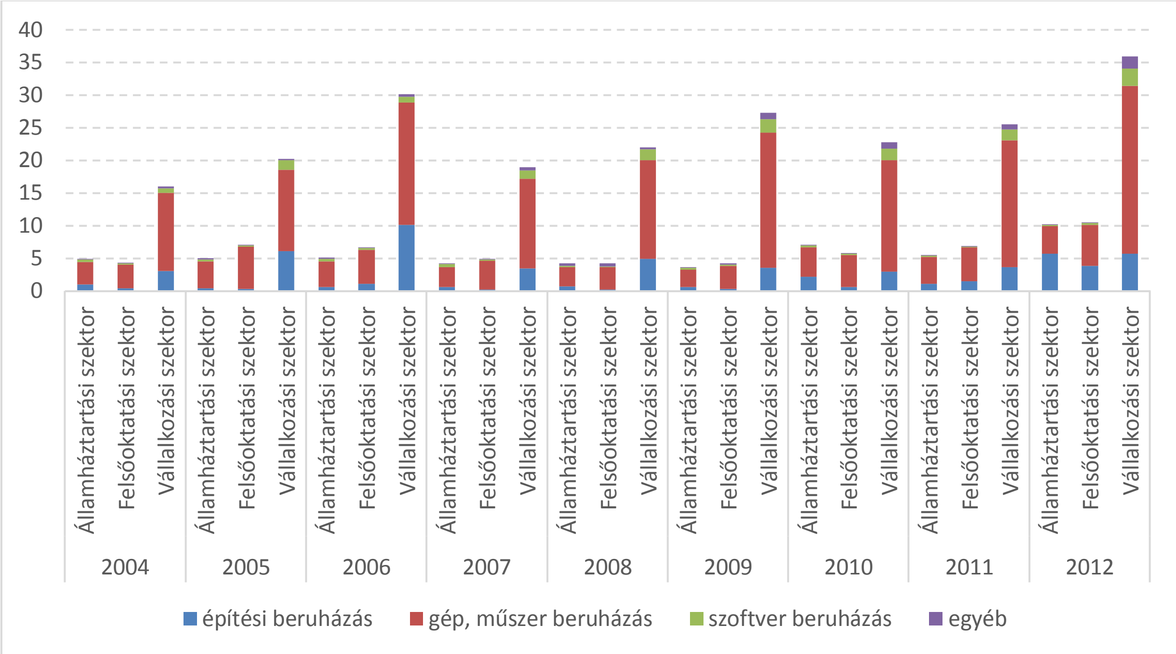


Source: KSH

Machinery, instrument and software investment

Statistics distinguishes three types within the R&D investments: machine and instrument investments, software investments and building investments.

Figure 2: Composition of R&D investments by type of investment and R&D sector in Hungary, 2004-2012 (HUF bn)



Source: KSH

The corporate sector is generally regarded as the biggest "builder". It used one-fifth of its investments for construction in the first year of the analysed period, and the ratio approached and then passed the one-third level in 2005 and 2006, respectively (30.2% and 33.5%). Then, it had dropped back to 22.5% and then to 12.9% in 2009, which was followed by slow and steady growth. In 2012, it was close to 16% of the overall R&D investment. The share of software investments fluctuated around 3-8% of the total amount. 61-75% was used for machines, instruments and equipment.

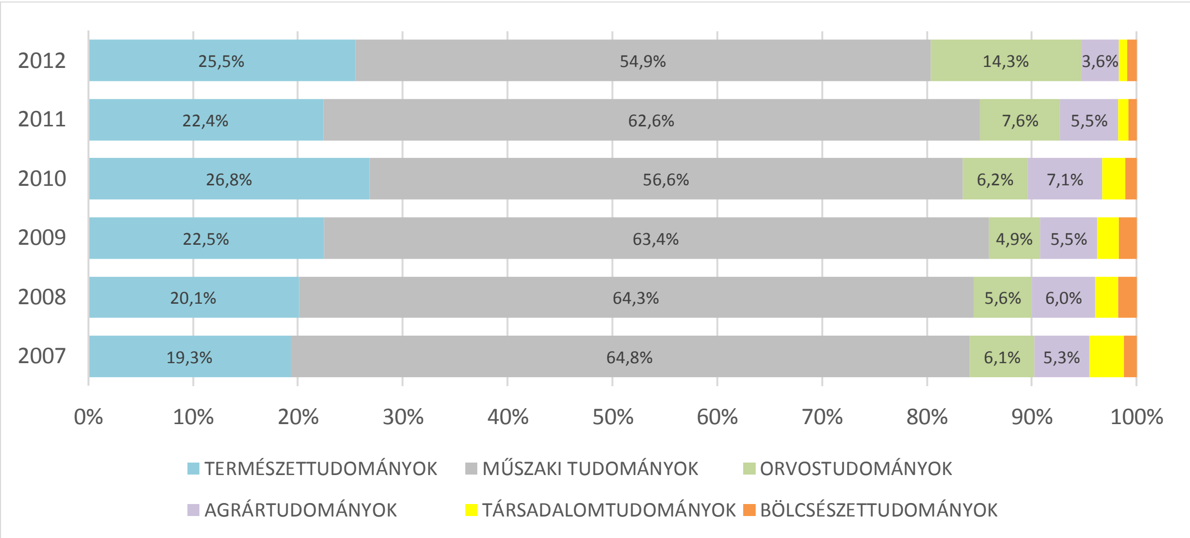
The public finance sector used the available R&D investment sources mainly for machinery, equipment and instruments in most of the period under review. Its share mostly ranged from 70% to 80%. However, this proportion decreased significantly in two years due to the extraordinary growth in construction sources (to 64.4% in 2010, and to 41.2% in 2012). There was a steady decline in absolute terms between 2006 and 2009 (in 2009, 76% of the 2005 value was spent for such purposes), but then a significant increase in 2010. The statistics show a lower value again in 2011 and 2012. In the area of building investments, the data from 2010 and 2012 are outstanding: The HUF 600-900 million expenditure of the previous years increased to over HUF 2.2 bn in 2010 and then to HUF 5.7 bn in 2012. (It was above HUF 1 bn in 2011.) In 2010, 31.8% of all investments has been spent on construction, and the figure rose to 55.2% in 2012.

The higher education sector shows a similar picture as the public finance sector. It used the investment sources primarily for machinery, equipment and instruments in most of the period under review, while the share of construction spending generally remained below 20%. In fact, it was a single-digit ratio in 2005, and in 2007-2009 (ranged from 3.1% to 6.8%). As in the public finance sector, there was a sharp increase in the spending for building investments at the end of the period under review and, in particular, in the proportion thereof to the total R&D investments: it increased to 22.0% in 2011, and to 36.5% in 2012. The sources spent on construction was significantly lower than in the public finance sector (excluding 2006 and 2011). It amounted to HUF 3.8 billion bn in 2012.

3.3. Distribution of R&D investments by disciplines

As regards the distribution between the various disciplines, we roughly follow the international trends: over 80% of the R&D investment is used in natural science and engineering science. They are followed by the agricultural and medical sciences with shares below 10% (with the exception of the 2012, when the share of medical sciences was 14.3%), while the share of the social sciences and humanities is 1-4%. It is noteworthy that the ratio of social sciences has significantly declined since 2010 (to 1% in 2011 from the previous 2-3%, and it continued to fall in 2012). The share of humanities fluctuates around 1%. (Figure 31) It should be noted, however, that natural and engineering sciences in the data of both Eurostat and the KSH include investments which primarily serve these areas, but are increasingly used by the medical, agricultural and, to some extent, social sciences (e.g.,, archaeology) as well.

Figure 3: Investment ratio of certain branches of science within the total investment value in Hungary, 2007-2012 (%)

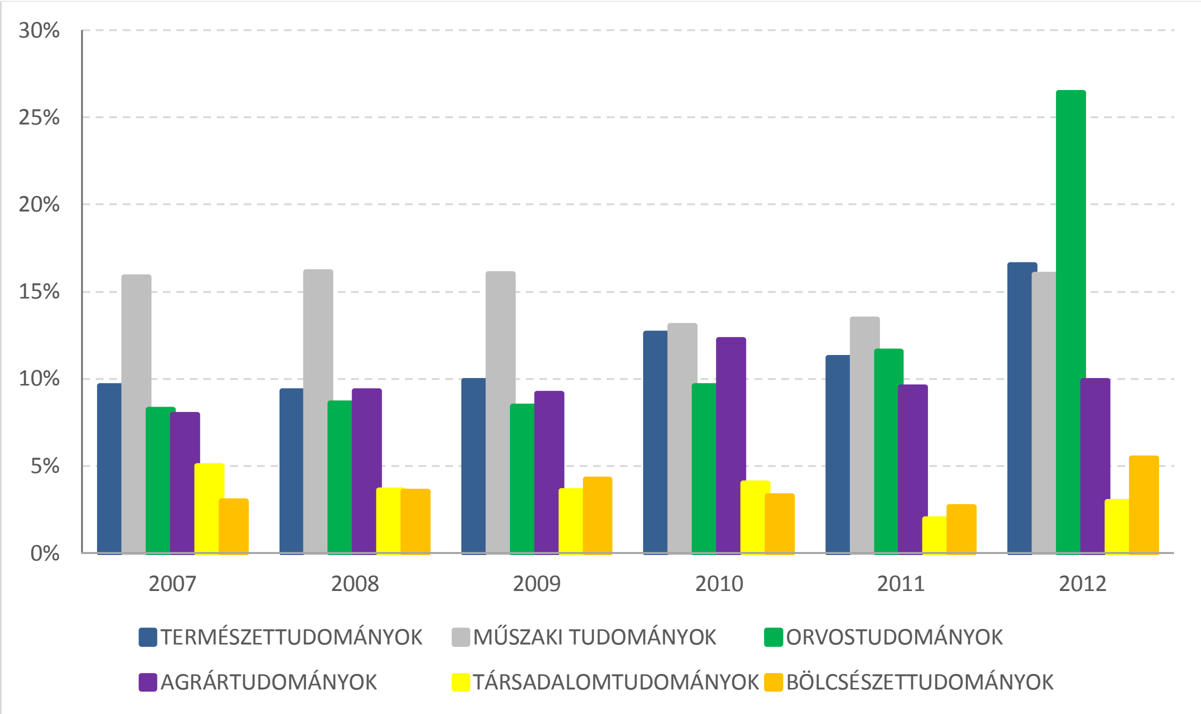


Source: Own calculations based on KSH data

The RI demand of the various disciplines is different, therefore, the amounts spent on investments differ significantly in the total R&D expenditure. **The investment rate** specifies how the source spent on investment relates to the total R&D expenditure.

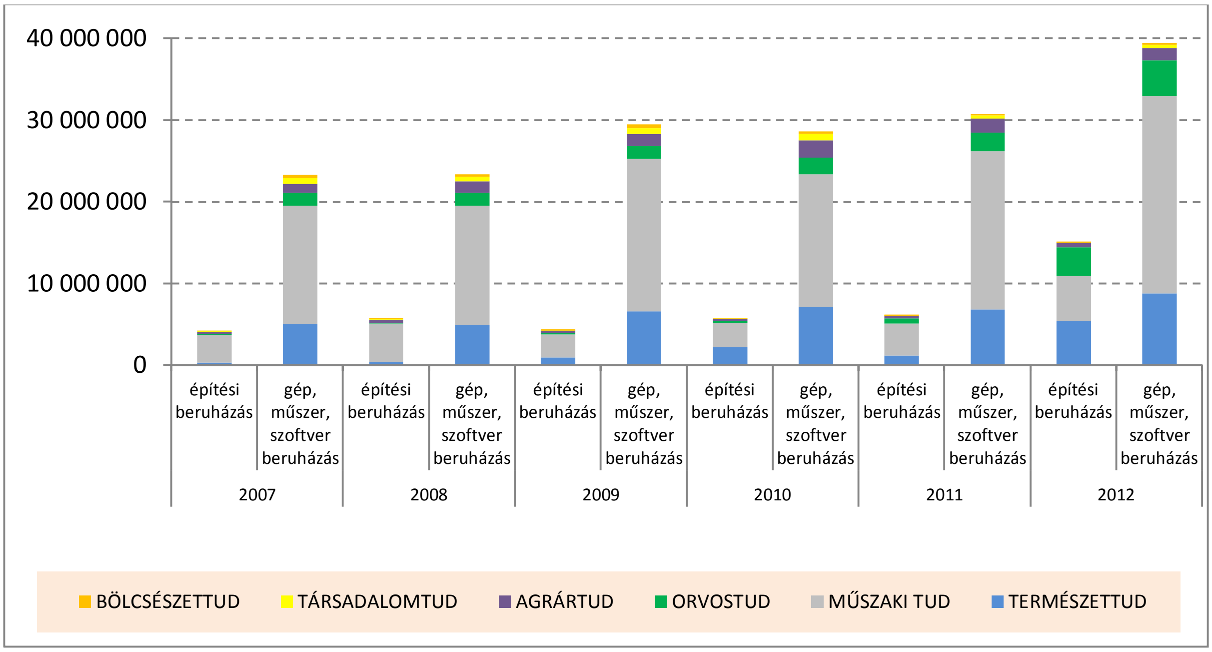
This rate is the highest in the technical sciences, which is followed by the natural sciences and agricultural and medical sciences. Humanities and social sciences have the lowest rate of investment. A very significant increase was observed in the medical sciences (from 11.5% to 26.4%) and natural sciences (from 11.2% to 16.5%) in 2012.

Figure 4: R&D investment of the disciplines in % of the total R&D expenditure of the disciplines, 2007-2012



Source: Own calculations based on KSH data

Figure 5: Types of R&D investment by branches of science in Hungary, 2007-2012 (thousand HUF)



Source: Own calculations based on KSH data

Analysing **the natural sciences,** the data show that:

- information technology is the most infrastructure-intensive area in Hungary in terms of the assets, although it is noted that IT serves a number of disciplines
- biological sciences are in the second place, while physics and chemistry alternately hold the third place

- there is no clear order in respect of the building investments; however, the impact of a major investment can be clearly seen in the aggregate data: there were such major building investments in the area of chemistry in 2010 and 2012, and in physics in 2012.

As regards **technical sciences**, it can be concluded that:

- chemical engineering, pharmaceutical, rubber and plastics industry research is the most infrastructure-intensive sectors in terms of assets in Hungary
- the second place is held by mechanical engineering, electrical, electronic and IT engineering sciences, and environmental sciences
- the chemical engineering, pharmaceutical, rubber and plastics industry as well the electrical, electronic and IT engineering sciences use the majority of investment funds also in terms of the building investments, with a significant jump in the first area between 2007 and 2009, respectively in the latter area in 2010-2011.

In regards to **medical sciences**, it can be concluded that:

- the general and clinical medical sciences are the most infrastructure-intensive sectors in terms of assets in Hungary
- the level of building investments is extremely modest, with only one significant jump in the field of general medical sciences in 2011-2012
- significant constructions are coupled with investment in devices and equipment in this area.

In regards to **agricultural sciences**, it can be concluded that:

- crop production, forestry and wildlife management sciences are the most infrastructure-intensive in terms of assets in Hungary, and they are followed by the agricultural biotechnology sciences
- the view is colourful and changes rapidly in respect of building investments: the crop production, forestry and wildlife management areas constantly have a relatively high value, animal production emerged in 2007 and 2012, and the veterinary area excelled in 2008 and 2010 - although the maximum amounts thereof were close to HUF 200 million and HUF 400 million only.

In respect of **humanities**, it can be concluded that:

- linguistic and literature sciences are the most infrastructure-intensive sectors in terms of assets in Hungary, although the value of the investments in this area decreased continuously, while, in parallel, the budget used for “other humanities ”continuously increased during the period under review
- certain years are outstanding in terms of building investments in respect of certain disciplines: 2008, 2009 and 2011 in the case of historical science, and 2012 in the arts and cultural history disciplines.

In respect of **social sciences**, it can be concluded that:

- economics and management sciences as well as education sciences are the most infrastructure-intensive in terms of assets in Hungary
- these areas spend the most also for building investment, but the value of these investments is very low.

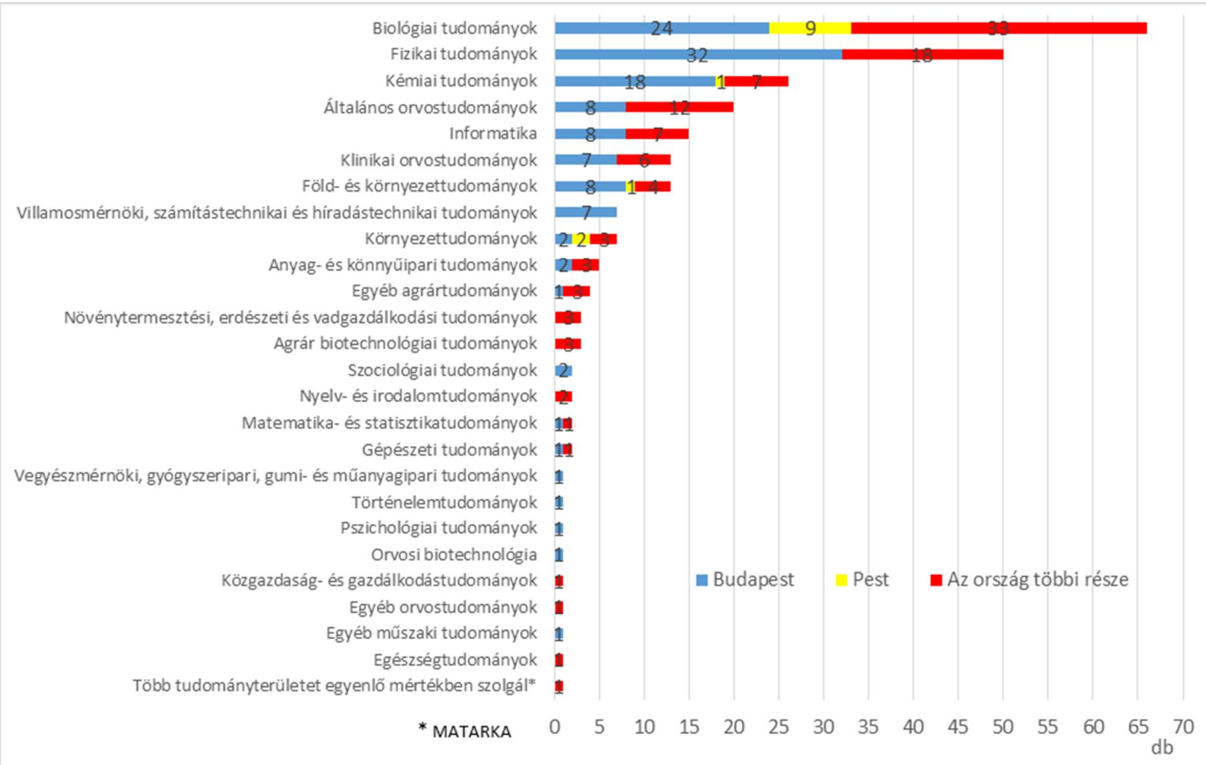
3.4. Regional and disciplinary presentation of the research infrastructure

An overview is provided of the country's research infrastructures by disciplines based on their geographic location below. The deadline for submitting tenders for updating the national database of research infrastructures, managed by the NIH RDI Observatory, was April 2014. We present the data thereof as follows. Due to its voluntary nature, the database is not complete, however, because of the number of infrastructure it contains (more than 400) we can say that it is suitable for sampling – adding that it was not prepared with a need for being representative.

Figure 6 contains the distribution of the research infrastructures by discipline, which had applied for the strategic research infrastructure (SRI) title and were nominated for the SRI title by the working groups. We highlighted both the primary disciplines of the SRIs, as well as the disciplines which relate to business of SRIs. Strategic research infrastructure means research infrastructures fulfilling all the following conditions:

- they contribute to solving national tasks of strategic importance;
- they allow the performance of high-level research activity by international standards;
- they provide research opportunities for several independent research groups, and users have an equal chance to access it if they comply with the conditions laid down in the publicly available rules:
- their organizational, financing, management and human resource positions ensure operation in accordance with the above conditions.

Figure 6: Based on the research infrastructure register managed by the NIH RDI Observatory, the distribution of the research infrastructures recommended for the strategic research infrastructure (SRI) title registered in the country is the following on the basis of their primary disciplines:



Although it is generally true for the domestic R&D that it is primarily concentrated in Budapest, the above figure clearly shows that the situation is not so obvious in the field of research infrastructures. For example, infrastructures related to the biological sciences, of which the most is listed in the register, are present in the KMR with the same share as in other parts of the country. The role of KMR is less significant in some scientific areas, e.g.,, more infrastructure can be found in the regions outside the KMR in the areas of agricultural sciences or crop productions, materials and light industry sciences.

3.5. Characteristics of the international and Hungarian scientific fields

In addition to the general trends, differentiating characteristics, namely shift in priorities and different RI development trends can be identified in the individual scientific disciplines compared to other areas. They appear in Hungary as well, which is not surprising given the characteristics of the individual disciplines of science are also true in Hungary because of the international nature of science.

Natural and technical sciences

Natural and technical sciences are extremely diverse in terms of the fields and often overlap certain fields of the life sciences (for example, research on the structure of high polymers, pharmaceutical research and development of imaging technology). The spectrum of RIs related to a field of science is also highly fragmented both in their nature and size. In addition, nearly all fields, except for a few (for example, astronomy or particle physics), use a high number of RIs and most RI types can be used to serve several fields (even life sciences and humanities combined, e.g.,, archaeology).

Although research in the field of natural and technology sciences is increasingly motivated by economic and societal challenges and, accordingly, the focus shifts from basic physical and chemical research to interdisciplinary areas consisting of materials sciences, technological, nanotechnology, energetic and environmental sciences, infocommunication and even life sciences, the basically physical nature of the RIs serving these targets is maintained. This explains the apparent dominance of the RIs of physical nature in the full RI spectrum.

The research of **living and non-living materials** involves the application of major physical equipment, such as research reactors and spallation neutron sources, synchrotrons, X-ray free-electron-lasers, ion accelerators and large optical laser equipment at an increasing rate and an ever better efficiency. They are typically research infrastructures built and operated in large international collaboration. Not even the richest countries can always afford to establish and operate these types of RIs relying exclusively on their own financial resources.

It is the vital interest of every country to allow their researchers to use these major equipment. It is also a major trend that

(i) a substantial part of the research is based on RIs other than the so-called major equipment in the long term, and

(ii) the major research equipment can be properly utilised only through the operation and continuous improvement of the appropriate domestic research infrastructures.

Life sciences

The major trends relevant from the perspective of RI development in the field of life sciences are as follows:

- The high-throughput and high-resolution measurement technologies have begun to develop rapidly.
- The genome sequence of an increasing number of species becomes known.
- The systematic collections of biological specimen sources (e.g., biobanks, genetically modified model organisms, ecological and biodiversity databases) are widely used.
- The development of the technologies and biological model schemes has resulted in the explosion of data and information, the systematisation and analysis of which necessitated the establishment of a high number of specialised databanks and analysis systems, namely, the creation of a new discipline, bioinformatics, and the birth of "computational biology and medicine".
- It can be evaluated as a significant change that, while the vast majority of the new RIs appearing in the life sciences used to be developments based on the earlier results of physical sciences (see the line of RIs applying electronic and chemical basic research), there have been more and more RIs since the early 2000s, which established new scientific areas linked to the life sciences already at the level of the basic idea (see the molecule sequencers applied in genetics or the new tools in nanobiology).

All these launched a paradigm shift in the life sciences: in addition to and relying on the "hypothesis-driven" research, "data-driven" research, namely research based on the collection and analysis of large amounts of data has become prevalent, and systematic approach and network research are becoming dominant in all branches of biology, including, in particular, medical biology, pharmaceutical research and development, as well as clinical research. The practical application of the results of frontier research has significantly accelerated particularly in clinical practice, biotechnology and the agriculture.

Research infrastructures functioning as local, regional and international service centres, which often operate successive complex instrumentations, have become more widespread. They also prepare the sample corresponding to the workflow, and also help in processing and analysing the data. These research infrastructures often perform these activities in the form of services.

Social sciences and humanities

The area of **social sciences and humanities** is very fragmented in terms of the number of disciplines and fields, but are much more uniform from the standpoint of research infrastructure. In the age of the Internet, the analysis of the past and the present primarily requires the interpreted processing of written and spoken texts, and well-organized easily accessible data and more complete databases, either for the study of culture or the establishment of a policy proposal. Research infrastructure in this area means tools which assist in the production, digitization and systematisation of such information, the sorting of information in databases and disclosure and interpretation of information.

The researchers working in many areas of the social sciences (in the areas of quantitative sociology, political sciences or economics) are analysing an ever increasing volume of empirical data produced in a standardised manner from samples comprising large numbers of samples, which can also be used directly in government decision-making.

In most areas of the humanities, the establishment and publication of archives represent the greatest infrastructure needs. The analysis of text and audio archives and repositories is an almost unforeseeable task, which can be well supported by technologies based on linguistic and IT foundations. At the same time, experimental psychology, which is multiply linked to the life sciences and physical sciences, has a slightly different RI need. As already mentioned, archaeology and art history use many of the RIs also applied by natural sciences. The evolution of linguistic and speech technology shows the connection of a group of human sciences to natural sciences, including computer sciences.

3.6. The role of foreign/ international research infrastructures

Not even the largest countries can afford to establish research infrastructures alone in certain research areas. So it is not surprising that several RIs were created through international cooperation in the last 50-60 years, which were established and have been operated as the result of the efforts of several countries. They can be used not only by the researchers of these countries, but, under certain conditions, others as well.

Examining the global development trends of scientific research and technological development, it can be concluded that the investment and operating costs of the infrastructure necessary for carrying out high-standard R&D activities have increased significantly, while the individual states, including even the richest, can only meet the demand for research and development within tight budgetary constraints. It should be emphasised that not only the construction costs of the major equipment, but also the maintenance thereof impose a serious burden on the operators and countries participating as members alike.

Some of the countries established/establish research infrastructures themselves, which satisfy not only the needs of their own researchers, but, due to their capacities, can also serve the scientific community of other countries. These so-called foreign research infrastructures (FRIs) are also important for the researchers of the smaller countries like Hungary.

Supporting the Hungarian participation in the pan-major European research projects, defined as an indispensable tool for the highest levels of research excellence, is essential in order to ensure access for the Hungarian researchers to the best European research infrastructures.

The Hungarian researchers are given the possibility to participate in research programmes using world-class equipment necessary for reaching internationally significant research results, which open new opportunities for the exploitation of the R&D results and the development of innovative products, processes and services which, in the long run, will contribute to the strengthening of economic competitiveness. An increasingly important category of the foreign research infrastructures, which requires special treatment, involves the international RI networks, which were made an infrastructure exactly because of the fact of networking; such as databanks. Allowing access to these is essential for the Hungarian academic life, as their costs, measured by the utilisation, are modest.

Of the international infrastructures, which will be presented in details below, the ELI is of outstanding importance. (See the annex for a more detailed description.) The ELI provides an opportunity for the Hungarian research community to join the forefront of the scientific life on the EU and international levels, which shall be given an absolute priority. It also provides an excellent opportunity for the domestic suppliers (also including regional actors) to directly participate in the development of ELI, which can produce knowledge and technologies in the domain of in-kind supplies which can be subsequently used in Union projects as well.

Through the successful implementation of the ELI project, Hungary and the Central and Eastern European region can be added to the "ERA-map"; contribute to its implementation and increase Europe's global (R&D) competitive capacity. In addition to the above benefits, successful implementation can obviously produce a number of ("spill-over") professional outputs (innovation results; increasing the R&D capacities and importance of the laser, materials science and other users; knowledge transfer; education; (inter-sectoral) mobility between the researchers-teachers-students and the enterprise developers; effect reducing the brain drain (and attracting human resources with a high level of competence); publications; national and international patents, etc.). The key (academic and industrial) "beneficiary" areas include healthcare and medical sciences, eco-friendly solutions (such as energy efficiency), food production, information technology, etc.

Equally important is CERIC, which fits well in the intellectual horizon of the national R&D strategy building, where "regional character" and the promotion of major regional cooperation are increasingly exposed European priorities in the context of research infrastructure (and it is in the focus of the ESFRI Action Plan). The expansion of the collaboration of regional research infrastructures is expected in the Central European Region, and it is also in actual initiatives (for which a new legal form in the Union, namely the "European Research Infrastructure Consortium", can provide a popular framework). Hungary is one of the 9 Central European states, which were the initiators of the "CERIC (Central European Research Infrastructure Consortium) project". CERIC is designed to create the region's largest ("distributed") infrastructure consortium, consisting of analytical and materials science infrastructures.

In addition to the most direct R&D&I results which can be expected from the professional cooperation, the collaboration of the regional research infrastructure can also contribute to the development of the European Research Area, the scientific and economic development of the given region, and, in the spirit of "open access", the promotion of the mobility of researchers and the combat against the global brain drain within the context of the more advanced areas.

4. RDI infrastructure and S3 – methodology, connection

Statistics (may) show only one – although very important – dimension of the national research infrastructures; generally, this is true for all statistics. In addition to analysing statistics, a broad consultation was held in accordance with the EPD process in the beginning of 2014 – at the same time continuing the NEKIFUT project – in order to get information on the national research infrastructures beyond the statistical data. This consultation and its methodology is in accordance with the ESFRI methodology – in fact, the NEKIFUT register (see Annex) was established in response to the ESFRI's call in 2010 – and appeared as an important element in the MERIL (Mapping European Research Infrastructure Landscape) project during the identification of the national RIs.

In addition to the consultation, a Working Group consisting of national experts has also been created, which has a general decision-preparing role in every issue concerning research infrastructures. As such, it also appears among the expert groups in S3 – probably in a number of areas, because of the comprehensive nature of research infrastructures.

The work of the **Research Infrastructure Working Group** (hereinafter referred to as: RI Working Group) is used to lay the foundation for all government decisions related to the research infrastructure. Regarding infrastructural investments in Hungary and decision-making on participation in research infrastructure projects listed in the ESFRI Roadmap; in respect of the typically signing *Memorandum of Understanding (MoU)* format documents that involve a major commitment by the state (as well); in preparatory matters concerning smart specialisation; and professional issued related to the unified national database of research infrastructures.

The composition of the RI Working Group ensures that all major disciplines are represented, and that both the university and the academic community are present. The state actors are also involved in the work, however, each member of the working group is a researcher himself, or involved in the field of research infrastructures, which ensures that any proposed decision concerning the research infrastructures is made along the professional aspects.

The RI Working Group cooperated with the research infrastructure committee of the President of the HAS and the experts of the NEKIFUT project in the prioritization of S3. In this regard, the RI Working Group compiled a shorter priority list professionally justified for Hungary, to be used as a professional input material. In order to collect information to prepare and establish policy decisions, data have been requested from the domestic stakeholders identified in respect of the foreign research infrastructures. In addition, criteria facilitating the policy evaluation (determining the policy indicators) of the project have been developed, enabling the policy assessment of the different participation requests based on professional prioritization.

The policy strategy documents and targets of Hungary and the Union, namely the national R&D&I Strategy, the S3, and the Union policy priority axes, have been given an appropriate importance in the policy evaluation based on prioritization supported by professional reasons, where potential professional connection to the "Key Enabling Technologies" and "Future Emerging Technologies" has become a prioritized evaluation factor. In addition to the components of a financial nature ("membership fee" and maintenance and development contributions, etc.) taken into account in the context of the policy indicators, the volume of the industrial and SME capacity supporting the connection, the supply capacity of the spin-off and start-up companies, and the volume of the domestic and Union budgetary and aid resources (which are expected to be available in the coming years) relevant to the financial burden of participation in certain projects (even if estimated only in this stage) were considered when formulating the proposals establishing and preparing the decision of the Government.

In terms of S3, the RI Working Group is particularly responsible for the preliminary assessment of the requests for connecting to certain foreign infrastructures with the involvement of experts, if necessary, to find out how the connection request meets the connection criteria described below. Its other important task is to play a decision-preparing and consultative role in each S3 issue concerning research infrastructures, depending on the nature of request from the side of S3.

NEKIFUT project

At the initiative of the European Strategy Forum on Research Infrastructures (ESFRI), invited by the EU, the majority of the Member States have started to develop their national research infrastructure (hereinafter referred to as "RI") development strategy. The development of a "single national research infrastructure development strategy and programme harmonised with the European

Research Area" started during the previous government cycle in the framework of the National Research Infrastructure Survey and Roadmap (NEKIFUT) project launched for the fulfilment of the task. The so-called "SRI Register" has been completed: the Register has been available in English and Hungarian on the web since April 2011. It contains 63 Research Infrastructures of Strategic Importance (SRIs) and the data of 361 individual RIs being a part of the networks among the SRIs; and major policy documents had been prepared that were included in this document. ("Development of research infrastructure in Hungary – Strategic foundations of the 2013-14 tender system"; "Hungary's participation in the international research infrastructures – Policy recommendations")

Furthermore, the data supplied by over 400 research infrastructures (in early 2014) enabled us to have an up to date picture of the status of the domestic research infrastructure on the NEKIFUT IT interface.

The broadest possible review of research infrastructures is particularly important so as the national research infrastructure roadmap can be prepared and be up-to-date. Therefore, the NEKIFUT is developed in such a direction that it should fully include the research infrastructures of undertakings, as well as the public infrastructures. The aim is not only the review but also the organisation of cooperation, the sharing and concentration of capacities, tools, technologies, the establishment of research institutes, and the development of technology centres established by entrepreneurs or with the participation of undertakings.

As regards the S3, the additional tasks of NEKIFUT involve the update of the National Research Infrastructure Register and keeping it up-to-date, and the publishing of its data, as well as the performance of related analyses.

5. The vision of research infrastructures

As stated above, such a vision is presented for the research infrastructures that takes note of the specific nature of research infrastructures, namely that – which can be also determined on the basis of statistical data – **it is reasonable to analyse the infrastructures of the various fields of science separately by disciplines** – the infrastructure of natural science and social sciences, respectively, can be hardly compared regardless of whether the quantity of the investment intensity is tested. From a scientific point of view, the effectiveness of certain infrastructure can be best measured by the publications related to them and the number of researchers who use the publications, but neither indicator can really be linked to regionalism or economic effectiveness. The latter is not a condition by each infrastructure, see for instance the frontier researches. There is not a really good measure presenting the cooperation between research infrastructure and economic field: the collaborations between the higher education and HAS research organisations serve as a reference in this regard; in the interest of comparability, it will be worth collecting similar data in the future. Of course, there are some trends and conclusions which can nevertheless be made in a regional or economic sense irrespective of the above situation, but we should not forget that **the really important and outstanding research infrastructures reach far beyond the given region (they can affect more sectors)** – similar to the international infrastructures which will be discussed in the following.

5.1. Development directions of research infrastructures

The direction of the development of the national research infrastructure is not only determined by how they can connect to the economic actors at the regional and local levels, but also, and much more, the national or even international results they are able to achieve. In the case of research infrastructures, therefore, it would suggest insularity if only the effects expected on the local level were taken into account. Instead, it is necessary to elaborate an RI development strategy which sets this national-international impact as the goal. Accordingly, the national research, development and innovation strategy approved by the government considers the strengthening of the knowledge bases as an essential priority.

Of course, the research infrastructure can have a significant influence on the economy at the local level as well: as a result of the cooperation, the economic operators can obtain R&D services cheaper than if they had to purchase the given infrastructure and the necessary human resources, as it is often not possible either financially or physically. Cooperation with the local actors can also help the better and more effective utilization of the RIs and, indirectly, exercise an effect which reaches beyond the local level. The infrastructure has reached the development level in many cases, which already affords to the creation of networks whose members are located in all parts of the country, thus covering the physical distances. This will ensure that the infrastructures stimulate the economy not just in a given geographical location, but their services are spread across the country to make their RI capacities available to all actors of the domestic economy.

Through the use of modern information technology and communication tools (also called e-infrastructure), the researchers will become able to reach the resources and devices regardless of where they are. This leads to completely new research methods, which is characterised by the shared use of resources between the different disciplines and the institutions in different physical locations. Virtual research teams are formed, and this process creates the European on-line research area. Those countries that are excluded from this process, no matter how powerful and advanced their existing scientific capacity is, will drop away from the forefront of the international scientific world very rapidly.

The above described nature of the research infrastructures is confirmed by statistics as well: the overweight of the KMR is obvious in the case of practically all other R&D indicators. Nevertheless, the situation is somewhat more balanced in terms of the infrastructures, especially if they are examined by the fields of science.

The following key findings should be considered in respect of the S3:

- The RDI infrastructures are hardly comparable with each other between the fields of science
- The impact of the RDI infrastructure, in case they are excellent, points beyond the local level and facilitates an international effect
- The resource demand of the RDI infrastructures is widely divergent across the academic disciplines
- The RDI infrastructures are the most effective when operating in networks, so the national development, expansion and operation thereof should be given priority over the allocation of resources
- Openness is essential in the case of certain infrastructures; the infrastructures operating in the Union also support this openness with the ESFRI projects. This should essentially be made the prevailing attitude in Hungary, too.
- There is a serious mismatch in the case of some disciplines between the infrastructures and the needs of the enterprises and the researchers.

Because of this, the development of the research infrastructures should follow guidelines instead of the preferences of the specific discipline or geographical preferences, which ultimately reach the desired effect, namely excellence in the research infrastructure and the improvement of Hungary's competitiveness through the furthering of collaborations, but without decomposing the interventions to the local level. Hungary can become an active participant in the European research area only in case it sets excellence as the target in the field of its infrastructural developments.

In-kind contribution is one of the priority areas in international connection. Excellence and competence are the primary criteria for selection in case of the supplier programmes of international RIs. From the side of partner countries, the regional RDI institutions and industrial concerns are the suppliers so the in-kind activity helps the national developments, investments, as well as advances technology transfer and increases the competitiveness of the SME sector or even the growth of start-up companies.

5.2. Strategic directions for developing the research infrastructure

- The promotion of networking and the unification of fragmented research organisations in order to build synergies. As a result, it can be expected that such RI services will be established that, due to the lack of networking, RI has not been able to provide until now; in the meantime, increase in utilisation rate is also to be expected. The technology and innovation centres, infrastructures established with the participation of entrepreneurs or undertakings are, where possible, a natural part of the networks.
- Openness, which is also a prerequisite for networking, should get a prominent role instead of the exclusive use of infrastructures. As we have seen it, this is also a premise at Union level; the use of open infrastructure is crucial to establish a research area and users shall have an equal chance to access it if they comply with the conditions laid down in the publicly available rules, except some special reason (e.g.,, national security, data protection) prevents this.
- The general principle for developing research infrastructures is that the research infrastructures that have a substantial chance for establishing connections with respect to their disciplines should get the support needed for access by developments and renewals, in the interest of striving for international excellence. Access does not only mean a "membership fee", but also that the given infrastructure should use the opportunities provided by the access as much as possible. This shall be generally reflected in terms of the increase in the number of researchers using the infrastructure or in the increase of the number of publications that can be linked to the infrastructure or, where applicable, the patents related to the research are also relevant. The relevant international infrastructures will be presented later.
- It is important that a research infrastructure shall not only be taken into consideration as a "locally" available infrastructure. On the one hand, this is not appropriate because of the networking and, on the other hand, it can be problematic because of the effects described above (the outstanding infrastructure has a widespread impact, etc.). The infrastructures should be rather taken into consideration as part of a given discipline or, in a broader sense, a national or international RI-network, which answers the question how the given infrastructure or discipline should contribute to the cooperation in the scientific or business sector.

- When joining an international project, the research networks that can use the benefits stemming from the project participation through the synergistic operation of the network members should enjoy advantage.
- The R&D projects in the framework of which the infrastructures can be partners of the corporate sector shall be provided with a special support by all means. This can be appropriately implemented so that the research projects should only receive funding if the research infrastructure and the undertaking can cooperate for the successful implementation by creating a synergy between them. This can be realised independently of the geographical location; it would even be preferable that the infrastructures have an impact as broad as possible (national or even international). Before joining the project, it is worth analysing (where relevant) if there is an enterprise sector requiring and utilising the services of the research infrastructure.
- An important element of the RI development is **in-kind contribution** (which also plays a key role in the ESFRI principles), which should be strengthened from targeted Union or national funding with a view to fostering international cooperation to be realised in the field of RIs.
- The so-called in-kind contribution may significantly assist the Hungarian suppliers in developing and producing high-tech instruments so as Hungary can participate in the given infrastructure. In particular, the potentially suitable undertakings should be strengthened with the help of a targeted call for proposal, in the framework of which they can prepare themselves for the future access as suppliers. This has a double advantage: On the one hand, the cost of participation will not be significant later, on the other hand, it will result in technological developments that will be integrated into the Union infrastructures and strengthen the regional stakeholders.
- Taking into account that the infrastructures of certain disciplines cannot be economically utilised in a direct way but are of significant scientific importance (which can indirectly result in economic benefits later), it is recommended not to consider these infrastructures so much as the infrastructures achieving a direct economic result; they should rather be measured and evaluated in terms of scientific excellence, through the number of researchers (users) and publications. Every major discipline is affected by these issues to a greater or lesser extent.

In accordance with the guidelines described above, the participation in international, e.g.,, ESFRI infrastructure is particularly important when:

- The participation in the infrastructure is substantially supported by the representatives of the discipline, and the participation is sustainable in the long term (it is up to the Research Infrastructure Committee to judge in a form to be determined later)
- The participation in the infrastructure is expected to result in research results of at least European significance
- The participation offers an opportunity for the Hungarian research infrastructure to be a part of a larger network
- The national research infrastructure will be able to provide a new or better-quality service to the corporate sector stakeholders because of the participation
- Hungary can contribute to headline targets important for the European economy and/or society through its participation

- Participation furthers scientific and economic excellence, and assists the Hungarian research network in achieving new, significant scientific result in collaboration with European researchers.

6. The possibilities for international connections of the national research infrastructures

It is a clear trend in the current EU-level policy processes, i.e., in the Innovation Union flagship initiative of the Europe 2020 strategy and in the Horizon 2020 Framework Programme, determining the community funding of R&D in the next financial period of the EU that the role of Pan-European research infrastructures of global importance will become even more significant than it is now. The basic philosophy of Horizon 2020 is based on the concept of excellence; it is striking that a greater-than-ever emphasis has been put on the requirement for world-class quality. In addition to other top priorities, such as ensuring industrial leadership, responding to societal challenges, the strengthening of scientific excellence – which has been set as a first priority – should lead to increasing European competitiveness. It is unimaginable that the European gap in this field will be reduced and the global R&D&I competitiveness will be increased without any world class research infrastructures.

The projects in the ESFRI Roadmap are such European research infrastructure investments that are beyond the possibilities of one country due to their global top-level position (as regards their professional standards) and volume; they are implemented in international cooperation between several countries, from a “common budget” based on voluntary state commitments.

Hungary is represented in some form in almost half of the 48 projects in the ESFRI Roadmap. Among these, the most intensive Hungarian participation is in the *Extreme Light Infrastructure (ELI)* – following the tender won together with the Czech Republic and Romania. However, the Hungarian scientific communities concerned have already stated the necessity to join other, professionally important RIs.

It is obvious from the analysis of the domestic situation that participation costs are significantly higher in certain disciplines than in other fields, but obviously the importance of a given infrastructure cannot be judged on the basis of this. This situation can even change within a certain discipline, depending on the fact whether it is an infrastructure consisting of a databases or not.

Similarly, the costs of infrastructures in each discipline may significantly vary; it is obvious – as we have seen – that the participation costs in infrastructures related to social sciences and physical sciences may differ in magnitudes, in line with the investment data of the Hungarian infrastructures.

Accordingly, the Hungarian participation in foreign infrastructures significantly depends on the available resources and the type of infrastructure per discipline.

6.1. Foreign infrastructures recommended for participation

The Research Infrastructure Committee has determined the research infrastructures recommended for participation on the basis of the following: it has taken into account the data of research infrastructures assessed and contacted in the NEKIFUT project; the data of the HAS Research Infrastructure Presidential Committee; and the results of the common data collection of NGM and NIH, in the framework of which every research infrastructure owner has been asked about the international infrastructures the participation in which they would consider important. The final prioritization has been made on the basis of the professional justification of projects. Moreover, the criteria enabling the policy evaluation of projects (determining policy indicators) have also been developed, as a result of which the policy evaluation of each participation request – based on professional prioritization – will be also possible in the future.

Agreeing with the above mentioned principles and bearing in mind the described specific features, the Committee has determined the European research infrastructures, the Hungarian participation in which is justified in the 2014-2020 period by discipline and type of infrastructure in the table regarding the participation in international infrastructures.

Participation in certain infrastructures, as well as the development of the national infrastructures is done according to the above mentioned criteria, by also taking into account the preliminary professional opinion of the RI Working Group.

The source for the participation in foreign research infrastructures and infrastructural developments of research institutes has been defined, the planned amount of which shall be as follows between 2015 and 2020 (in HUF billion):

	Total	2015	2016	2017	2018	2019	2020
Development of the infrastructure of research organisations	56.37	8.29	8.70	9.14	9.59	10.07	10.58
Support for the participation in international research infrastructures	20.5	3.01	3.16	3.32	3.49	3.66	3.85

The foreign infrastructures recommended for participation – i.e., the subject for the opinion of the RI Working Group – broken down by discipline and type are the following:[3]

Table 1

Discipline	Recommendation for the further use of infrastructures	Participation costs	ESFRI recommendation for participation	Participation costs	Recommendation for participation in non-ESFRI programmes	Participation costs
Physical Sciences and Engineering	CERN (+ SLHC + ILC)	6,050 k euro/year				
Physical Sciences and Engineering			ELI	13,170 k euro/year		
Physical Sciences and Engineering	ESA	10,000 k euro/year				
Physical Sciences and Engineering	EGO-VIRGO (+ET)	500 k euro/year				
Physical Sciences and Engineering			FAIR	500 k euro/year		
Physical Sciences and					CCDC CSD	5.3 k euro/year

[3] We note that the government guarantees the costs for joining and participating in the following infrastructures in the budget of next year: **CERN, CERN ALICE, CERN CMS, ESS, ILL, ESRF.**

Engineering						
Physical Sciences and Engineering	ESO	1,000 k euro/year				
Physical Sciences and Engineering			SPIRAL2	500 k euro/year		
Physical Sciences and Engineering					CERIC	100 k euro/year
Physical Sciences and Engineering					MESA+	
Energy Sciences	EFDA-JET (EURATOM)	14 k euro/year				
Material Sciences and Analytics			European XFEL	2,134 k euro/year		
Material Sciences and Analytics	ESRF	245 k euro/year				
Material Sciences and Analytics	ILL	360 k euro/year				
Material Sciences and Analytics			ESS(Neutron)	2,000 k euro/year		
e-infrastructures	PRACE	50 k euro/year				
Life and Medical Sciences	EMBL	EUR 0				
Life and Medical Sciences	ELIXIR	1,000 k euro/year				
Life and Medical Sciences			BBMRI	40 k euro/year		
Life and Medical Sciences			EuroBioImaging	65 k euro/year		
Life and Medical Sciences			ECRIN	100 k euro/year		
Life and Medical Sciences			INSTRUCT	1,130 k euro/year		
Life and Medical Sciences			EU-OPENSCREEN			
Environment			ICOS	50 k		

al sciences				euro/year		
Environmental sciences			IAGOS	5 k euro/year		
Environmental sciences			LIFEWATCH	500 k euro /year		
Agricultural Sciences					CARPATCLIM	90 k euro
Agricultural Sciences					TRANSFAC	2 k euro
Agricultural Sciences					GENOMETRAX	4 k euro
Social Sciences and Humanities	CESSDA	5.15 k euro				
Social Sciences and Humanities	CLARIN	12.28 k euro				
Social Sciences and Humanities	SHARE	360 k euro				
Social Sciences and Humanities	European Social Survey – ESS (Social)	40 keuro				

7. Evaluation, monitoring

The regular evaluation of the Hungarian research infrastructures – in accordance with the Union methodologies, e.g., ESFRI – is essential for their development. This means a continuous, iterative process, as one result of which the demand for connections to foreign research infrastructures has been assessed. The actual participation is done on the basis of the RI Working Group, the RI Committee of HAS President and the NEKIFUT database.

It is also recommended to operate an independent monitoring unit in the field of RIs since – as it has been presented above – the RI is one of the key elements of the National Innovation System, but it is far not the only element.

It is worth measuring the performance of research infrastructures by a separate indicator; this is also required because of the evaluation. Possible indicators:

- ✓ The number of publications by external researchers per research organisation (number)
- ✓ The utilisation rate of research infrastructure by external researchers (%)
- ✓ The average value of economically oriented projects implemented in research infrastructures (euro per project)

8. Annexes

NEKIFUT Register 2010-2014

From the beginning, the establishment and regular maintenance of a broad Hungarian RI database has been one of the objectives of the National Research Infrastructure Survey and Roadmap (NEKIFUT) project launched in December 2008. The uploading of the NEKIFUT Register started with the so-called Research Infrastructures of Strategic Importance (SRIs), i.e., the most important research infrastructures from a scientific, economic and societal aspect in 2009–2010. The SRI classification was won by networks made up of RIs possessing a unique and uniform development concept as a result of an open and transparent evaluation process, which is based on the decision of bodies consisting of researchers, teachers, developers and economic actors that are balanced in all respects and enjoy general trust. The Register is available in its current format – in Hungarian and English languages – from April 2011 on the internet, on the address https://regiszter.nekifut.hu.

The update and upgrade of the Register became due three years after the launch. On 17 February 2014, the National Innovation Office (NIH) therefore invited new applications from the research infrastructures operating in Hungary so as the Register includes the broadest possible scope of research infrastructures. The updated and upgraded Register that is expected to be made public at the end of 2014 will not only contain the research infrastructures classified as strategic but also every RI requesting and obtaining registration (i.e., RRI).

On the one hand, the previous SRI -study should be performed (to keep or delete the present title of a SRI or award new SRI titles) and, on the other hand, further SRIs not applying for the classification or unprepared to obtain the title but still requesting their inclusion into the Register should be evaluated during the 2014 update of the NEKIFUT Register.

The applications submitted to the 2014 call of NEKIFUT Register have been evaluated, the evaluation process has been similar to the evaluation of the 2009-2010 applications in the case of SRIs: it has been a multi-stage process, primarily based on the evaluation of the Working Groups of the three large disciplines (physical sciences, life sciences and social sciences and humanities) and external experts, the result of which is expected to be approved by the NEKIFUT Steering Board in December 2014. The evaluation of RRI applications are based on fewer criteria since, in this case, only the fact should be evaluated whether the infrastructure complies with the definition of RI. The decision-making mechanism of NEKIFUT is based on bodies (Steering Board and three Working Groups covering 6 disciplines) in hierarchical relationship with each other.

There will be an opportunity for the continuous submission of RRI applications; the submitted applications will be evaluated in a simplified procedure during the predetermined periods. The biennial or triennial update seems rational in the case of SRIs. Furthermore, there will be an opportunity for the regular update of certain data of the Register, which will significantly increase the accuracy and usefulness of the Register.

The new Register is available on the new interface of the NIH Kaleidoscope information system, on the addresshttp://nekifut.gov.hu/.

Short summary of the research infrastructures

Extreme Light Infrastructure (ELI)

ELI is the common European project of the highest-intensity lasers, the purpose of which is to assess the interaction between laser light and material in basic and applied research in the broad field of physical, chemical and life sciences. ELI is a distributed research infrastructure, which has three pillars (nodes) currently under construction; out of which one is built in Szeged as the biggest research and development investment of the country. Our ELI membership is laid down in an international treaty based on a government decision; our long-term participation in ELI is largely justified by its scientific and socio-economic effects; the latter include the significant order volume of primarily Hungarian SMEs and the related technology transfer.

It is a unique opportunity and challenge for Eastern Europe, and more specifically for the Central and Eastern European region, that – after Hungary, together with the Czech Republic and Romania – has won the site tender invited related to the ELI project, one of the pan-European projects of the ESFRI Roadmap will be implemented in this region.

The ELI is an investment of three, simultaneously operating European research institutes:

- the "Beamlines Institute" in Prague will perform research based on high-intensity X-ray and particle sources;
- the Attosecond Light Pulse Source research centre in Szeged will enable research into the superlaser of ultrashort pulse duration of exceptional scientific significance;
- the Nuclear Physics Institute near Bucharest will focus on the study of laser-induced nuclear phenomena.

On 7 January 2011, the government announced that the innovation project in Szeged will be funded in the framework of the National Programmes financed by the New Széchenyi Plan. At the expense of the 2007–2013 Programming Period, HUF 36.998 billion can be allocated to the implementation of Phase 1 of the large project. The planned total cost of Phase 2 of the ELI-ALPS project is HUF 28.58 billion, which will be funded from the budget of the 2014-2020 Programming Period.

15% of the investment amount is financed from the national budget, and 85% is financed from EU funding. The tender documentation of the large project prepared by the developer (ELI-HU Nonprofit Kft.) has been approved by the Hungarian Government on 26 April 2013 (Government Decision No. 1240/2013. (IV. 26.) then it was submitted to the European Commission for approval. According to the plans, the construction leading to the implementation of the project will start this year. The premises for laser research shall be handed over by 31 December 2015, then the research work may start in 2016.

CERN (+ SLHC + ILC)

The high-energy physics world laboratory of CERN is situated in Geneva, where currently the largest acceleration device of the world operates. The research performed at CERN searches the answers to the fundamental questions of the Universe; however, CERN also has a key role in knowledge and technology transfer. After the commissioning of the CERN Tier-0 centre in Budapest (MTA Wigner FK), the economic role of CERN has also become significant. The CERN membership of Hungary is laid down in an international treaty based on a government decision. CERN is directly used by approximately 50–60 researchers, but its indirect effect is even larger. Our CERN membership shall be maintained in the long term and we shall also participate in the long-term developments of CERN (SLHC, ILC-HiGrade).

EFDA-JET (EURATOM)

EFDA is the umbrella organisation of the European Commission's EURATOM programme covering the European laboratories dealing with the implementation of fusion power generation. JET is the largest currently operating European fusion equipment. Hungary – as a member state of the European Union – participates in the world-wide ITER programme, which intends to demonstrate fusion power generation for the first time; this can only be implemented in an effective way if the EFDA membership is maintained and the JET is used. The EFDA-JET membership also results in a significant knowledge and technology transfer. With regard to our utmost commitment to participate in the ITER programme, our EFDA-JET membership shall also be maintained, and shall also be taken from the level of the HAS to the level of the government.

ESA

ESA (European Space Agency) is an organisation holding together European efforts for space research. Hungary has been the member of PECS for ten years, which is often considered the „ante-room" to ESA; the PECS membership was extended for an additional five years in 2008 as an extraordinary measure. The ESA membership would not only enable the Hungarian research community to participate in space research, but also it would provide highly experienced and recognised Hungarian SMEs engaged in the space industry with a business opportunity in the value of around 90% of the membership fee or even exceeding that, which, in turn, would preserve jobs and also result in a significant technology transfer. Pursuant to Government Decision No. 1391/2013 (VII. 2.), negotiations shall be initiated with ESA for a full membership status, and the effects of the ESA membership on the national economy shall also be assessed. The long-term and full ESA membership of Hungary is largely justified due to its effect on SMEs and technology transfer.

European XFEL

The European XFEL in Hamburg will be one of the largest and, due to the unique time structure of its beam, the most efficient and widely applicable X-ray free-electron laser in the world – which enables us to perform tests that are not possible with synchrotrons – when it will be commissioned in 2017. The basic and applied research carried out here will be applied directly or indirectly in the development of new materials in the pharmaceutical industry, biotechnology, the energy sector and several other areas. European XFEL will also have a key role as a knowledge centre and later SMEs can also be suppliers. The international treaty, based on a government decision, that cannot be terminated until 2026, makes Hungary a full member of European XFEL. The maintenance of membership is also justified in the long term

EMBL

European Molecular Biology Laboratory's European Bioinformatics Institute (EMBL-EBI, www.ebi.ac.uk) is the largest European organisation for research into natural sciences, and one of the strongest European networks of experimental and molecular biology. EMBL-EBI is a project leader of several projects and has exceptionally good relations with enterprises and institutions serving as sponsors of translational research. The participation of the entire Hungarian Genomic Network is of key importance from the aspect of ensuring the country's research potential and sources of research. EMBL has a potential in Europe that provides a platform for innovation and technical development.

EMBL does not primarily provide measurements, but manages research programmes, provides technology transfer, provides continuous further-education and can be considered an elite European channel of samples, know-how and expertise. The benefits of joining EMBL exceeds by far the direct access to measurement opportunities.

CESSDA

A searchable virtual FRI managing the social sciences databases of all EU member and partner states, which is essential in searching comparative data for public administration and academic purposes. The FRI was launched in the 70s and ESFRI was among the first ones to include it; CESSDA-ERIC was founded in 2013 with its seat in Norway and the generous financial support of the Norwegian government. Its Hungarian member is TÁRKI, which exceeded the SRI requirements with regard to CESSDA.

ESRF

ESRF in Grenoble is Europe's largest and the world's most diverse and most reliable synchrotron used by 10 Hungarian research groups at 7 independent academic and university research centres in the fields of material sciences, solid body physics, chemistry, life sciences and earth sciences; the number of direct users is around 50, while the number of its indirect users is three times higher. Some of its results achieved have been published in journal with the highest impact factors of the world, while the Hungarian ESRF membership has also resulted in an ERC project. ESRF is one of the most important knowledge centres in Europe and also the most important preparatory base for the use of the European XFEL. From a scientific aspect, the long-term maintenance of our ESRF membership and its promotion from the current level of HAS to the level of the government is absolutely justified, the primary condition of which is to ensure the non-HAS part of the membership fee from governmental sources.

EGO-VIRGO (+ET)

EGO-VIRGO is a European gravitational observatory near Pisa, originally an Italian-French cooperation, which has later become the home of 19 European research centres, among them MTA Wigner FK. VIRGO, operated by EGO, is one of the world's four laser interferometer gravitational-wave detectors that are partly connected to each other and under development. The development of VIRGO and the interconnected detector system is expected to have a breakthrough within a few years that will result in the birth of a new disciple, i.e., the experimental gravitational-wave astronomy. The development of VIRGO is not only promising from the aspect of basic research, but also from the aspect of supplies on a SME level: Hungarian enterprises would have a good chance of participating in the development and supply of laser and vacuum technological equipment. The Hungarian school of gravitational theory is in the forefront of the world. In view of the above, the participation in the EGO-VIRGO project on a government level seems to be desirable. This participation would establish the Hungarian participation in the future development and construction of an advanced European gravitational detector, the Einstein Telescope (ET).

ELIXIR

EMBL-EBI is also the leader of this project, and 32 institutes from 13 countries participate in the consortium. The HAS Institute of Enzymology is the Hungarian member of the consortium; the institute is represented by László Patthy in the consortium (as of 1 January 2012 the HAS Research Centre for Natural Sciences).

The most important objective of ELIXIR is to create, develop and preserve the existing (and future) biological data sources. The project establishes such a European infrastructure with a secure financial background that enables the optimised storage, integration and analysis of biological information for the European research communities.

FAIR

FAIR is a legally independent, extreme intensity heavy-ion and antiproton accelerator and storage ring system under construction in the GSI site of Darmstadt with the cooperation of 8 EU member states, Russia and India. The objective of FAIR is to continue basic research into particle and astrophysics; however, the infrastructure will also be applied in traditional nuclear physics, plasma physics, atomic physics, but also in life sciences and medical therapies in some cases. The Hungarian community of nuclear physics traditionally has good relations with GSI; nearly 40 Hungarian researchers have participated in the preparation of FAIR; however, this is not stipulated in a government-level agreement. Not only Hungarian researchers, but also Hungarian SMEs could participate in FAIR, primarily related to the construction of detectors and performance of digital data processing. The participation of Hungary in FAIR is absolutely necessary on a government level, at least as an associated member. However, considering the CERN commitment of the same community, it shall be assessed how the necessary human resources can be ensured for this purpose.

CLARIN

CLARIN was established by the ESFRI process, its founders are two Dutch and one Hungarian centres of language technology; CLARIN-ERIC, already operating as a virtual FRI was founded by 10 member states with a seat in the Netherlands. Language technology serves as a sort of background infrastructure to social sciences and humanities. The initial Hungarian advantage will be irretrievably lost unless a globally recognised Hungarian network of language technology with a SRI approval joins the network. The presence of Hungarian SMEs in this applied science can be enhanced with the help of governmental support.

BBMRI

There will be an ever increasing opportunity in the already existing, and, particularly in existing, but officially not registered and accredited biobanks. These biobanks – with direct fundraising – also constitute an essential background of basic (e.g. systems biology) and translational (e.g. genomic pharmaceutical engineering) scientific research.

The participation of the Hungarian biobank system in BBMRI ERIC generates considerable income (sales of biological samples) and enables the accession to major European competitions (EU7, EU8) due to special national population materials (e.g. Roma communities).

PRACE

PRACE is the largest research-focused European network of supercomputers that is open and free to every researcher of the world through competitions and jury assessment based on the quality criteria. Hungary is a member of this distributed research infrastructure through NIIFI but HAS Wigner FK is also engaged in negotiations in order to join PRACE with a GPU-based supercomputer and data centre service. The long-term maintenance of the Hungarian PRACE membership is absolutely justified.

ILL

ILL in Grenoble is the highest flux research reactor of the EU, and currently in the world, with its measuring points used for various experiments applying the methods of neutron dispersion in the areas of material science, solid body physics, chemistry, life sciences and other disciplines. Hungary is a participant of ILL through the consortium membership of MTA Wigner FK. ILL is directly used by about 50 Hungarian researchers, while the number of indirect users is almost the same. Besides scientific use, the Hungarian participation in ILL is also justified by the Hungarian SME base dealing with neutron; there is an actual chance that a significant part of our obligation for contribution can be fulfilled in kind, which also induces technology transfer. ILL is one of the most important European knowledge centres. The long-term maintenance of our ILL membership and its promotion to the level of the government is absolutely justified. While doing so, it shall be assessed whether there is a real possibility of compensating our ILL membership by granting access to the Budapest Neutron Centre (BNC).

EuroBioImaging

The role of microscopy and medical imaging is even more central with the penetration of molecular resolution methods. One of the most rapidly developing branch of medical science is diagnostic imaging, which has already extended to the therapy controlled by imaging devices. Bioimaging is crucial in the molecular-level examination of diseases, as well as in pharmaceutical engineering and trials and in improving the quality of life. As a result of the membership, the Hungarian participants are granted access (even "remotely" on-line) to the central imaging infrastructure of the EU.

ESS(Neutron)

ESS, which is currently under construction in Lund and expected to be commissioned at the end of this decade, will be the highest intensity spallation-based neutron source in the world. The Hungarian community of neutron dispersion primarily using the Budapest Neutron Centre (BNC) and ILL currently has a total number of 200 users, together with the indirect users. After the expected decommissioning of BNC in 10 years, ESS will become the main neutron source of Hungarian researchers as well. The Hungarian government has undertaken participation in ESS for 11 years, with a membership fee in the amount of EUR 1.6 M. 30% of the amount is cash contribution, while 70% is in-kind contribution to be spent in Hungary. Hungary has also undertaken to be one of the three ESS-ERIC founding members.

ECRIN

A well-proven research network of great traditions for medical biology joining the most productive teams of Hungarian medical schools and national public health institutions. Through joint, coordinated and targeted clinical research, Hungarian research organisations may participate in state-of-the-art multinational academic/university examinations. The ethical-professional supervision of the activity of the Hungarian organisation (HECRIN) is performed by the Medical Research Council.

The concepts of national health are focused on and aligned with the continuation and improvement of the most up-to-date system-oriented academic research, research into rare diseases and medical equipment, pharmaceutical developments and research systems related to food safety.

SHARE

The foundation of SHARE has also preceded the ESFRI process but ESFRI was among the first to validate this infrastructure. The various data of the elderly are collected by regular surveys and made available to researcher communities free of charge. 21 EU member and associated countries are represented in the organisation, which was among the first to transform into ERIC in 2011 with its seat in Tilburg and with 6 members plus an additional observer. TÁRKI and the CEU Department of Economics are the Hungarian participants in the surveys. A SRI classification was also granted to the Hungarian SHARE organisation.

ESO

ESO is the largest international organisation of European astronomy with a membership fee proportionate to the GDP of each individual member state. The centre of ESO is near Munich, but its observatories are operated in Chile. Access to the observatories of ESO can be gained electronically through competitions decided by the assessment of a jury. The number of potential direct Hungarian users of ESO is around 10, while the number of its indirect users is several times more. In the case of joining ESO, SMEs may also act as suppliers. If possible, Hungary shall join ESO and maintain its membership in the long term. Accession is only possible on a government level.

LIFEWATCH

Joining one of the largest European ecological systems will result in the world-class quality of environmental protection, ecological sustainability and ecological information technology in Hungary. All of these enable ecosystem services and the analysis of natural capital using state-of-the-art methods, which is of vital importance to the future life prospects of humanity. The infrastructural implementation of an integrated experimental and virtual ecosystem laboratory is a task of the highest priority. The role of LIFEWATCH knowledge centre is significant in developing scenarios for nature, environment and land use, through which it contributes to a well-grounded “foresighting”. The ecosystem services (service, regulatory, supplying and cultural services) can be regarded as “public goods” representing a value comparable to the performance of real economy. The foreseeing and ecologically sustainable use of these “public goods” is an issue of national strategy. The threatening challenges of climate change and ecological–environmental problems may only be dealt with by predictive modelling and risk assessment adapted to the region of the Carpathian Basin. The participation in LIFEWATCH enables us to gain a respectable international position in the first phase of the development. We have a chance to establish an international LifeWatch Centre for Habitat and Ecosystem Research.

European Social Survey - ESS(Social)

ESS(Social), founded in 2001, carries out comprehensive surveys for social sciences concerning the beliefs, attitudes, etc. of each member state every two years, which are made available to the research communities free of charge. 35 (EU member and non-EU member) countries participate; it was granted ERIC status in November 2013. Its Hungarian interest groups are TÁRKI and MTA TK. Furthermore, ESS (Social) also has a Hungarian SRI classification.

ICOS

ICOS is an international network in Europe and the surrounding regions for the purpose of monitoring the balance of CO2 and greenhouse gases in general. The current measuring stations are located in the Western part of Europe, therefore the participation of Hungary would have particular significance. In the case of our participation: Hungary would gain access to up-to-date information that are essential for climate research and climate policy and simultaneously make the achievement of new scientific results possible. The Hegyhátsál measuring station of the National Meteorological Service could serve as a basis for participation. If possible, Hungary should join ICOS with a commitment of the government.

INSTRUCT

This multi-centric infrastructure is created by leading Hungarian workshops of research into structural biology. The activities are connected to super-high resolution, near unique molecular-level resolution, multimodal and manipulation optical systems and the instruments studying in vivo applicable techniques and the structural research of biological macromolecules. The Hungarian RIs and SRIs lead to results, on the basis of which the solution of certain biological issues is enabled by the usr of state-of-the-art infrastructures funded from the resources of INSTRUCT and operated at the core laboratories of INSTRUCT.

SPIRAL2

The SPIRAL2 accelerator soon to be commissioned in Caen, France, at the site of GANIL centre will enable the production of radioactive beams of rare isotopes. HAS ATOMKI was a consortium partner of the SPIRAL2 preparatory phase. The accelerator will host a basic research of nuclear physics into the production and examination of hitherto unknown isotopes; the short-period access of relatively small groups will be provided on the basis of competition decided by the assessment of a jury. Considering the different nature of use in comparison with CERN and FAIR, the Hungarian research community is less burdened with regard to SPIRAL2. The membership fee of SPIRAL2 may be settled in 100% by detector construction and electronic supply services, which induces considerable technology transfer. If possible, Hungary should join SPIRAL2 on a government level.

IAGOS

IAGOS is an infrastructural network for environmental science, which analyses the gas and aerosol composition of the atmosphere and clouds based on samples collected on passenger planes. The condition for participation of a country is the development and production of instruments to be installed on planes, as well as the use of the measured values in scientific research. The database of measured values is available to the researchers of participating countries by virtual access. The Hungarian participation would be noteworthy both with regard to science and the supplier role of SMEs. If possible, Hungary should join IAGOS; however, since the interest group of Hungarian users is currently being organised, the method of participation and the extent of commitment can only be clarified later.

CARPATCLIM

CARPATCLIM database was established through a non-ESFRI cooperation of 8 countries in the Carpathian Basin (CZ PL SK RO UA SR HR and HU); the Hungarian participant is OMSz. The availability of the current part of the database: http://www.carpatclim-eu.org/pages/home/. It contains daily weather data for all parts of the country (and its surroundings) for 40 years back, which is interpolated into a dense raster (10x10km). The database is crucial for the agriculture in order to prepare itself for climate change, and several universities and research institutes (ELTE, SZIE Gödöllő, NAIK ERTI, NyME, and numerous agricultural corporations (e.g. LajtaHanság Zrt.)), as well as the Agrárklíma project already use it. Unfortunately, the data regarding a narrow strip of the country's territory (west to longitude 17) is not accessible, this shall be purchased. This would make the infrastructure the fundamental source of information for other research groups (in addition to agriculture, for ecology and environmental protection as well, but it would also be important for general infrastructure and regional development, as well as research into socio-economics).

Based on the offer of OMSz, this supplementation would cost HUF 27 million as a one-off fee.

TRANSFAC

The TRANSFAC database contains the binding sites of transcription factors in promoters and enhancers in case of eukaryotic genes. TRANSFAC is one of the largest databases collecting the binding sites of transcription factors and transcription factors that are updated regularly and several times a year. The TRANSFAC database can be considered the most extensive database of a wide range of species with detailed information on numerous transcription factors, promoter regions, binding sites and other related information. Besides the relatively small and less frequently updated free version of the database, there is a much broader version, which is available for a subscription fee, summarising a vast amount of information sources and literary data making TRANSFAC the most comprehensive database of its kind. TRANSFAC operates as a business scheme and the high annual subscription fee may often be a limiting factor.

GENOME TRAX

Genome Trax is for the analysis of full genome or exome sequencing data. With the help of Genome Trax, the entire genome can be mapped and the subset of biologically relevant mutations indicating the sick genes can be identified within 1 hour. The database contains the most comprehensive HGMD Professional collection of mutations causing sickness and their pharmacogenomical versions from PGMD. This database integrates public data sets on somatic mutations, allele frequencies and clinical variants from their most up-to-date versions.

Genome Trax enables biologists, geneticists and pathologists to quickly find relevant mutations without any expertise in bioinformatics, using a simple and easy-to-use online platform.

CCDC CSD

Cambridge Crystallographic Data Centre (CCDC) provides high-quality information, software and services in the fields of chemistry and crystallography. The X-ray structure of single crystals of smaller organic molecules is collected by the Cambridge Structural Database (CSD).

Crystal structures are accessible for a fee, and the unique crystal structures may be studied or even statistically analysed by various softwares (including the program package developed and continuously updated by Cambridge Crystallographic Data Centre (CCDC)). The database often contains the single crystal structure of various polymorphs of a certain material.

EU-OPENSCREEN

Hungary joined the project consisting of 17 member states and several institutes active in the area of chemical biology at the end of a three-year-long preparatory phase in November 2013. With the support of the President of HAS, the HAS Research Centre for Natural Sciences has become the Hungarian coordinator. Starting from 2016, EU-OPENSCREEN will undertake the creation of a central compound directory of 200,000 small molecules considered from the aspect of molecular pharmacology screening. The member states will also establish the screening infrastructure of the large academic directory of molecules, and may submit applications for screening at Screening Centres with suitable capacity during the five-year operation cycle. The Hungarian lead commissioners in biology may benefit from a research assay suitable for a high-throughput screening (HTS), while chemists may gain advantage of it by "submitting" various compounds created by them. Namely, based on the operational model, the biologists and chemists will be able to share the intellectual property obtained from an HTS "match".

Accredited Screening Centres will undertake EU-OPENSCREEN projects according to their expertise, gain full access to the central molecule directory, and their costs related to the project will be completely funded from the central budget. In addition to screening in molecular pharmacology, the project aims to create new molecules that may help us uncover the secrets of the operation of living material. The researchers can request funding on a competitive basis after two years.