Draft Strategy prepared for public debate

SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT STRATEGY OF THE REPUBLIC OF SERBIA 2009 TO 2014

Focus and Partner

Ministry of Science and Technological Development of the Republic of Serbia

June 2009

VISION OF SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT OF SERBIA

Serbia as an innovative country where scientists reach European standards, contribute to the knowledge of the entire society and the technological development of the industry

Contents

Foreword

We shall take advantage of the Foreword to answer a seemingly simple question: Why does Serbia need a strategy in the area of science and technology? Technology is all around us. All of us will agree that the only sustainable position of Serbia in the 21st century is one in which it is involved in areas of industry generating a high value added, in other words - knowledge. We are all proud of our famous scientists. Every scientific event, such as the Science Festival, attracts a lot of attention. On the other hand, the decisions taken by our society reflect a substantially different image. Budgetary allocations for science and technology have not seen a significant increase, remaining at the level of about 0.3% of GDP. There have been no major investments in science infrastructure. The number of young scientists and highly-qualified engineers leaving our country is still significant. The number of students opting for natural sciences and mathematics at universities keeps decreasing. Investments in technology made by the industrial sector are still insignificant. All this is reflected in what Serbia brings out into the global market. Serbian exports today are not much different from the exports of medieval Serbia.

We do not play a significant role in any of the scientific disciplines in Europe or the world. Indisputable individual talents cannot make up for the fact that none of our universities have been listed on the Shanghai Top 500 List. None of our institutes can be qualified as being one of the leading centers of excellence in the European Union. Globalization has led to a multiplication of technological and scientific centers. In addition to the traditional players: Western Europe, the United States of America, Japan, and Canada, the past twenty years have seen the recovery and reappearance of Russia, as well as India, China, Brazil, and even the Middle East. All of them have been making significant investments in science and technology.

The increasing aging of the affluent societies of the West and competition from the East will lead to a very strong migration of scientists in the direction of countries that lack demographic potential. In the next eight years, Germany intends to employ as many as 400 thousand engineers and scientists, with a substantial number of them coming from abroad. China has been investing huge resources in attracting its scientists to return from the United States. The lack of scientific and technological talent is the key reason for the adoption of the so called "Blue Card" by the EU in November 2008, which, alike its US counterpart - the "Green Card" - is supposed to enable Europe to get hold of a part of the global talent. Serbia's most talented researchers will be in high demand. We cannot afford to allow our best human resources to leave the country once again.

It is easy to say that we need to invest in science. However, it is much more difficult, but necessary, to identify the areas where a country of the size of Serbia and with the situation that Serbia is in, can become relevant on the global scale within a reasonable period of time. It is easy to say that we want to have more young people in the area of science, but providing reliable resources for doctoral studies is much more difficult, as well as providing long-term funding, developing centers of excellence and improving living conditions for researchers. This is the only way to proceed so that young scientists can have a sufficient reason base their lives and their future career in Serbia, with a normal and desirable amount of mobility. It is evident that we must do more to establish a link between science and the industry, but that will require tax and budgetary incentives during the economic crisis. Defining a legal framework for co-financing technological development programmes through public-private partnerships based on an equitable distribution of income from intellectual property among stakeholders in

the process of creation of such property is a complex, yet indispensable undertaking. We may easily concur that the government must stimulate local technology through programmes designed at different levels of governance including public enterprises, by giving a chance to local knowledge and expertise. However, it is certainly much more difficult, yet necessary, to define requirements which are going to be used not only as a way of evading public procurements and pushing through solutions that make no contribution to the competitiveness of the whole country.

The starting point for this Strategy was the strategic document prepared by the National Council for Scientific and Technological Development, as well as numerous meetings and round tables with Serbian and foreign scientists, businessmen, statesmen, members of the civil sector and many others. We thank all of them for their valuable input, and take full responsibility for eventual errors and imprecision, that we believe will be corrected during the course of the three-months-long high-quality public debate scheduled to close at the end of September.

In conclusion, it is important to note that this Strategy does not discuss ideals that we could all easily agree on (without proceeding any further) and that instead, it discusses how, within the next several years, Serbia can transform – to its own advantage - the harsh global reality which threatens to block its only way to progress.

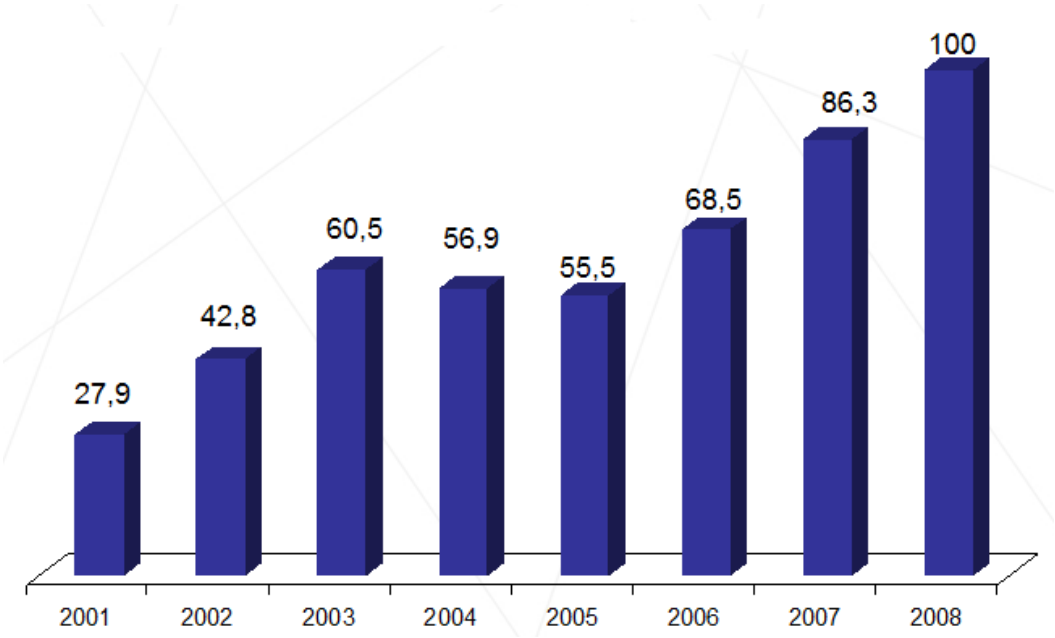
Our vision is Serbia as an innovative country where scientists have attained European standards, contributing to the overall level of knowledge of the society and promoting the technological development of the economy. Two key words are used – “focus” and “partner”. Focus, because just like those who are far more powerful than us, we too, must define a list of our national science priorities where we can make the most progress. Partner, because scientific development is a matter of the entire society and not just of a single ministry, as well as being an issue where Serbian science must find research and business allies, in the country and abroad.

That is why we expect this Strategy to be a subject of debate, and even contention, because it is the result of an uncompromising and unbiased analytical approach that has always relied on facts. Considering that in science everything has to be subject to the test of reality, and that this should also apply to science strategies, this Strategy will also be subject to adjustments and a change of circumstances, but its essential purpose is to serve as the key document for setting the direction of research and education at universities and institutes, defining the stimuli to be provided for students and professors, the method and priorities in financing scientific and technological projects, as well as relations with the economy and international partners.

1. Serbian science, despite improvements over the past few years, is still on an unsustainable path

1.1 Public R&D expenditures have been rising since 2001, however, in percent of GDP, expenditures have stagnated

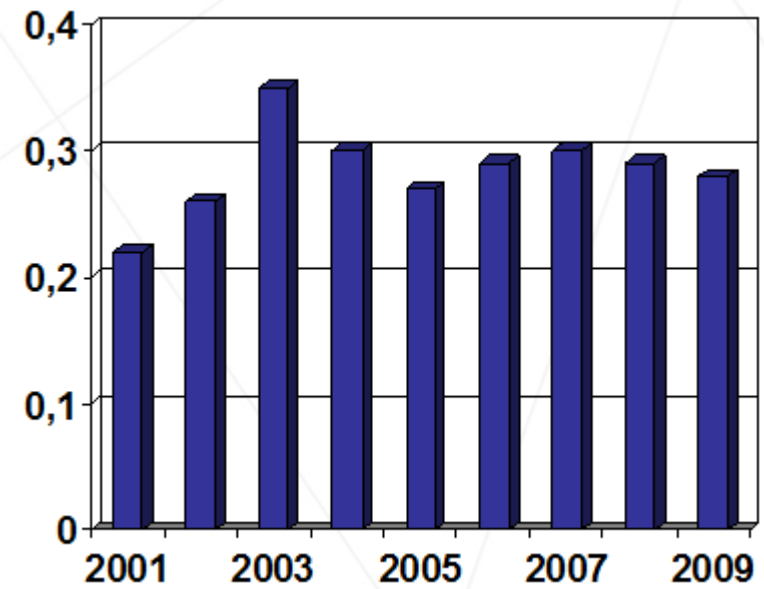
In Lisbon, March 2000, the Council of Europe voiced their appeal for the old continent to increase its allocations for research and development from 1.9 to 3% of the GDP by 2010. Two years later, an action plan was adopted in Barcelona referring to increasing the level of investments in research and development.



Graph 1.1. Budgetary allocations for science (in million euros excluding NIP) (Source: Budget Law of the RS)

In the same period of time, having emerged from the difficult period of the nineties, Serbian budget allocations for science have marked a significant growth in the gross amount, from the modest sum of EUR 28 million in 2001, to about EUR 100 million in 2008 (Graph 1.1.). During that seven-year period, the salaries of researchers grew multifold, and almost 30 million euros were invested in capital equipment for scientific research work. Still, the share of science in GDP in 2003 amounted to 0.3% continuing to stagnate at that level right until now (Graph 1.2.).

In addition to the budget funds of the Ministry of Science and Technological Development (MSTD), there are also other sources of investment in science in Serbia. Other ministries and public administration authorities also provide for modest budgetary allocations for science and technology, including the Autonomous Province of Vojvodina. Institutes generate income through cooperation with the industrial sector and take part in international programmes, the estimates being that the income of the institutes in 2008, apart from the MSTD budget, amounted to about 12.5 billion dinars. At the same time, higher education received 23 billion dinars from budget financing in 2008, having also generated approx. 12 billion dinars of own income, making a total of 1.3% of the GDP.



Graph 1.2. Budgetary investments in science (in GDP %) (Source: Budget Laws of the RS)

Nevertheless, compared to developed countries in the world, we are severely lagging behind. In 2007, allocations for science in the USA amounted to 2.6% of GDP, in Japan 3.3%, in China 1.3%, in Russia 1.1% and the European average was 1.84% (Ref. OECD 2007). The fact giving rise to concern is that in this respect we are significantly lagging behind in relation to the countries in our neighborhood, all of which, except for Albania, have allocations in excess of 0.5% of GDP, while Slovenia, the Czech Republic, and Croatia allocate more than 1% of GDP.

Apart from the low allocations for science, another disquieting fact is the absence of a clear and positive trend in the allocations. In all highly- and medium-developed countries in the world, investments in science have been growing on a steady basis, and the trend has not been interrupted even by the effects of the global economic crisis. Quite the contrary, in certain parts of the world, allocations for science have marked spiraling growth: the USA has announced doubling its budgetary allocation in the next ten years, while China has been increasing its science budget every year by almost 20%.

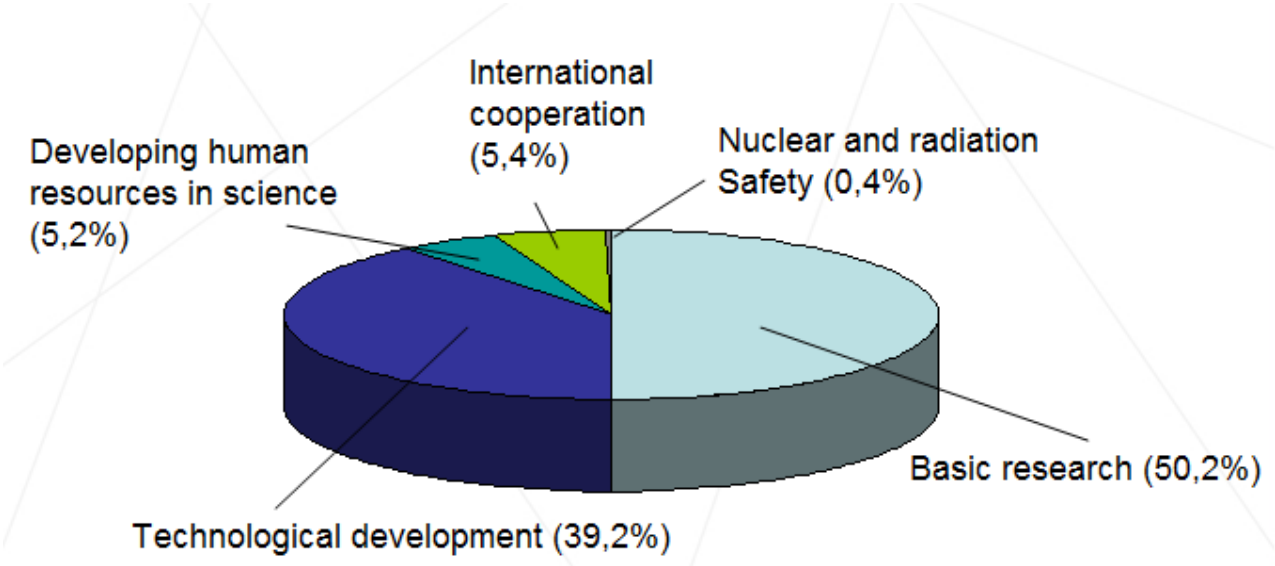
1.2 The structure of financing is dominated by basic research and small projects

One of the key objectives of the Lisbon Agenda is to ensure that of the 3% of the GDP, which is the targeted amount of allocations for science, only one third comes from the budget of the European countries and the EU, while as much as two thirds should be covered by investments in research activities, made by the private sector. Although not all European countries are close to accomplishing this goal, the European average for 2007 shows that in the case of EU-27, only 35.4% of the allocations for science originated directly from the budget, 54% from the economy and 10.6% from other national and international sources. Some countries, such as the USA, Sweden, Germany, Switzerland, and China have already reached the level where investments in science made by their economy account for tow thirds of the overall investments. In Japan, the share of the private sector has reached a record

76.1%. Even the countries in our region have had significant investments in science from the private sector: in the Czech Republic as much as 54% of allocations for science come from the industry, in Estonia 38.5%) in Hungary 39.4%, and in Romania 37.2%. Another consequence of this trend is the fact that scientific research activities do not take place only at universities and state science institutes; the relevant developments have made it possible to employ a large number of scientists in the private sector where some of the most advanced global research activities have been taking place.

One of the consequences of the nineties in Serbia is the fact that the military, once a leading financier in the area of applied scientific research activities in Serbia, no longer has the funds for supporting development projects. Also, the development centers of our formerly major companies have been dissolved over time after the companies lost their markets during that grievous period of time, and the privatization of the companies frequently resulted in either reducing the size and potential of these centers or their dissolution.

One of the major problems Serbian science is faced with is that the small amount of resources invested in scientific research mainly from one source, have been distributed across more than 1,000 projects. In 2009, the MSTD is financing 501 projects in the area of basic research for which the amount allocated equals 50.2% of the total budget (Graph 1.3). Apart from these projects, the Ministry finances also 471 projects in the area of technological development for which the sum allocated amounts to 39.2% of the budget of the Ministry. As opposed to Serbia, this proportion is the opposite in the majority of European countries and most developed countries in the world, while allocations for applied research activities represent the major part of the state budget. Also, practically 80% of the funds intended for science projects are actually salaries for researchers, and a disproportionately small part of those funds goes for the costs of experiments and the like. Although equipment worth EUR 27 million has been procured thanks to NIP funds, following a period of twenty years of no investments in equipment, it often happens that the lack of resources for everyday functioning leads to a situation where that equipment is not used to its full capacity, or is not used at all in some cases.



Graph 1.3 Distribution of the science budget by departments
(in percentage of the total budget in 2009) (Source: MSTD)

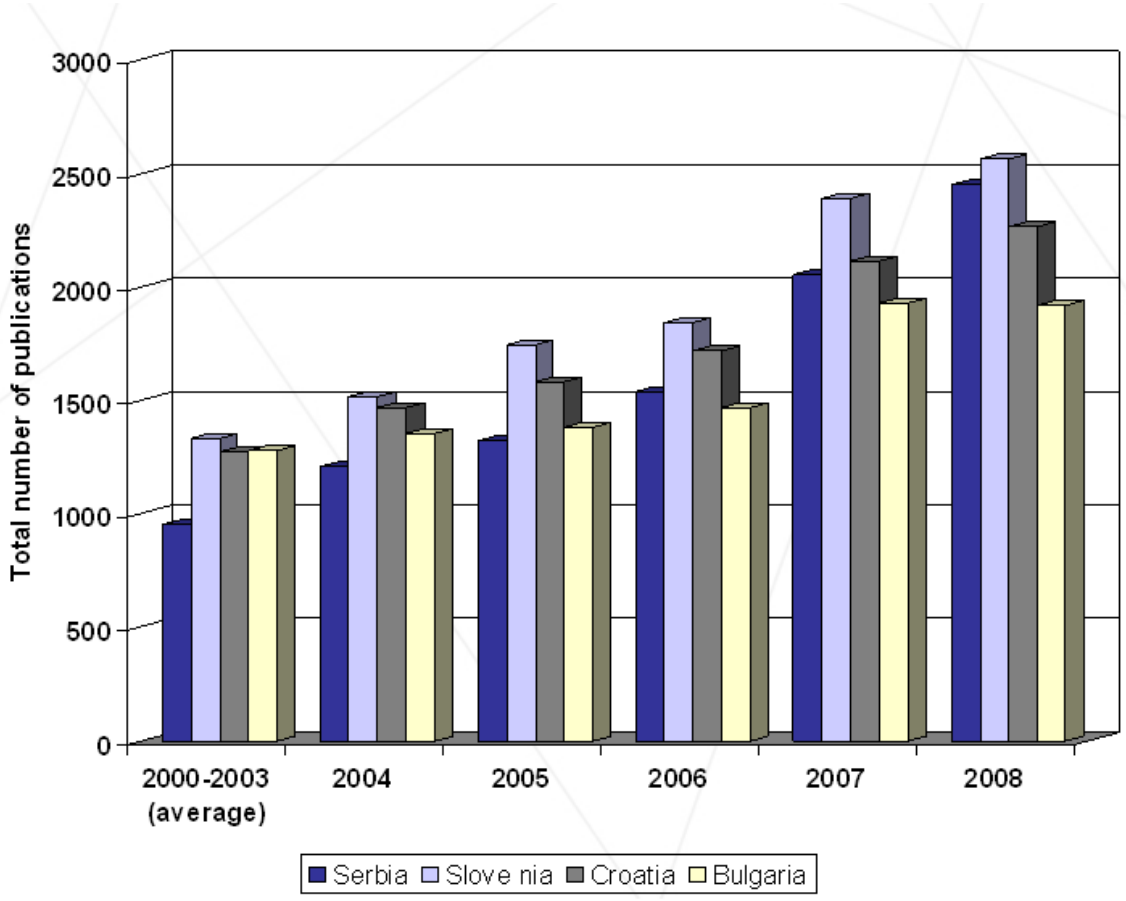
The fragmentation of the already inadequate allocations has led to a lack of large

multidisciplinary research teams that have the potential for finding answers to certain major scientific issues of interest to Serbia and the world.

1.3. Serbian science has reached neighboring countries in the number of publications

The productivity of science can be measured by different indicators, and the impact it produces on the industry and the economy is of great importance, but that is an aspect which is at a rather low level in Serbia without manifesting a remarkable growth tendency.

The state of affairs in science in 2000 was at a very low level and required a radical reform. For instance, in the period from 2000-2003, Serbia published 607 papers per million inhabitants on average, while Sweden published 14.5 times more in that same period, i.e. 8.845 science papers. In order to improve the given situation, the Ministry took steps to implement different incentives which contributed to a significant increase in the number of scientific papers published. One of such measures was awards for 20% of the best scientists in Serbia according to internationally recognized criteria (number of papers and quality measured in terms of the impact factor, citations made). After that, during 2005, criteria were established regarding the evaluation of projects and researchers for the new 2006 – 2010 project cycle, based on which researcher categories where formed in the basic research areas, differing in terms of funding. On that occasion, some 500 researchers lost financing, however, the best researchers were granted larger incomes.



Graph 1.4 Total number of scientific papers in Serbia compared to countries in the region (Source: Web of Science)

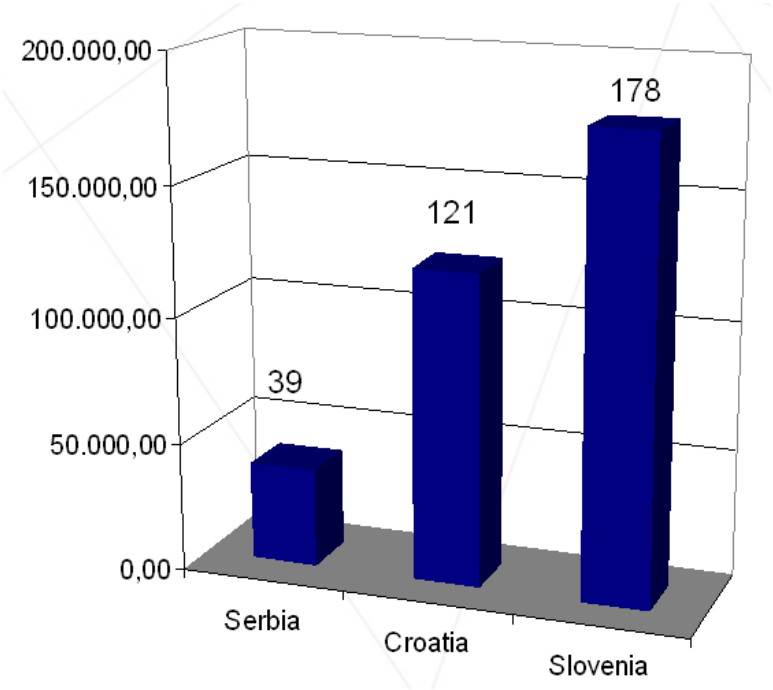
The number of papers published in Serbia in the period from 2000 to 2004 marked a low

increase, however in 2004, and especially in the period from 2005 to 2007, there was a large increase in the number of publications. Thus, the figure of 927 scientific papers published in 2000, grew to 2.047 in 2007, with the upward trend continuing in 2008 when the number of scientific papers published was 2,558 (Graph 1.4).

In contrast to the period from 2000-2003, when we were at the bottom of the list in Europe according to the number papers on the SCI list and according to the number of citations, also lagging behind severely in relation to the countries in the immediate neighborhood, in the recent period - 2006, 2007, and 2008, we managed to surpass certain countries in the region in terms of the number of papers (Bulgaria, Croatia, and we managed to even catch up with Slovenia (Graph 1.4). Of course, in terms of the number of inhabitants we are still significantly behind them. Our lagging behind in the area of social sciences and humanities is very serious, both in relation to the other scientific areas in Serbia and in relation to the neighboring countries (of the 2,047 papers in 2007, only 30 were in the area of social sciences and humanities). In that same period of time the Czech Republic published 454 papers in the above areas.

It is interesting to note that if the number of papers published in Serbia is brought into correlation with the amount of funds invested in research and development, Serbia is among the leading countries in the world. Compared to the countries in the region, the amount of funds invested per one paper published in Serbia is about one third of the amount invested in Croatia, and about 4.5 less than in Slovenia (Graph 1.5). However, that indicator has not been used as a measure of a nation's success.

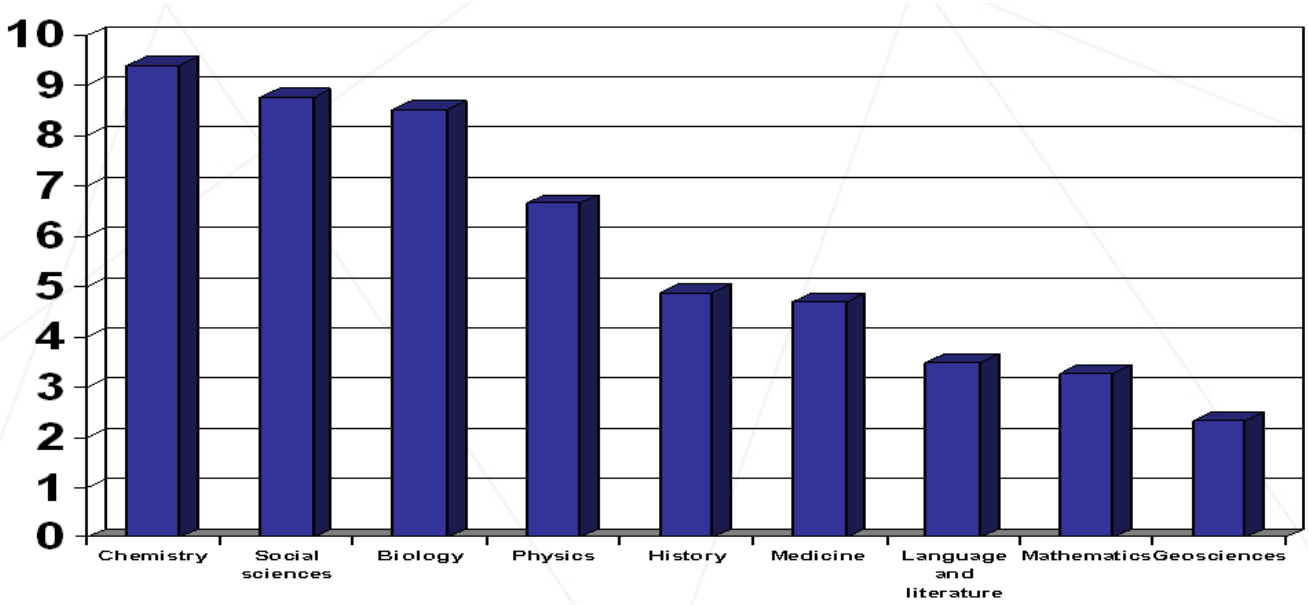
Finally, even though a very serious progress has been made with regard to the number and quality of the papers (the sum of impact factors of all the papers published in 2008 is 2.8 times the figure in 2003), and the number of citations made, there is yet no palpable impact on the economy of the country, and that is something that absolutely has to be improved in the coming period.



Graph 1.5 Funds expended per one paper published (in thousands of euros) (Source: Web of Science)

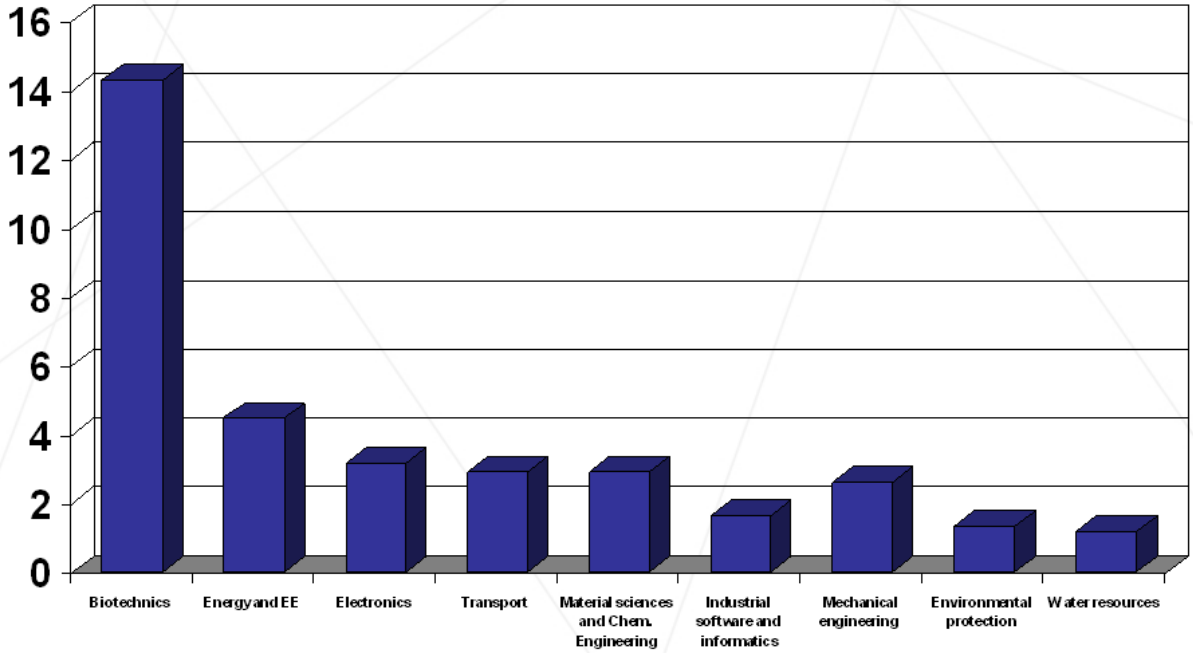
1.4 Serbia does not have critical mass in any field of research

If the budget of roughly EUR 100 million is distributed over all the scientific disciplines, we can see that none of the basic research areas receive an annual budget allocation of more than EUR 10 million. The largest funds are allocated for chemistry (EUR 7.7 million) followed by social sciences (7.1), biology (6.9) and physics (5.4) (Graph 1.6).



Graph 1.6 Financing of basic research in 2008 according to scientific fields (in millions of euros) (Source: MSTD)

In the field of technological development, apart from bioengineering and agroindustry which are allocated EUR 14.2 million annually, none of the other fields are allocated more than EUR 5 million (Graph 1.7). The total science budget of Serbia in 2008 was about EUR 100 million (of this amount, our major Institute Vinca receives an allocation of approx. EUR 12 million) which is not comparable even with certain renowned universities or institutes at the global level, whose annual budgets are above one billion euros as a rule.



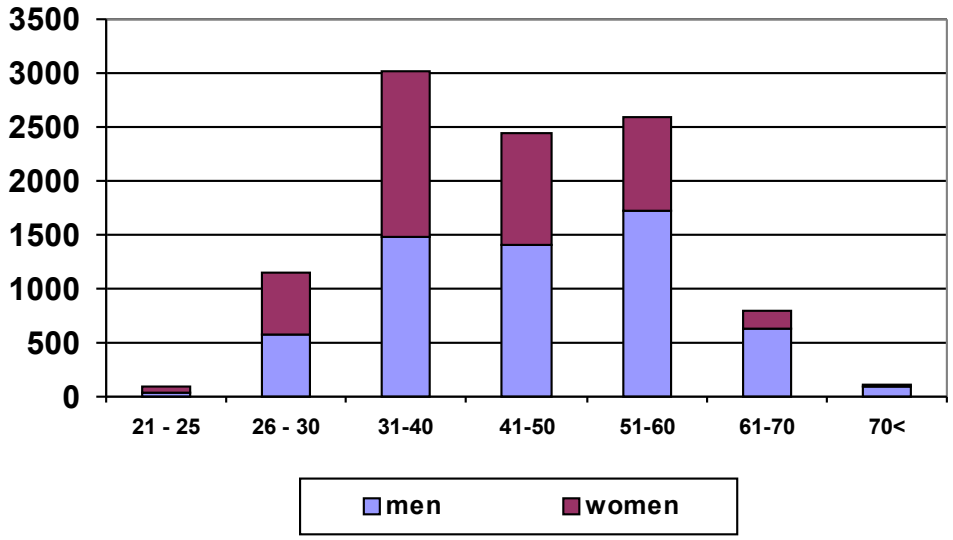
Graph 1.7 Financing of technological development in 2008 according to scientific fields (in million euros) (Source: MSTD)

It must be stressed that Serbia does not have a single scientist listed among the 5,000 most quo e
world. The list includes a university from Slovenia and as many as 5 from New Zealand.

1.5 The age pyramid of our scientific community is worrisome: few young researchers and many soon to retire

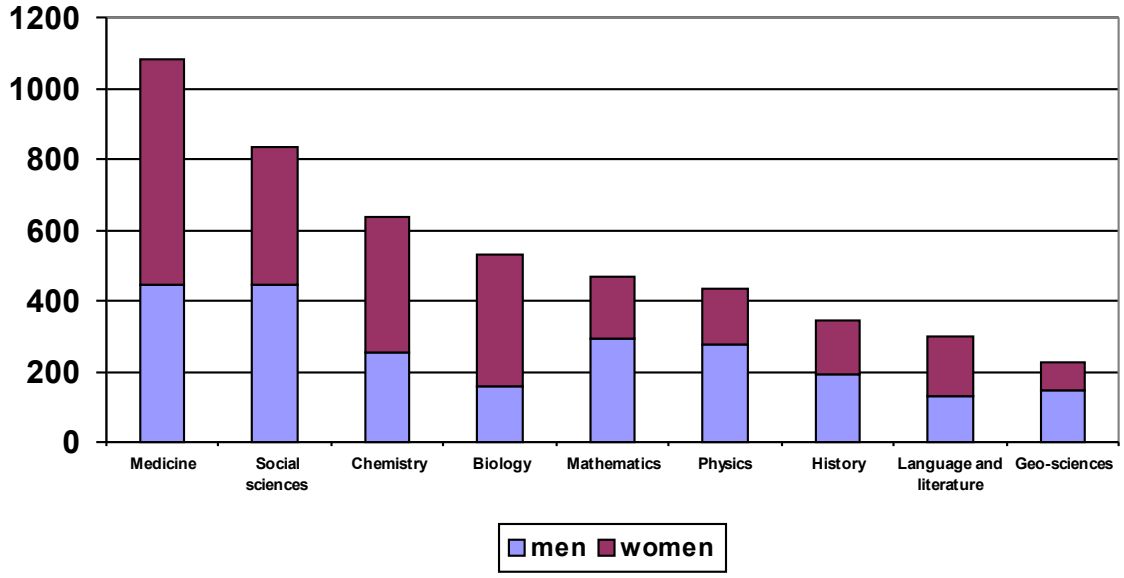
According to the projection of the Republic Statistics Office, the number of population in Serbia will be reducing by about 2% every five years; in other words, in 2022 we are going to have 6.3% inhabitants less than today. The age structure of the population of Serbia is unsatisfactory. The average age of the population is 40.25, classifying Serbia among countries with old population.

The reduction in the number of inhabitants and the current age structure of the population in Serbia and its neighborhood will impact the possibilities for preserving and strengthening the scientific community, in addition to other factors affecting it. According to the data of the Republic Statistics Office, Serbia has 10,220 researchers in total of which 8,800 have been engaged in MSTD projects. The average age of the researchers is 44.3 years, which is above the average age of the population, pointing to the need for taking action to provide for young scientific researcher generations. Of the total number of researchers, 43% are women, a figure contributing to a positive gender structure which is much better than in the majority of European countries. The number of researchers according to age structure, gender and scientific areas is shown on Graphs 1.8, 1.9, and 1.10.

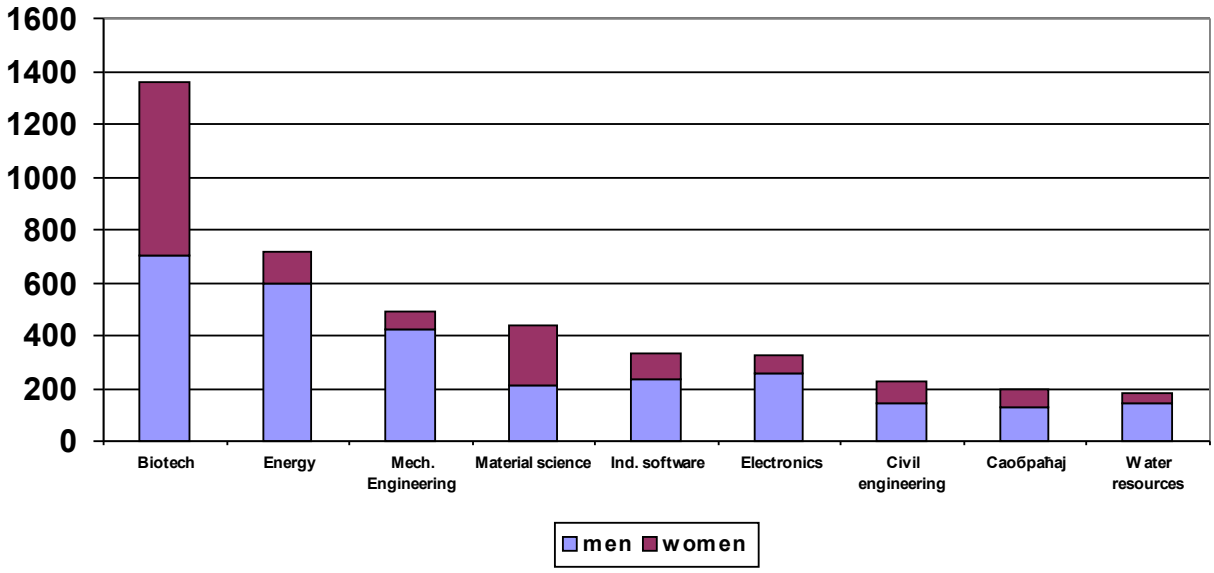


Graph 1.8 Number of researchers by age and gender (Source: MSTD)

In view of the negative demographic trend in Serbia, preservation of the body of young scientists and promoting their development is of particular significance, and this is conditional, upon good higher education policy, among the rest. The present 8% of highly educated population in relation to the total number of inhabitants cannot provide for the development of Serbia in any way whatsoever. An increase in the number of graduated students, as the future scientific potential, can be achieved by increasing the number of students enrolled for studies as well as by a more efficient system of studies. Transition to the educational system based on the Bologna Declaration will enhance the efficiency of studies despite significant difficulties at the outset, and new doctoral study programmes will yield scientific researchers of a much younger age structure.



Graph 1.9 Number of researchers by gender and basic research field (Source: MSTD)



Graph 1.10 Number of researchers according to gender in the field of technological development (Source: MSTD)

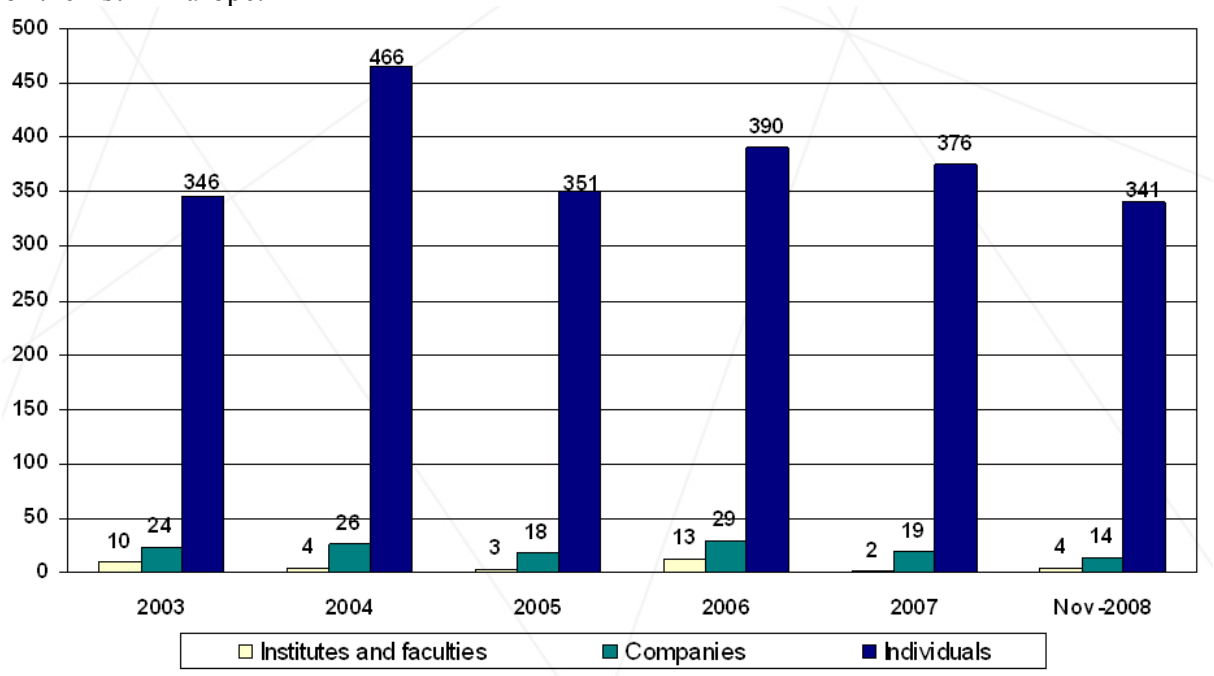
One of the significant problems in preserving and strengthening the scientific community is the ongoing drain of the highly educated population from the country. In the period from 1990 to 2000, about 73.000 inhabitants left Serbia, and among them 17,000 of those with

university degrees (Source: *V. Grečić, 2002)*. The most frequent reason for the emigration of our scientists is, in addition to higher earnings, better conditions for scientific research work. Students leaving in order to complete their master's or doctoral studies elsewhere make up a significant portion of young people departing from Serbia (14% of highly educated emigrants). Departure of the population continued after 2000 as well, and some 50,000 people have left, of whom about 2,000 highly educated individuals *(V. Grečić, 2009)*. As for the structure of the emigrants in relation to the scientific discipline they were involved in, there are no relevant data. Nevertheless, it can be claimed with certainty that the majority of the highly educated individuals who have left the country, are from the area of engineering and technological studies (information technologies) and from the area of natural sciences. It is exactly for these reasons that a change has to be introduced in the higher education policies, including the introduction of stimuli for keeping the best graduates and researchers in the country, along with the adoption of a long-term plan for the return of our scientists from Diaspora.

1.6 In Serbia, intellectual property is either not being created or not being protected

In accordance with the basic definition and purpose of technological development projects, they are to result in the implementation of technical solutions, patents, pilot facilities, new innovation types, technological upgrading and solutions that can be directly applied. The past period (2003-2007) saw the implementation of over 3,400 technical solutions in the field of technical development.

Despite such a high number of technical solutions, the number of patents registered by scientific-research organizations in the period from 2003-2008 was just 21, including 36 patent applications (Graph 1.11). The relevant figures in the corporate sector were not remarkably better, with about 20 patents registered per year, while natural persons registered more than 300 patents in the same period. In view of such results, Serbia is at the very bottom of the list in Europe.



Graph 1.8 Structure of patent applications by domestic applicants (Source: Intellectual Property Office)

2. Investing in science and technology is, for Serbia, the only way to create a sustainable economy and society

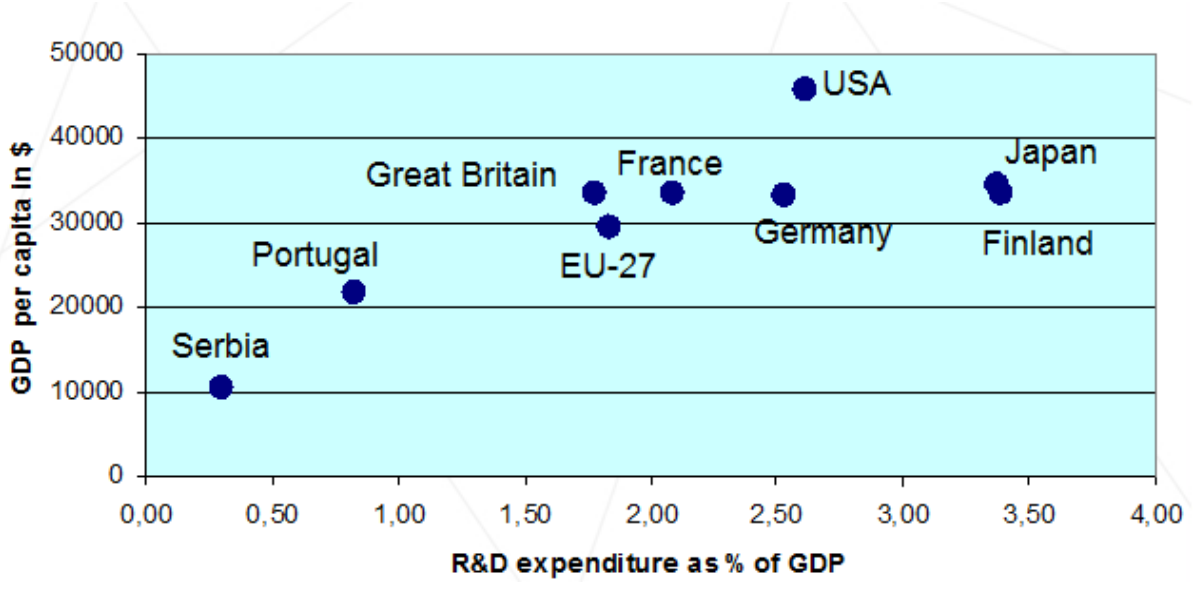
2.1 Investing in science and technology is a precondition for economic development

There are many studies, both theoretical and empirical, proving the key role of scientific-research (SR) and research-development (RD) activities, and innovation activities in general, as the driver of employment and competitiveness, SR and RD results and innovations as the fundaments of development of a country's economy and society. As suggested by numerous studies, the threshold that has to be attained in order to be able to rely on a more rapid system of support for SR and RD activities including innovation activities in a country, is 1% of the GDP.

Only a rather small number of states within EU-15 have failed to achieve the threshold of 1% of the GDP of the state for expenditures earmarked for SR and RD activities, and of the EU-12 countries which became members in 2003, only Romania, Bulgaria and Malta failed to attain 0.5% by 2005. On average, EU states spent 1.84% of their GDPs for SR and RD activities, i.e. EUR 412 per capita. Among the Western Balkan countries, Croatia stands out with its 1.22%, while Serbia with 0.3%, and Macedonia with 0.24% are far from the 1% threshold.

In addition to the expenditures for SR and RD activities, the picture about the magnitude of development resources of a country is complemented by indicators about the human resources engaged in the SR and RD system.

The average number of FTE (Full Time Equivalent, i.e. the equivalent of employees employed on the full working hours basis) researchers per 10,000 inhabitants in EU is 24.8. Serbia has less than a half of that average (11.55) which is somewhat better than Macedonia (7.05), but far worse than Croatia (16.07) and Slovenia (19.19). It is interesting to note that the EU with 1.2 million in 2005 falls behind the USA (almost 1.4 million) in terms of FTE researchers, and that China is very close to EU (1.1 million). The figure of 11.55 per 10.000 inhabitants in Serbia is the equivalent of 8600 FTE researchers, pointing to the need for a significant increase in the number of human resources with higher educational qualifications in the SR and RD sectors in Serbia.



Graph 2.1: Correlation between GDP per capita and investment in science in GDP percentage points (2007) (Source: World Bank)

Graph 2.1 shows the correlation between the expenditures for science and the GDP per capita. An important fact for Serbia, and the only relevant one at that, is that a strong correlation between investments in science and the level of development of the country exists in the countries which have a GDP of less than USD 30,000 per capita, and where investment in science is the main mechanism.

2.2 Investing in science is, for Serbia, the only way to create a sustainable economy and society

Serbian exports are characterized by an unfavorable sector structure. They are dominated by products of a lower processing stage, mainly raw materials and semi-finished products. Intermediary products account for more than 50% of the total export, and if this is coupled with the export of energy and other commodities (mainly agricultural produce) it can be stated that sectoral structure of Serbian exports is very unfavorable.

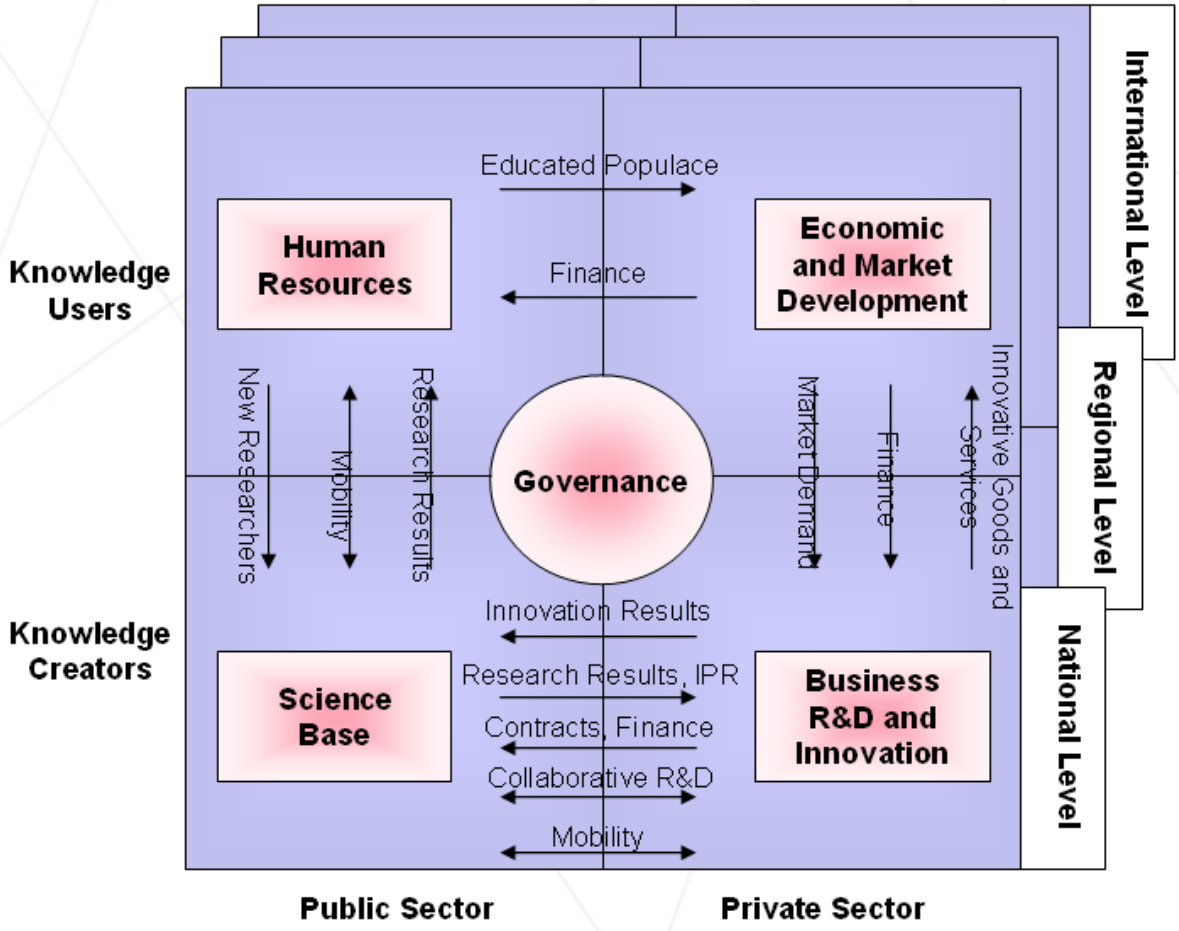
In order to change this situation, Serbia must set a goal for itself; similar to the one EU has set. Support for scientific-research and research-development activities and innovations and innovation activities is considered as the crucial basis of the strategy adopted by the Council of Europe in Lisbon in March 2000, which is aimed at attaining the objective for EU to become a dynamic knowledge-based economy by 2010, the most competitive economy in the world, with sustainable economic growth and an increasing number of employment opportunities and better jobs, as well as greater social cohesion – so called "Lisbon Strategy". Serbia must define its own role in that movement that has been developing on our continent.

2.3 The ultimate objective is to create a national innovation system

In Serbia, science has been regarded and has been functioning much too often as an activity that is an end to itself, an activity functioning exclusively through scientific-research projects financed by the MSTD. Such a principle is untenable since development and prosperity of the whole economy and the whole society of a country has to rest upon knowledge. Science can only yield positive effects if an integrated national innovation system is established. A national innovation system represents a complex network of companies, universities, RD institutes, professional societies, financial institutions, educational and information infrastructure, state agencies and public resources, for the generation, dissemination and application of scientific and technological knowledge in the country. The process of dissemination of innovations and technology has been undergoing essential changes. The main driver is the growing pressure of the market, leading to a more comprehensive integration of technology, as well as of scientific and technological development, into commercial strategies.

Production of goods and services is becoming increasingly science-intensive thanks to the enhanced exploitation of the existing scientific knowledge. It is becoming more technologically-intensive thanks to the diffusion of modern equipment, as well as becoming more intensive in respect of the level of educational qualifications with regard to managing larger knowledge bases required for production activities. Absorption capacity is the ability for absorbing new knowledge and adjusting imported technologies, and it is of key importance for economies in transition, and therefore, also for Serbia.

The development of a national innovation system is an absolute necessity if we are to be able to establish a knowledge-based economy and society. The MSTD is going to work rapidly together with other competent state institutions and relying on the existing resources, in the direction of development, integration, and elaboration of a national innovation system as the only way of generating and marketing new technologies on the long run (Schematic)



Schematic: Example of a national innovation system

3. To become relevant in science and technology and become an innovative country, Serbia needs to FOCUS on a few national priorities

3.1 Domestic capacity is the foundation for international cooperation

Very often Serbian science community and public at large regard financing of basic science and applied science as two incompatible options, having the same approach to the option of relying on own forces or joining international projects and integrations. Fortunately enough, reality is more complex and dictates simultaneous development in all the areas mentioned, along with observing strictly defined priorities. Serbia needs clear guidelines in its basic research activities. Foreign guests from prestigious university departments are often surprised realizing that some of their Serbian colleagues have the possibility of devoting themselves for years, and sometimes even decades, exclusively to theoretical work, without being obliged to apply their results or involve themselves in lecturing activities. Such a relationship is practically impossible in much richer environments. At the same time, Serbia has never so far identified a list of state priorities in the domain of basic research work, or the relevant interdisciplinary approach. On the other hand, integration of advanced technologies with the society is impossible unless there is an adequate scientific and educational base in the area of basic disciplines and research activities.

The current 55-45% ratio of financing the basic as opposed to applied research must progress to 40-60% in favor of applied science, in the next five years. However, this should not be achieved through a reduction of the current funds available for basic research activities, but rather, by an appropriate and gradual allocation of additional public and private funds for applied disciplines, in the coming years.

In addition to this, if Serbian science is to be brought to the level required for international cooperation and competition, it is necessary to invest in the science and university infrastructure. The last serious steps in that domain date back to the seventies of the last century. Although criticized for failures in its implementation, the roughly EUR 30 million investment from the NIP made a huge contribution to settling urgent issues and re-starting the procedure of drafting mid-term projects in the scientific community.

Serbia must identify its own priorities in accordance with its European aspirations and realities of the globalization in the 21st century. Only under such conditions will it have a chance to build a relationship with international scientific and corporate centers. International scientific cooperation can no longer be only self-initiating but it has to maintain and implement a defined strategy and priorities. Proactive attraction of international companies and development of domestic companies in prioritized areas, despite its higher complexity, is perhaps an even more important activity in that same spirit that it should implement.

3.2 The first encouraging steps in the area of international cooperation must be made in conjunction with attracting hi-tech companies

In the period from 2001 to 2009, our researchers accomplished encouraging initial results in the domain of international scientific and technological cooperation. The basic programmes through which this was implemented were the Sixth and the Seventh EU Programmes, as well as COST, EUREKA, NATO SPS, including cooperation with the International Atomic Energy Agency (IAEA), and bilateral cooperation programmes.

The Sixth and the Seventh EU Programmes are actually the main instruments of the European Union for attaining the objectives of the "Lisbon Strategy".

The Sixth Framework Programme

With regard to the Sixth Framework Programme which was in effect in the period from 2002 to 2006 with a budget of EUR 19.1 billion, the Republic of Serbia had the status of a so called third country, implying that participants from Serbia did not have access to all the programmes / calls, and that our researchers could not act as project coordinators. Regardless of that, participation of Serbian institutions (scientific-research organizations, governmental organizations and NGOs, public and private companies, Military Academy) was significant, resulting in 111 participations in 89 projects that were funded, the budget realized equaling EUR 13.1 million. For the sake of comparison, Croatia, which became a participant in the Framework Programmes in 1998 as a the third country, obtaining the status of associated country in 2006 within the framework of the Sixth Framework Programme, has participated in 134 projects under the Sixth Framework Programme (154 participations) realising a budget of EUR 14.2 million. Of the above number of projects, in the past year alone, it participated as an associated country in 70 projects, i.e. it had 82 participations, using a budget of EUR 10.2 million. As opposed to Serbia and Croatia, the Czech Republic, which had the status of associated country as early as the Fifth Framework Programme, became a member country under the Sixth Programme, achieving 1068 participations in 876 projects under the latter programme and realising a budget of EUR 130 million. The examples of both Croatia and the Czech Republic highlight, among the rest, an important aspect which is present in certain countries within the framework of the programme, in the sense of the existence of a positive correlation between the degree of participation and the success in these programmes as well as the funds obtained.

The most intensive activities by Serbian institutions were realized under the regional calls involving the countries of the Western Balkans, namely, 36 projects and/or 47 participations, which resulted in the inflow of EUR 8.3 million, accounting for 63.4% of the total budget realized.

Our most active scientific-research organizations were: Vinca Institute of Nuclear Sciences which participated in 11 projects in total, the Faculty of Agriculture in Belgrade which participated in 7 projects, the Institute of Physics from Belgrade with participation in 6 projects, the Faculty of Natural Sciences and Mathematics from Novi Sad which participated in 5 projects, the Medical Research Institute and Mihajlo Pupin Institute from Belgrade with participation in 4 projects each, etc.

On the occasion of his two visits in 2006, Mr. Janez Potocnik, Science and Research Commissioner of the European Commission, proposed associated country status for the Republic of Serbia under the Seventh Framework Programme, which was implemented in 2007.

Seventh Framework Programme

The Seventh Framework Programme of the European Union spans the period from 2007 to 2013, with a budget of EUR 50.5 billion. Funding and implementation of research activities is carried out via the four basic programmes, namely **Cooperation, Ideas, People** and **Capacities.** Each one of these covers a certain number of priority areas. On the basis of the Memorandum of Understanding signed by the Republic of Serbia regarding its Association to the EU Seventh Framework Programme for Research and Technological Development as well

as experimental activities Serbia obtained the status of Associated Country on June 13, 2007. That status provides an opportunity for Serbian researchers to participate in practically all priority areas, and to engage in project coordination, but also the possibility of influencing research policy through the involvement of Serbian experts in different programme committees of the Seventh Framework Programme.

The first results of the participation in 2007 were encouraging, especially those achieved at the regional level. Thus, Serbian science institutions took part as coordinators in 7 of the 11 projects funded under the regional call for tenders referring to research infrastructural enhancement, TegPot-3, as well as participating in the realization of 3 of the 4 remaining projects.

On the basis of statistical data for the first two years of the programme (by the end of January 2009) 628 researcher groups / partner organizations from Serbia participated in the preparation of 499 draft projects applied for. Of that number, 63 projects involving 79 research groups/organizations from our country were granted funding, making a success rate of 12.6%. The success rate within the framework of the Cooperation programme in certain European priority areas largely varies (Table 3.1).

Area	**Success rate**
Nanosciences, nanotechnologies, materials, and new technologies	43%
Energy and transport	21%
Food, agriculture, biotechnology and fisheries	17%
Information and communication technologies	14%
Health	4%
Environment	3%

Table 3.1 Percentage of success by Serbian researchers in the Seventh Framework Programme (Source: European Commission)

The average success percentage of our researchers at the level of 12.6% is encouraging and close to the success achieved by new EU members, such as Bulgaria and Romania. Still, this percentage is lower than the European average which is 21.8% and it is also lower than the average for the OP7 associated countries that we belong to, where the average is 20.8%.

It must be emphasized that Serbian institutions also carried out two coordinating functions within the framework of the Cooperation Programme, at the level of consortia in the field of ITC (Faculty of Electrical Engineering, Belgrade) and nanosciences, nanotechnology of materials and new technologies (The Institute of Physics, Belgrade). The funds stipulated on the basis of the total number of successful applications in the first two years of implementation of the Seventh Framework Programme amount to EUR 15.19 million.

Initial results are visible also in other international programmes, such as:

COST – intergovernmental framework for European cooperation enabling European level coordination for research funded at the national level and involving the institutions of no less than five countries. The SFR of Yugoslavia was one of the founders of COST in 1971, and Serbia (FR of Yugoslavia) became a full member in June 2001. Currently, Serbian research teams participate in 83 COST actions, being the coordinator in one action (the area of materials, physics and nanoscience).

EUREKA – an EU programme designed for stimulating and materializing cooperation between companies and scientific institutions. The purpose of this programme is to increase the productivity and competitiveness of European industries and economies in the global market by developing market-oriented advanced technologies, products or services. Serbia has been a full member of EUREKA since 2002. Serbian researchers and businessmen currently participate in the implementation of 36 EUREKA projects the total budget of which is EUR 15.3 million.

NATO Science for Peace and Security
Established in 2006 with the purpose of contributing to security, stability and solidarity among nations, by applying state of the art technical expertise, as well as with the purpose of enhancing cooperation in all the partnerships based on innovations and civil science. On July 27, 2007 the Republic of Serbia signed a Presentation Document concerning the participation of the RS in the Partnership for Peace Programme committing itself to cooperation frameworks with NATO in the field of science and technology. Serbian researchers joined the programme late in 2007 and the results achieved so far have been reflected in the implementation of eight projects.

Cooperation programme with the International Atomic Energy Agency (IAEA) -
Cooperation between the Republic of Serbia and the IAEA over the past several developed primarily through technical assistance programmes involving equipment, expert knowledge and training courses, as well as through regional and interregional activities. Technical cooperation mainly referred to programmes for decommissioning a research nuclear reactor and radioactive waste management, however it also involved nuclear and radiation security, radiation medicine and health, and nuclear and radio-chemical application of isotopes in hydrology, agriculture and industry.

Bilateral cooperation programmes – Currently, two programmes are being implemented in collaboration with Slovenia, Croatia, France (two programs: Pavle Savic and cooperation with CNRS), Slovakia, Germany (DAAD Programme), Switzerland 9SCOPES Programme). In the near future cooperation will be launched with Hungary, Greece (new cycle), China and India, while framework agreement has been achieved with several other countries and the relevant procedure is underway (Austria, the Czech Republic, Portugal, spain, Russia, USA).

In addition to the cooperation programmes, Serbia has significantly participated in European and international scientific organisations such as CERN (European Nuclear Research Centre) where our physicists and engineers made a notable contribution despite the fact that Serbia is not a member of that organisation. For that reason, Serbia filed an official application for membership in CERN, in March 2009. In November 2008, Serbia joined the membership of the Partnership for Advanced Computing in Europe. Serbia's membership in leading international organisations of this kind is one of the key factors in the development of its international cooperation.

The MSTD is the focal point for the above programmes and in view of that, it is responsible for the adoption and implementation of measures for a broader inclusion and higher competitiveness of our research groups, including innovative companies and corporations. Some of the measures include timely conveyance of information to research and other partnership organizations regarding open calls for tenders, organization of info days and workshops, assistance in preparing draft projects and their subsequent administration, approval for subsidies for successful teams etc, the measures having been implemented through the endeavors of the associates in the Sector for International Cooperation and European Integrations MSTD, national contact persons network for the Seventh Framework Programme (formed towards the end of 2006) and the Consultative Bureau for International

Projects (formed in March 2008).

Regardless of the aforementioned encouraging results achieved in the period since 2001, what has been noted in respect of the Seventh Framework Programme is a very modest participation of our scientific-research, innovative and corporate organizations. There are numerous reasons for that, starting from insufficient motivation of the researchers/innovators/ businessmen as a consequence of the complex procedure for producing project drafts and the comparatively low rate of their acceptance, as well as the more simple procedure in applying for national programmes/calls for tenders and the high rate of acceptance, inadequate networking with the international community. The estimate is that less than 20% of our researchers have been involved in European projects.

Finally, save for several exceptions, Serbia has not yet managed to attract significant international technological companies who would be ready to realize a part of their development programmes in our country by investing in the existing research capacities or by forming new ones. The Seventh Framework Programme can be a catalyst for this cooperation, facilitating it by joint participation in project consortia, however government measures are of extreme importance in this regard, in the form of tax and budget subsidies focused on attracting technological companies.

There are positive examples of cooperation that has been realized, but they are very scarce. Microsoft, global leader among high-tech companies, and at the same time a leader in investing in research and development (in 2007 – EUR 5.58 billion) opened one of its five development centers - Microsoft Development Center Serbia (MDCS) – outside the USA, in 2005 - in Serbia. Also, Siemens acquired a team of local engineers and over time extended its development capacities in Serbia. Several local institutions and companies have successful cooperation with international leaders (The Faculty of Electrical Engineering in Belgrade, „Mihajlo Pupin" Institute, Institute for Crop and Vegetable Growing and others). However, this is still a very small volume of operation.

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3.3 Even the most developed countries have defined a limited set of national priorities

Strategy means implementing interrelated measures for accomplishing a defined objective based on decisions on allocating limited human and financial resources. It is indisputable that larger investments should be made in science. The crucial issue is when, with what objective and based on what measure of success. Leading nations in the world invest dozens of billions of euros a year in science and technology, either through national budgets or companies. The required investments for the most advanced experiments have induced leaders to cooperate through the "CERN" or "ITER" projects. Europe is clearly heading for the rationalization of its science infrastructure.

The major science nations in the world have identified their priority shortlists because of the necessary investments and in order to provide for critical mass and relevance (Table 3.2).

Table 3.2 Examples of national science priorities.

Great Britain	Energy, e-sciences, Genomics/Proteomics, Stem Cells, Neurosciences, Rural Economy and Land Exploitation
France	"Life Sciences", Biotechnology and Health, Energy, Security, Socio-Economic Sciences and Humanities, Environment, Earth and Space Studies
USA	Advance Defence Systems, Health Protection, Agriculture, Energy, Space Exploration and Exploitation, Basic Research
Japan	Primary fields: "Life Sciences", Information and Communication Technologies, Environment, Nanotechnologies and Materials, Secondary fields: Energy, Production Technologies, Social Infrastructure, Multidisciplinary Research
China	Energy, Water and Mineral Resources, Environment, Agriculture, Production Technologies, Transport, Information Technologies, Population Health, Town Planning, Public Security
European Union	Health, Food, Agriculture, Fisheries, and Biotechnology, Information and Communication Technologies, Nanosciences, Nanotechnologies, Materials and New Production Technologies, Energy, Environment (including Climatic Changes), Transport (including Aeronautics), Socio-Economic Sciences and Humanities, Space, Security

Serbia, with hardly one hundred million euros a year in the form of state investments in science, and with practically none from the corporate sector, has many more reasons to focus

on its own endeavors. Our annual budget is approximately ten times less than the budget of any of the fairly renowned universities or institutes in the world. We must get focused.

How to identify Serbian priorities in science and technology?

This is the key issue of the whole Strategy. We have to start from reality, from what we have. The relative success achieved so far and the existence of qualified staff is a good recommendation for further investments. However, we must crossbreed our reality with European and global trends in order to be able to prepare the nation for future challenges and potentials rather then for the present or past ones. Ultimately, we have to also include national challenges and needs at this moment of history, because science, just like the rest of the society, has to make its contribution to state politics.

All in all, the following criteria have been applied:

- Being in line with other national strategies
- Possibility of successful participation in the Lisbon agenda and alignment with EU research priorities
- Number and quality of current human resources, in country and abroad
- Investments so far over the past seven years
- Success of researchers up to now
- Amount of future investments needed to have critical mass and be relevant
- Applicability in industry, in Serbia and abroad
- Current international collaboration and potential for improvement
- Multidisciplinarity
- Importance for national agenda and affirmation of national identity

Nine basic sciences have been analyzed including thirty five sub-areas, as well as nine technological research domains with forty six sub-areas (elements posted on the site: www.nauka.gov.rs). Following the preparations and analyses made within the framework of the top officers of the Ministry, a debate was organized with leading researchers, businessmen and state institutions in the relevant domains. Consultations have been organized also with the National Council for Science and Technological Development and the Serbian Academy of Sciences and Arts. We are expecting the debate on the Strategy to provide an even more in-depth analyses and motivated decisions. However, the list cannot be longer than several priorities if we are to implement the Strategy, rather than, as has been the case so far, diluting everything ‘for the sake of peace at home’ leaving Serbia without a critical mass in any of the themes. Such evasion of assuming responsibility would be disastrous at this moment.

3.4 Focus by defining seven national priorities in the field of science and technology

The analyses of scientific fields in Serbia has resulted in the identification of seven national priorities in the domain of science and technology:

- Biomedicine and human health
- New materials and nanosciences
- Environment protection and countering climate change
- Agriculture and food
- Energy and energy efficiency
- Information and communication technologies
- Improvement of decision making processes and affirmation of national identity

3.4.1. Biomedicine and human health

Significance of research in the field of biomedicine

The fascinating progress of molecular biology and molecular genetics achieved in the second half of the 20th century was the basis for spectacular and significant scientific breakthroughs not only in the field of genomics and proteomics, but also in the area of science in general, and particularly in the field of biomedicine. Considering that the pathogenesis of different diseases essentially stems from disorders in the regulation and expression of genes and transduction of signals in cells, research in molecular biomedicine today represents one of the most propulsive fields of global science. We are living in the era where civilization is affected by an increasing number of multifactor diseases, with very complex pathogenesis.

The preservation and improvement of human health is the key priority of each nation. Molecular biomedicine is introducing new approaches in modern medicine of the 21st century, with the purpose of improving the quality and efficiency of preventive medicine, diagnostics and therapy, and thereby also of clinical medicine. Bearing in mind the incidence of cardio-vascular and malignant diseases, as well as the increasing number of individuals suffering from diabetes, it is necessary to define integrated biomedical research activities, in correlation with the adopted National Program for struggling against the above diseases.

Research directions in modern biomedicine are very versatile and achievements in this field have been applied in different fields of science and everyday life. Nevertheless, research activities attracting the greatest attention at this moment and those being of the greatest interest to the public and in terms of attracting capital investment, are (primarily human) genome and protein research activities for their implementation in medicine for the purpose of developing new drugs and therapies. That type of research includes studying of complete genomes, studying of proteins and identifying protein targets for drugs, and finally, practical application of the results thus obtained, achieved by designing new medicinal substances and drugs.

Biotechnological research activities resulting in the synthesis of new biologically active compounds applicable in treating different diseases (malign diseases, diseases caused by viruses, disorders caused by neurotoxins) represent an area of applied and development-oriented biomedical research at the moment. Development of new biologically active compounds leads to the generation of new drugs, bioactive molecule transporters, as well as to obtaining new organic molecules with advanced biological characteristics (directly active compounds, "lead-compounds").

On the basis of information provided by way of structural and functional genome research, as well as proteomic research, the next ten-year period is expected to be marked by significant progress in the area of medicine, pharmaceutics and the food industry. Obtaining concrete information from the genetic code reading and identification of the molecular basis of the pathogenetic mechanisms (particularly where inherited diseases are concerned) must be the theoretical and experimental basis for the individualization of therapy protocols, as well as for designing new, narrowly specific medicinal substances and drugs which would be in accordance with the genetic code of the individual, as a result of which they would be incomparably much more efficient than the existing drugs.

Systemic genome and extra genome research will enable a better insight into the gene expression regulation mechanisms, more detailed knowledge of the structures and functional characteristics of regulatory and structural proteins, their dynamics and molecular interaction in the living cell in both homeostasis and disrupted homeostasis conditions as a result of the effects of neuro-endocrine oxidative, physical, chemical, psycho-social and other stress factors.

The role and significance of biomedical research is reflected in the following domains:

- Development and application of prediction methods and preventive approaches in the field of preventive medicine
- Introducing individual medical approaches in the clinical practice
- Development and application of efficient diagnostic approaches, especially in latent disease stages
- Significance for the patient – efficient diagnostic and therapeutic approach
- Significance for doctors – targeted genotypisation of certain patients, facilitated choice of drugs, particularly for patients needing prolonged therapy (anti-hypertension drugs, neuroleptics, psychopharmaceuticals…)
- Significance for the society is reflected in the reduced consumption of inadequately selected drugs

Current research potential

The major participants in the realization of biomedical projects are the following institutions: Institute of Medical Research, Institute of Molecular Genetics and Genetic Engineering, TORLAK-Institute of Immunology and Virology, Institute of Biological Research «Siniša Stanković» (IBISS), Institute for the Application of Nuclear Energy (INEP), Institute of Nuclear Sciences "Vinča", National Cancer Research Center, IORS, Joint Center of Biochemical and Biomedical Engineering, University of Belgrade (JCBBE), Faculties of Medicine (Universities of Belgrade, Niš, Novi Sad, Kragujevac), Faculty of Pharmaceutics (University of Belgrade), Faculty of Biology (Universities of Belgrade, Niš, Novi Sad, Kragujevac), Veterinary Faculty (University of Belgrade), Military Medical Academy.

The individual segments of these programs are implemented at the Faculty of Chemistry and the Faculty of Technology and Metallurgy of the University in Belgrade, as well as within the framework of several research development centers.

There are 106 ongoing projects in medical sciences, involving 905 researchers, as well as 61 projects in the area of biological sciences, involving 619 researchers. At the international level, which is rather modest for the time being, the following projects have been implemented: FP7: according to 2009 statistical data, of the 63 projects funded by the EC, 3 are in the area of (bio)medicine, i.e. 4.7% of the total number.

COST: of the 68 currently implemented actions involving Serbian researchers, 12 belong to the field of biomedicine i.e. 17.6%.

Priorities in biomedical research

The suggested priority themes in biology and medicine, and/or biomedicine (does not have strict limits) are as follows:

- Molecular bases of genome and extra genome mechanisms induced by endogenic and/or exogenic factors in physiological and pathological processes
- Environment and adaptive mechanisms
- Molecular bases of hormone signal transduction
- Biochemical and cytogenetic radiation effects
- Molecular bases of monogenic, polygenic and multifactor diseases
- Preclinical and clinical research making an original and innovative contribution to predictive, preventive, diagnostic and therapeutic approaches
- Pharmacogenomics, regulatory mechanisms and pharmacological modulations
- Nutrigenomics, nutrigenetics, and preventive medicine
- Biomedical engineering

In addition to the insufficiently funded biomedical programs, which are expensive as a result of the nature of the research considering that they are multi and interdisciplinary, meaning a complex staff structure, expensive equipment and consumables, one of the major drawbacks in this area is the dispersion of the research staff. A network of biomedical institutions must be established with networking achieved through the establishment of an Excellence Center, and this will actually be the basis for defining the national program for biomedicine. The national biomedical programme which is to have clearly defined priorities will provide for a better rating of the country also in the international scientific and business markets.

The end users of research results and accomplishments are health institutions, the pharmaceutical industry and the food industry. Preclinical and clinical testing of drugs, medicinal substances, food additives, products in the domain of functional food and other categories of biologically active substances will be carried out for domestic and international companies.

3.4.2. New materials and nanosciences

Significance of research in the field of new materials and nanoscience

Periods of abrupt industrial development in the past commenced usually with the discovery of new materials, firstly iron and steel, and then polymers, light alloys, composites, semiconductors, ceramics and finally nanomaterials. Nanomaterials, biomaterials, eco-materials, materials for information technologies as well as alternative energy sources have been recognized as drivers of further industrial development by the European Union, USA, Japan, China, India and all major world economies. For instance, the FP7 EU Framework Program defines *nanosciences, nanotechnologies, materials and new production technologies (NMP)* as one of the priority themes through which research is funded within the framework of the EU. Research in the field of materials and nanotechnologies in Serbia has proved to be compatible to that in Europe, as a result of which the major part of the scientific community in Serbia is oriented towards cooperating with the European Union, a fact indisputably supported by statistical data about the participation of our research-development organizations in European projects. Serbia took part in 83 projects under the FP6 Framework Program, while in the FP7 Framework Program Serbia has already been involved with 43 projects. Serbia currently participates in 3 projects having NMP as a priority.

The basic objectives of the research in the field of modern materials refer to understanding the correlation between synthesis, processing and characteristics of materials, as well as the description of materials, the composition and characteristics at the atomic, molecular, microscopic and macroscopic levels. Material science has a multidisciplinary aspect and requires research in the fields of physics, chemistry, mathematics, engineering, and the most significant challenges are at the borders of these basic areas.

Basic directions of development of modern materials are:

- Innovative application of the existing materials which is to be based on good understanding of the structure and characteristics of the materials and exploitation requirements
- Synthesis of new functional materials and materials with new and superior characteristics
- Advancing the fundamental understanding of the characteristics materials and of the consolidation phenomena through theoretical research
- Application of nanosciences and nanotechnologies with a view to improving the characteristics, obtaining completely new functional characteristics, as well as for the purpose of miniaturization
- Development of clean technologies which highly contribute to environmental protection, reduction in the toxicity of materials and risks to the environment

Current research potential

Considering the comprehensiveness and multidisciplinary character of the research in the field of new materials and nanotechnologies, they are carried out in a large number of scientific research organizations: Vinca Institute of Nuclear Sciences, Institute of Physics, Institute of Chemistry, Technology and Metallurgy, Multidisciplinary Research Institute, Technical Sciences Institute of the Serbian Academy of Sciences and Arts, the Faculty of Electrical Engineering, the Faculty of Physical Chemistry, the Faculty of Mining and Geology, the Faculty of Chemistry, the Faculty of Physics, the Faculty of Technology and Metallurgy, the University in Novi Sad: the Faculty of Technology, the Faculty of Technical Sciences, the Faculty of Natural Sciences and Mathematics, the University in Nis and the University in Kragujevac. Over the past several years, the Republic of Serbia invested about EUR 30 million in the development of infrastructure and procurement of capital equipment

for scientific research centers in Serbia. A large part of the funds have been invested exactly in science research organizations dealing with materials and nanotechnologies. This has created a basis consisting of the most urgently needed equipment for further progress and research in the field of materials and nanoscience. Still, Serbia does not have sophisticated equipment such as, for instance, HRTEM, FESEM, XPS, etc., high resolution equipment required for research in the field of materials, and particularly in the field of nanotechnology. Also, at present, Serbia is faced with the problem of a lack of equipment for the synthesis of materials by means of modern methods.

Future activities will be directed towards forming the integrated Center for Material Research and Nanosciences, a central laboratory equipped with state of the art synthesis and characterization equipment the supply of which is planned for all science research organizations in the Republic of Serbia. Apart from the state-of-the-art characterization equipment, significant funds will be invested in material synthesis equipment as the basic precondition for the development of new technologies and their implementation in the domestic economy.

The scientific research staff in Serbia is well educated and represents one of its essential development factors. Serbia has 589 researchers engaged in 48 projects under the Technological Development and Basic Research programs in this domain.

Research priorities in the field of new materials and nanosciences

The following classes of materials are of special interest and carry the greatest potential:

- Ceramic materials, in the form of bulk, thin films and coatings are materials produced from non-metallic inorganic compounds, and they have been widely used in the process industry, energy industry, as cutting tools, ballistic ceramics, in the aircraft industry, etc.
- Metal materials and intermetallic compounds with a broad industrial application in practically all the branches
- Composites, two- or multi-metal hybrids, very often comprising reinforced ceramics, metal or material with organic matrix, combining the best characteristics of their constituents, with implementation in the military industry, aircraft industry, etc. Nanocomposites used as electrocatalysts and their carriers, supercapacitors etc. are of particular importance.
- Biomaterials and biomolecular materials representing different types of materials compatible with human tissue and/or biological phenomena as well as materials of biological origin. Applied in pharmacy, medicine, dentistry and having particular significance in medical diagnostics, regenerative medicine and targeted therapy and malign diseases.
- Carbon nanostructures and nanocapsules, by introducing photosensitive sub-units nanoclusters are obtained with significantly altered photophysical characteristics, which enables their testing in nanobionics as well as in the field of photodynamic therapy of different diseases (malign diseases, viral diseases, neurotoxins)
- Materials for new and renewable energy sources such as materials for fuel cells, photovoltaics, nanocatalysts with application in transport devices, stationary energy units, batteries etc.
- Electronic materials, so called active functional materials, such as ionic conductors, sensors, semiconductors based on ceramics, polymers and metals, with application in electronic industry, information technologies, automotive industry, industry of household appliances, energy and all the branches of electronics and production management
- Magnetic materials based on metals, ceramics or organic materials. Application in automotive industry, audiovisual technology and information technologies, consumer

electrical appliances, medicine, etc.

- Polymers, large molecules with other sequences are modern materials with programmed and accurately designed characteristics (liquid crystals and molecular machines, bio-nano particles, etc.). Textile fibers with particularly designed characteristics and with particularly treated surfaces, bactericidal deposits on textile, hydrophobic and hyper-hydrophobic materials.
- Optical and photonic materials transmitting light or acting as light sources produced from glass in different shapes (optical fibers) or complex functional materials having a significant role in modern communication systems
- Eco materials are materials using renewable raw materials for their synthesis and/or materials whose environmental impact is of prime significance. Characteristic examples are geopolymers with application in the building industry, transport, mining, agriculture, etc.

The objective of strategic options for the development of materials and nanoscience in Serbia is to advance and enhance the existing resources and infrastructure with the purpose of incorporating them with European and global research activities, which will ultimately be valorized in new products and technologies for the benefit of the whole society. Apart from this, development policy in the field of modern materials, and particularly nanosciences and nanotechnologies has the task of stimulating industrial companies and SMEs, in the effort to create a stronger interaction between research and the industry.

Implementation of scientific knowledge in the economy implies the use of high technologies which are capable of providing high-quality materials from the aspect of their functionality and structural characteristics. Industrial production will largely shift from classical, conventional procedures to sophisticated methods that ensure the obtaining competitive materials, suitable for providing response to the needs of modern development. It is necessary to encourage business entities to develop closer cooperation with scientific-research organizations through different facilities, along with making them aware of the advantages of that cooperation, such as participation in international projects, the possibility of extending production and promoting quality, mastering of new technologies and raising the level of competitiveness in the world market. Small and medium-sized companies can benefit most of all from that science, and hence, activities will be directed in the future towards small and medium-sized companies and their needs, but also towards the formation of new companies.

3.4.3 Environment protection and countering climate change

Relevance of research in the area of environment protection and climate changes

Ecological safety, sustainable development and environmental issues in the process of EU integration constitute a part of regional initiatives and factor of internal stability and economic development. In recent decades it became evident that our global environment is seriously threatened by the consequences of human activities leading to comprehensive pollution of water and air, depletion of natural resources, as well as forest and fish stocks, extinction of plant and animal species and their habitats and to a growing threat of global warming.

Despite numerous laws recently enacted about the environment, Serbia is facing vast ecological problems, because of non observance of the laws and lack of long term strategies in all the domains of natural resources protection. Waste management in Serbia, for instance, has not yet been implemented in any adequate manner despite the fact that the National waste management strategy was approved in 2003. Big pollution of natural resources, water primarily, as well as soil and air, in Serbia and the fact that the climate changes are much faster than anticipated show the need for prioritizing environmental sciences in the strategy of scientific and technological development. The application of research results on the improvement of the environmental status is of exceptional importance for the future development of the country.

Status of research potential

MSTD is currently financing 144 science research projects in the field of environmental protection. The total financial support for the projects connected with the protection of environment and climate change in all the domains of science in 2008 amounted to 9.7 million Euros, which accounts for 9.7% (2.3% in the basic research and 7.4% in the program of technological development) of the whole budgetary allocations for science and technological development.

Most of the projects involve research in the application of new materials for the protection of environment and development of new technologies for warehousing and recycling of waste, followed by fundamental research projects, projects of research in the field of environmentally friendly energy efficiency, while the least is concerned with the analysis of economic aspects of environmental protection with the impact on the behavioral system. In the past, insufficient cooperation between research institutions and direct users of research results, such as small and medium enterprises and industry, was evident.

Of 25 existing bilateral projects with Greece, Hungary, Croatia, Slovenia and France, 14 projects relate to the research in the field of environmental protection. In addition to the projects financed by MSTD, in 42 projects of the framework programs FP 5, 6, and 7 the share of science research institutions from Serbia was 1.37 million Euros, which is a modest result.

In the sector of environmental protection some 12,000 people are employed in almost 400 enterprises which in 2007 received some 120 million Euros of direct foreign investments. A great number of science research institutions are in a way included in research in the domain of environmental protection. That research mostly involved: the Faculty of Forestry, Faculty of Agriculture, Faculty of Biology, Technology - metallurgy faculty and Faculty of civil engineering of the University in Belgrade, Faculty of natural sciences and mathematics, Mechanical engineering faculty and the Faculty of agriculture of the University in Novi Sad, Faculty of agriculture in Cacak, Faculty of natural sciences and mathematics, Technological

faculty and Faculty of ergonomics of the University in Nis, and numerous institutes: Institute of soil, Forestry institute, Water management institute "Jaroslav Cerni", Institute for plant protection and protection of the environment, Institute of valley forestry and the environment etc., and other institutions: the Republic administration of hydrometeorology, Nature protection administration, Public Health Institute Belgrade, and others.

An important goal in the in the area of environmental protection and climate changes and in other priority areas of science in Serbia is to establish stronger cooperation between science research organizations and users of the research results. Environment spans almost all the segments of our society and that is why it is necessary to unite all, both researchers (multidisciplinary approach to research), and the competent ministries, companies, local administration and others.

Priority of research of environmental protection and climate change may be classified into the following main groups:

- Development of technology for the protection of environment
- Integrated management of the protection of the environment (quality of water, air, soil)
- Scientific monitoring of eco systems and protection of biodiversity
- Environmental hazards and eco systemic risk assessment
- Monitoring and research of climate change and its impact on the environment

Protection of the eco system requires a multi disciplinary approach to solve the problems-from observation and understanding to adaptive management. The activities were anticipated relative to the resources of water and air, biodiversity of urban systems and forests. Considerable problems faced by the inhabitants on a daily basis are the pollution of cultivated land and lack of treatment of industrial and urban waste waters released into river flows. In the soil quality area priority shall be assigned to the research in remediation of soil. The research of phyto extraction application, immobilization of contaminants and technique of the so called "Clean up" of soil are at the forefront. Research activities should be extended to the development of new technologies focused on reliability and risk of urban water systems, particularly in the context of water shortages and unregulated water supply conditions. Technological solutions should be opened and integrative, technically simple and cheaper to exploit and maintain.

The status of eco systems constitutes the key indicator of climate changes effects, while their monitoring implies long-term follow-up of a set of ecological parameters, indicators of climate and other changes in the natural, semi-natural and agro eco systems. It will be necessary to develop a consistent monitoring system which relies on the existing European networks such as ILTER-Europe, regional network within the International network of long-term ecological research (ILTER). That would ensure the exchange of data and close scientific cooperation with the regional and European institutions with the view to understanding the changes in eco systems under the influence of climatic changes and their impact on biodiversity.

Ecological assessment of hazards and risks today, primarily required under the Water Frame Directive of EU (WFD) implies monitoring of the status of ecosystem on the whole, because the integrity of eco system is considered as a measure of its ecological status. Such a concept relies far more on the monitoring of effects of individual hazardous materials (required under REACH Directive), but also synergies of a great number of hazardous and harmful materials on biological systems - from the individual to the population through to the overall ecosystems, which cannot be determined by purely chemical analyses, but a wider spectrum of eco toxicological methods.

Climate change, according to different scenarios and reports will crucially influence the changes of natural systems and some core resources in the environment (agriculture, water resources, forests), and thereby the sector of economy. However, the speed and the consequences of change during the 21st century are quite uncertain, particularly in regional terms, although most probably they will be dramatic. Since the environment management system is going to be dictated, to a great extent, by the trend of global warming in 21 century, it is necessary to ensure, on the basis of strategic priorities and policies in the area of environment, the conditions for implementation of systemic monitoring and research in climate change impact on the environment as a base for drafting strategies of adaptation processes.

Since no complex studies were launched in Serbia in this context, and having in mind different scenarios of climate changes in this century, it will be necessary to initiate a complex macro project of a regional character, including the core resources of the environment. Serbia was assigned the responsibility of establishing, in 2007, a regional center for monitoring climate change. The focal institution is the Republic hydro meteorological administration. Development of regional model enables forecasting changes which will be reflected in the management of the resources of wood, carbon bonding, biodiversity protection, water yields, protection and planning of spatial management with risk assessment and socio economic consequences.

Necessary measures:

- Stronger support to research in the areas of environmental protection and climate changes via "top down" funding and multidisciplinary projects
- Establishment of national laboratories for control of water quality, water, soil and air
- Support to the institutions for consistent monitoring systems relying on the existing network within the International network of long-term ecological research (LLTER) and the institutions for monitoring system of climate changes
- Incentives for broader inclusion of our researchers into the projects under FP7 program of EU and bilateral ones

3.4.4 Energy and energy efficiency

The importance of research in energy and energy efficiency

Energy is a strategic infrastructure of a country necessary for its overall development and security. Serbia is not self-sufficient in terms of energy resources, hence it has to import larger part of its strategic energy generating products (oil, gas and high quality coal), and a portion of energy equipment, particularly that which is modern - efficient and ecologically acceptable. That is why, in addition to safe supplies of energy its rational consumption is at stake, in the strategic interest of Serbia and reduction of import dependence and reconstruction and expansion of domestic manufacturing of energy equipment and equipment for the protection of the environment, contributing to the reduction of unemployment rate.

Status of energy sector of Serbia and its research potential

Despite enormous effort and considerable funds invested into revitalization of plants within the energy generation sector in Serbia, particularly electricity, the situation in Serbia is unfavorable and there is no sufficiently safe infrastructure for its economic development.

Serbia is unavoidably facing the introduction of new, efficient ecologically friendly energy technologies, technology for dislocated energy generation, technology for the protection of environment, technology of use of low quality fuels, biomass, off balance coal reserves, coals from underground exploitation, technologies for the use of renewable sources of energy (RSE): biomass, small hydro power plants, wind energy, geothermal energy, energy of the sun, household and industrial wastes. On the one hand it would require an investment effort but on the other a challenge for science and technological development and the opening of new production.

Unlike relatively well developed energy generation, the culture of energy efficiency is underdeveloped. The main reason is inadequate market valuation of the generated electrical energy reflected in irrational and inefficient energy management of output. Hence, slight lagging behind is evident in the research of new technologies for energy generation, ecologically friendly and from renewable sources.

The available scientific and professional potential in the domain of energy is very good. For many decades now the institutes and faculties have been active in the entire scientific domain of interest to all the sectors of energy system of Serbia. MSTD pursues the policy in those areas in two ministerial committees - for energy and for energy efficiency, and funds a special National program of energy efficiency. About 750 researchers are engaged, investments by MSTD have been at the level of 4 million Euros a year, while the research equipment in the past was very poorly funded.

Priorities within the energy generation in Serbia and research priorities

Priorities in science and technology development must be adjusted to the energy generation priorities. Still, in the period to come the focus will be on the revitalization of power plants, primarily in electricity generation, starting from the equipment on open pits, thermal and hydro power plants, to the transmission and distribution network, distance hearting industrial plants. But, no doubt technological upgrading of energy generating facilities will be needed, improvement of technological and operating performances of the facilities under exploitation, by means of introduction of modern technologies when building replacement capacities and adding equipment for the protection of the environment. Harmonization of legislation will be necessary in the energy generation and ecology with the EU regulations and standards and

international conventions and obligations due to tightened ecological standards - with the view to approximation to EU, preservation of natural environment and public health.

The stated objectives could be hardly achieved without active and organized participation of science, fundamental, applied and development research, which should be upgraded in all the segments (development and introduction of modern energy generating technologies, processes, coal technologies and exploitation equipment, lignite and coal in small mines, processes, technologies and equipment for gas exploitation, primarily in households; etc.) but clearly the general priority is energy efficiency: higher efficiency of energy transformation from the generation of primary and secondary energy to the final consumption in the industry and utilities and households, substitution of electrical energy for distance heating in households and public and commercial facilities, reduction of loses in electricity and heating distribution. Within higher energy efficiency, there is a need to do research and apply energy sources with gas-steam cycle, for coupled generation of electrical and heating power (co-generation), and an increased share of co-generation of electrical and heating power in utility and industrial consumption.

Although the use of RSEs in absolute terms shall not contribute in the short run and to a significant extent to the energy audit (particularly electricity audit), or the reduction of the import dependence on the whole, the science research strategy must devote considerable attention to those activities. For quite some time the fallacies prevailed about available energy potentials of renewable sources of energy in Serbia. Favored were the sun and geothermal energy despite the obvious fact that Serbia disposes of big quantities of biomass, primarily waste biomass, forestry and agriculture and timber industrial waste. Overestimated were the possibilities of substitution of fossil fuels by renewable sources. Only the studies under the National program of energy efficiency, the Strategy of economic development of Serbia till 2010 and finally the Program for implementation of the Development Strategy of energy generation of Serbia till 2015 (Module 14), defined approximate volumes of those energy generating potentials and established realistic proportions. The achievement of strategic goal of higher use of RSEs, both electrical and heating, must rely on the energy sources with the highest potential, and those are: biomasses, small water flows, and to a lesser extent, wind energy.

Priority themes for research in the energy generation and energy efficiency:

- Increased energy efficiency in generation, distribution and use, with special attention for higher energy efficiency of buildings
- Development of new technologies for the exploitation of renewable sources of energy and clean technologies with zero emission, primarily small hydropower stations. Co-generation and use of biomass
- Contemporary metering techniques of energy consumption, monitoring and optimal automatic control
- Efficient use of existing mines and exploration of new deposits

Priorities were reconciled with three existing documents:

- Strategy and development of energy generation of the Republic of Serbia till 2015
- Program of implementation of the Strategy for development of energy generation of the Republic of Serbia till 2015, for the period between 2007 and 2012
- National strategy of sustainable development

Necessary measures:

- Enactment of lateral legislation for exploitation of SRO
- Tax credits for SRO equipment and insulation of buildings
- Reduction of VAT and customs duties on relevant equipment

- Long-term credit financing at subsidized interest rates
- Equipment of experimental and attest laboratories with modern equipment

3.4.5. Agriculture and food

Significance of research in agriculture and foods

Research in agriculture and food has always been directly connected with the advancement of agriculture and food industry of our country. The experience so far suggests that for each country it is important to have good quality science research and teaching institutions. They are imperative for the development of each country. Their mission in the future should resolve, guide and review the needs of producers and consumers in the long run.

The changed economic and systemic circumstances in the world and in Serbia require the response from scientific research to the social, ecological and economic challenges (increasing demand for safer, healthier and better quality food) and sustainable use and production of renewable bio resources. In the future, research should unify the fundamental, applied and development research which should together contribute to the construction of the Serbian bio economy based on knowledge by means of pooling scientific, industrial and other stakeholders with the goal to:

- Preserve land, plant and animal resources
- Construct sustainable and efficient agricultural and food sectors which can compete on the world market, contributing to the growth of national income
- Provide food which satisfies the needs of consumers in terms of quality and safety
- Develop technologies which shall preserve the environment from the effects of agricultural production
- Adapt the agriculture and food industry of Serbia in terms of EU integration

Current research capacities

Evaluation of science research results since the year 2000 was another chance to realize the resource and potential of the market. It was made possible first of all by opening the external market and negotiating autonomous trade preferential with EU (contained in the Resolution 2007/2000 EC and supplemented by the regulation 2563/2000 EC), which together with other documents and measures positively affected exports volume. Today in Serbia agro industry has a share of some 20% in the social product of the country. Serbia has very favorable natural conditions for versatile agricultural production, experienced producers, supreme experts and scientific staff. Since 2005 Serbia has positive trade balance on exports of agricultural and food products, the share of which was 20% in the total exports, far more than other Western Balkan countries (some 10%). In 2008, the total agrarian trade of Serbia with the world amounted to over 2 billion USD or by 16% above 2007. Export of seeds is especially significant because hybrids and varieties created in our research organizations are being exported. It is worth mentioning that our varieties and hybrids have a competitive edge on the international market where more than 3 million hectares were annually sawn with our varieties and hybrids. Scientists have developed optimum technologies in several disciplines, relying mainly on the traditional bio technical methods and procedures.

The main proponents of the projects in this area are: Plant and vegetable institute of Novi Sad; Maize institute "Zemun Polje", Belgrade; Institute of food technologies, Novi Sad; Fruit growing institute, Cacak; Stock breeding institute, Belgrade; Institute of meat hygiene and technology, Belgrade; Soil institute, Belgrade; Vegetable institute, Smederevska Palanka; Institute of pesticides and protection of the environment, Belgrade; Medicinal herbs "Josip Pancic" institute, Belgrade, Institute of plant protection and the environment, Belgrade; Fodder institute, Krusevac; Veterinary institute of Serbia, Belgrade; Veterinary institute "Novi Sad", Novi Sad; Institute of agricultural economics, Belgrade; Agricultural faculty in Zemun, University of Belgrade; Agricultural faculty and Technological faculty in Novi Sad,

University of Novi Sad; Faculty of agronomy in Cacak, University of Kragujevac; Veterinary faculty in Belgrade, University of Belgrade; Chemistry faculty in Belgrade, University in Belgrade; Technology and metallurgy faculty in Belgrade, University in Belgrade.

All the above mentioned institutions cover certain sub-areas such as: soil, crop farming and vegetable growing, fruit and vine growing, live stock breeding and animal health, food technologies, development of new enzymes and micro organisms in bio processes and agro-economics. The total number of projects financed is 117 with more than 1.300 researchers. Investments into this area went up more than six times compared to 2002 and reached over 1.2 billion Dinars for the year 2008.

In recent years, it was the most visible area internationally. Thus, in the Seventh framework program of EU "Cooperation" within the thematic area "Food, agriculture, fishery and biotechnology" the research groups from Serbia ranked at the European average according to success rate (about 17% success rate). In COST (12 of 83), EUREKA (5 of 36), NATO and other international programs the Serbian researchers partake, and in the bilateral cooperation programs, alike.

Research priorities in the area of agriculture and food

Future research should include the following thematic frames:

- Bio rational use, higher fertility, remediation and soil protection
- Evaluation and use of cultivated and wild genetic resources by means of the conventional and molecular methods of crossbreeding to obtain productive varieties /hybrids/breeds, which shall serve as a basis for the production of safe, functional, nutritive and special food
- Advancement of knowledge in sustainable management, production and use of biological resources
- Development of new technologies and products in the food processing industry and technology based on traditional products
- Research and development of application of new enzymes and micro organisms in bio processes, new products, production of biomass

In line with the above mentioned thematic groups the future research should be backed by the following **measures:**

- In cooperation with the Ministry of agriculture, forestry and water (MOSV) comprehensive research projects should be formulated. That would contribute to intensified science research, better application in practice and finally the accomplishment of better results in agricultural production
- Establishment of the National technological platform "Food for life"

It is necessary to establish stronger and more functional ties between MSTD and other ministries, the chamber of commerce, producers and market players (large systems and MSEs). The organization in the state institutes should be harmonized and brought to the level of competence with the corresponding institutions in the developed countries through the following activities:

- Founding a national institute either centralized for all sub-areas or decentralized by related sub-areas in research)
- Rationalization of institutes which practically work in the same branch /discipline would contribute to strengthening their potential in science research (personnel, equipment, office space, etc.)
- Privatization of the institutes in different ownership status: state/private, in the cases assessed to result in increased stability, competitiveness and profitability on the

market (finding foreign partner in the same activity with the view of preservation of development activities in Serbia).

- Definition of the place and role of the institutes of public character, being an important part in the establishment of a single control system in agriculture and food safety

Priorities were harmonized with the following documents:

- National strategy of economic development of the Republic of Serbia from 2006 to 2012
- Agricultural development strategy in Serbia
- National program of agriculture in Serbia 2009-2011.

3.4.6 Information and communication technologies

Significance of research in the domain of information and communication technologies

Information and communication technologies (ICT) are the most dynamic technological area of crucial importance for sustainable development and advancement of each society. This Strategy, discuses under the above title electronics and telecommunications, too, with their corresponding areas. ICT application is conducive to the accomplishment of the basic goals in society: innovativeness, competitiveness and transparency. ICT is completely interdisciplinary in its application and hence an intrinsic part of strategic plans in the fields of health, energy generation, food and environmental protection.

Current research potential

ICT is well developed in Serbia and constitutes an important branch of both the economy and science. In the area of software development and partially hardware, there are several companies dealing with the placement of knowledge and are good market players, at the level of the region, too. As to the production of hardware, the existing modest local technology is unfortunately unprotected, and un-encouraged. Sudden drop of industrial capacities in military and related industrial spin offs resulted in the halt in production and general orientation to the import of most products, even in the presence of local substitutes.

Major partners of the ICT industry are Telekom, Public Power Company of Serbia, Electricity network of Serbia, but also the Ministry of Interior and Defense, which means that ICT for the time being mainly relies on public enterprises and state institutions. As to software, in addition to one large, there and many small companies developing new products not only in the traditional fields but in many others (for cell phones, digital TV sets, internet routers etc.). The demand for telecommunication services is on the upward trend. Still, the best situation is in the field of software installation with firms employing over one hundred engineers. A cluster "Embedded.rs" was organized with a plethora of small companies.

Research in ICT is pursued in several institutes and faculties where R&D, and even manufacturing capacities in some SROs are reduced compared to the past, which necessitates consolidation of their infrastructure and recruitment of research staff. Good scientific resources are available and there is great interest among students in respective university studies. Relatively good numbers of papers has been published in international journals and the faculties and several institutes have good cooperation with industry. Transfer of know how to the economy is at a medium level. There are business incubators and a preliminary design for the development of an IT campus. We have several good computer centers (RCUB, Institute of physics Belgrade, Novi Sad), insufficiently exploited by the economy. MTSD pursues its policy via two ministerial committees - for electronics and telecommunications, and for industrial software and informatics. Approximately 700 researchers are involved, investments by MSTD are at the level of 5.5 million Euros a year, while new research equipment in the last three years was funded with half a million Euros.

Research priorities in ICT

- Installed electronic systems - manufacturing of equipment and software, modeling and optimization of performances in real time, management and control
- Development and implementation of modern hardware and software solutions in embedded technology (new generations of signal processors and controllers, embedded operating systems) adapted for communication based on GR technology;
- Intelligent sensors - actuators and multi sensor systems - systems for surveillance and warning (meteorological, police, military and others); wireless communication

networks for surveillance and control in industry, agriculture and ecology; control and monitoring of food production; medical instruments and sensors;

- Management and control of complex distribution systems - generation management and distribution of power (power electronics, automations and control); management of traffic, utility services, surveillance of environment, exploitation of wireless communications, GPS systems, multi sensor networks, satellite photos
- IT of libraries and digitalization - computerization of all library and archives stocks in Serbia, accessibility via internet, digitalization of all publicly accessible property, presentation of all cultural and natural goods
- Telecommunication systems of broad band access and digital transmission - research, development, demo equipment and devices for fiber glass and wireless telecommunications, digital TV, multimedia facilities
- Radar and infra red identification and control systems, R&D security equipment for application in security areas, traffic, agriculture, medicine, analysis and processing of signals, recognition of shapes
- Expert systems
- Information security

The priorities have been reconciled with two existing documents:

- Strategy for development of information society in the Republic of Serbia
- Strategy for development of telecommunications in the Republic of Serbia from 2006 to 2010 (including revision of 2009)

3.4.7 Improvement of decision making processes and affirmation of national identity

Importance of research in social sciences and humanities

Social sciences and humanities play a complex role in the development of economy, society and the state.

They are an import element of state continuity on one hand and preservation of national traditions and culture heritage on the other. All the democracies recognized the important and specific functions of those sciences. For Serbia, after the breakup of SFR Yugoslavia, with a significant number of Serbs living beyond its borders and a numerous diaspora all over the world, the role of social sciences and humanities in the effort to preserve and strengthen the national identity gained vital importance. A modern Serbia, which recently reinstated its own statehood, needs a strong scientific support for the sake of international affirmation and defense of all its national interests. Particularly so in terms of peaceful, legal and diplomatic struggle for territorial integrity and sovereignty over Kosovo and Metohija. In the Serbian history, its cultural and scientific institutions like *Matica Srpska* played a key role in the assertion of national goals. Serbia has a strong multi ethnic and multi confessional character, the affirmation of which is a factor of tolerance, diversity and riches of cultural heritage and life in such a society. At the same time, Serbia is an important pre-historic, Roman, Byzantine, etc. country. Validation of such heritage testifies to the deep European roots of Serbia.

On the other hand, social sciences and humanities are an irreplaceable resource for reform in society. They play the key role in defining the strategies of public policies, identification of possible options, optimization of functional institutions, enhancement of human resources and the system of management and achievement of selected objectives, comparison with the international experiences and achievements, introduction of the system of monitoring the results accomplished and corrective measures. Many of the most developed countries have, within different tiers of power, teams devoted to strategic planning and public politics. Social sciences and to some extent humanities are their main intellectual support. This role is of major importance for countries in transition on the way to EU membership.

Finally, a growing number of multi disciplinary studies and teams simultaneously engage life sciences/mathematics, technological but also social sciences and humanities. The complex problems, as a rule, call for a holistic approach where strict limits of scientific disciplines must give way to demanding objectives assigned to the scientific and economic communities. Such an approach continues to be exceptional in Serbia. Rarely do teams cover several social sciences, or unite the entire spectrum of science and technology. However issues like environmental protection, food safety, energy efficiency, bio medicine, etc., cannot be addressed without the contribution of social sciences and humanities.

Current research potential

Social sciences and humanities in Serbia are insufficiently affirmed. Although some 1,900 researchers have been active, out of 2,047 scientific papers published in international journals in 2007, only 30 came from social sciences and humanities. Debate about an optimum system of evaluation of papers cannot mask the fact of the lack of independent reviewers in some disciplines and a generally unnoticeable presence of our social sciences and humanities at the international level. The researchers maintain weak ties with the proponents of state policy that is, civil servants. They rarely write about the hottest topics in the state, not to mention that they are hardly consulted in decision making. SROs network has not at all been reformed

in the last few decades. Some SROs are at the verge of human and financial sustainability.

In the domain of social sciences, 1,156 researchers took part in 6 FP6 projects, 5 COST initiatives and cooperated within 6 bilateral international agreements. In the sphere of history, archeology and ethnology 386 researchers have been engaged within 6 bilateral agreements. In languages and literature, 342 researchers participated in 3 bilateral projects.

Despite frequently reaffirmed advocacy for cultural and national heritage in the public, Serbia remains among the last European countries without a series of capital national works, like dictionaries, atlases, spelling rule book, systematic inventory of different cultural sites, etc. The situation is grimmer in view of the fact of some overlapping in the domain of lexicographer production. In the sphere of humanities, publications in English are rare, even worse on the Internet, while the publications in Serbian are largely limited to a narrow circle of specialists. With few exceptions, like some monasteries and *Viminacium*, the culture heritage has not been adequately presented to the public at large or the international audience.

Priorities in social sciences and humanities

In the period to come, the role of social sciences and humanities will be of key importance in the following domains:

- **Affirmation of the role of social sciences in formulating public policies**: it will be important to avail the latest knowledge of social sciences in formulating the public policies. Cooperation between SROs, faculties and proponents of public policies must be systematic, with clearly defined responsibilities and expectation that researchers are independent but under defined confidentiality obligation for data and knowledge generated in the course of joint work. The works in the field must by better funded, quantitative methods applied, with representative samples and clear methodology to ensure relevance and reliability of research.
- **Support to integration processes**: the coming years will be marked by different integrations, first of all by the preparations for EU entry, but also by the regional issues, Russian Federation, USA, sector approaches in the domain of energy generation, climate changes, struggle for suppression of organized crime and financing terrorism, etc. The scientific capacities will have to be tapped towards defining negotiating platforms, in depth analyses of the partners and their policies.
- **Completion of capital projects**: dictionary, atlas, spelling rule book, etc. Deadlines will have to be set and funding of the projects conducive to the completion of the important works for distribution via modern and cheap electronic media. Possible overlaps will be tackled and teams consolidated, if needed.
- **Affirmation of national history and culture heritage**: the community shall have to clearly prioritize the reconstruction and construction buildings and complexes of national and European importance. Partially commercial sustainability will be required, first of all due to the need to check whether the exhibits will be presented in an understandable manner, attracting public at large.

3.5 A message for those that are not listed as a national priority

While the Strategy has been drafted, some scholars and institutes, who did not find themselves on the priority list, negatively reacted, even dramatically, like: "It's the end of my career ", or "You condemn our Institute". Things should be clarified.

Definition of the list of national priorities in science and technology shall not imply reduced support to any scientific area. Serbia cannot afford extinguishing any branch of science. They are all needed for education purposes and absorptive capacities of society. Finally, freedom of scholars must be preserved to direct their research to the discipline of their choice.

It is of major importance to avoid the feeling in the scientific community in Serbia, otherwise small one, that prioritization means "splitting" in two parts: the one dealing with priority areas and another with non priority. Unity of science research system is of crucial importance and this is the reason why all researchers, projects, teams and institutions will be scored according to the same criteria, irrespective of the degree of priority. In the same vein, the whole infrastructure will be equally accessible to all the researchers. The priority will be concentration of additional funds rather than selectivity, or even worse extinction of any discipline.

3.6 Success in all scientific domains implies development of supercomputing capacities and IT infrastructure

The trend of success today in all the domains, is to create and use powerful computers installations, most often in the forms of:

- Supercomputing centers with hundreds or thousands of blade servers, powerful cluster computers with high data processing capabilities, that is parallel use of a big number of processors and
- Data warehousing centers with high capacity of disks for storage and archiving.

Since even very powerful supercomputing installations may turn into "bottle necks", the use of the concept of computer networking that is grid computing for several computers at a time allows for processing of data by one program. Cluster of grid computers with stand alone heterogeneous computers at different geographic locations can work as one, if appropriate, in distributed parallel processing of major and joint tasks. The use of fiber glass broad band computing grids of high capacity and transmission speed nationally or globally, the computers in the network which constitute the so called grid infrastructure may ensure, within a very short time span, both high performance of simultaneous data processing and also warehousing of great amount of data.

Individual science research organizations (SROs) from Serbia take part in the international research projects in grid computing. For instance, the Institute of physics has been participating, in the meantime, in the international projects CX-CMCS, EGEE-III, SEE-GRLD-SCI and others. In November 2008, Serbia became member of PRACE- Partnership for Advanced Computing in Europe.

Thanks to application of the concept of grid computing capable of orchestrated performance it is possible to build a special computing network ("NIONET" program). More SROs in Serbia (universities and institutes) are required to meet the demand for:

- NIOs R&D
- Teaching and advancement of IT experts (development of curriculum and educational aids but also methods and technologies within e-learning)

- Provision of supercomputing services to clients beyond science research and academic community (corporate sector, state administration etc.)
- Provision of a single system for monitoring and management of the projects sponsored by MSTD and all its services for NIOs needs: warehousing and mining for active data on researchers, projects, published works and achieved results, doctoral theses, developed technologies and technical solutions, science research infrastructure and processing of applications in all the programs of the Ministry, access and search of bibliographic sources, etc.
- Warehousing of data and documents for permanent archiving (with the possibility of intelligent search) for the requirements of not only SROs but state administration, government and public institutions, public and private enterprises and other clients.

Perennial NIONET program will be of strategic character and enable further advancement of computing grid for the science research community (academic network) which should link all SROs (institutions of higher education and research organizations) and enable equipment of SROs with computers for realization of the project and functions of NIONET program. The experiences gained and human resources and software developed for computing infrastructure to be used by NIONET PROGRAM will be of great importance for the development of similar computing infrastructures in the economy of Serbia, particularly within the program of e-government at all the levels of state administration.

Within NIONET program the concepts of the so called cloud computing services would be developed:

- IaaS - infrastructure as a service;
- PaaS -platform as a service;
- SaaS - software as a service)

The users of those services (primarily SROs, but also enterprises and state institutions) could get the needed services quickly. They would need no own development of IT systems, which would reduce IT applications costs, speed up the use of modern information systems based on the so called web services. In addition to the benefit of direct access to such services another relevant advantage of NIONET program is certainly the development of knowledge and professionals necessary in the application of modern computing infrastructure and IT services in the economy and in society.

4. Implementation of the Strategy through PARTNERSHIP and system improvement, is as important as the Strategy itself

4.1 Identification, development and support for talented young researchers is of crucial importance

The following measures will be taken within the strategy of scientific and technological development to ensure advancement and fostering of talents in Serbia:

- The competent ministries will prepare a strategic document to comprehensively define how to identify, follow-up, educate and advance the talented and gifted children as a future potential in science research
- Reform of curriculum by the competent ministries, adjusted to the talented and gifted pupils and launching the initiative to establish consultative centers for talented and gifted schoolchildren
- Special incentives to secondary schools for talented and gifted children by expansion of capacities and advancement of instruction subjects (Mathematics gymnasium etc.)
- Stronger support to the existing non-school institutions (Research station "Petnica" etc.) which provide additional education to the talented and introduction into science research, and establishment of new ones
- Scholarships for gifted and talented schoolchildren and students at all study levels will be continued
- Special bylaw, already underway, which will be adopted by competent ministries will regulate funding of doctoral studies;
- Finance for advanced studies of scholarship holders of the Ministry of science and technological development will be increased
- 1,000 flats for young researchers and scientists shall be completed to ensure, coupled with other benefits, their stay in the country

The interest in gifted children and youth has been growing, focusing beyond professional researchers and teachers to parents, the gifted and other important social groups and institutions. The talented and gifted children should stay in regular schools or in special classes of regular schools, provided coverage by differential curricula and possibility of undertaking other activities. To satisfy the educational demands of the gifted, the competent ministry will undertake to change school curricula and raise their quality. A major support to the development of talent at school will be provided by an organized action of advisory centers for the talented children, their parents and educators. The measures stated relate to both elementary and secondary education.

Many renowned scientists of Serbia originate from the Mathematics gymnasium and similar gymnasiums and consolidation of infrastructure and scientific capacities of those schools is a precondition for making future scientists. Within the project applications with the European Investment Bank and other financial institutions capacity expansion was envisaged, allowing more children to attend, namely to be admitted from other towns in Serbia.
MSTR has been supporting for years now the activities of non-school organizations in Serbia which educated talented children and youth.The research station "Petnica" is of special interest to this Ministry, because it teaches methodology of scientific and research work.

The financial resources allocated to that institution in the past several years were much (16 million Dinars for 2008). In the period to come money will be procured for the construction of a new building with adequate conditions in the Research station. The number of high school organizations for advancement of the talented is insufficient and therefore the establishment of new ones is one of the goals of the strategy implementation.

Scholarships are but one aspect of supporting the youth and encouraging them to opt for science research. Higher financial support will be provided for the proficiency courses abroad (summer schools, camps, traveling to scientific conferences, the international student exchanges and the similar), procurement of foreign literature and use of electronic data bases, magazines, material costs of research etc.
One of preconditions for the young scientists to start home is tackling of their existential needs, first of all their residential problem. In early 2001, the construction of university village was started in Belgrade and so far 2 building were completed with some 300 flats. Smaller number of flats was built in other university centers. The needs for tackling this problem are enormous. In Serbia today about 2,500 researchers have inadequate flat (in Belgrade around 1.000). If this problem is solved Serbia will ensure the stay of the most talented young people and return of some who have left.

4.2 Higher education and science will clearly and quantitatively determine by school year 2010/2011 a midterm plan for enrollment

Strategy goals implementation relies on the sufficient number of young professionals who will choose the career of science researchers. One of the preconditions is a harmonized policy of enrollment and expediency of studies at the institutions of higher education with the priorities of development of science and technology in Serbia. Higher education in the Republic of Serbia is available at 7 accredited state universities (83 faculties), 8 private universities (46 faculties) and 6 higher schools of academic studies. The number of students enrolled (238,710) in the last ten years almost doubled, as well as the number of graduates (29,406). However, the ratio of enrolled to graduated students is of concern.

The enrollment policy so far resulted in as inadequate number of enrolled (and consequently graduated) students by professional and scientific areas relative to the needs of science and technology development. Thus for instance, the proportion of graduated students at the University of Belgrade 2006/2007 was: social/humanities 45.5%, technical/technological 31.5%, medical 16.9% and natural/mathematics sciences 6.0%. The ratio of graduated students by scientific areas was similar in other universities. Evidently, the lesser number of students enroll the faculties of natural and technical sciences and higher the faculties of social sciences. The orientation to teaching activities caused, among other things, lagging of social sciences and scientific publication relative to other sciences. In the same vein, the lack of qualified staff in industry and education is ever more present in fundamental sciences. That is why it is necessary to implement planning policy of enrollment of students to the faculties adjusted to the priorities of the nation.

The plan for the years to come is to define, together with the competent ministries, the number of enrolled budgeted students by individual areas in line with the determined strategic priorities. In addition, indirect incentives will be introduced for the studies of natural and technical sciences of importance for scientific technological development. Hence it is

necessary to change the system of financing of the higher education (financing per capita), and to earmark the scholarship funds to the students of priority scientific areas. The required ratios of enrolled budgeted students are about the following: 15%- life sciences, 35%-technical, 15%-medical and 35%-social-humanities. With the view to the expediency of studies so far, it may be expected that the number of graduates will be at the level of 20% of the enrolled, which in Serbia would come to one fifth of 250,000 namely 50,000 graduated a year.

The achievement of the stated measures is a precondition for very important policy of doctoral studies. The total number of students who completed post graduate studies and obtained master diplomas or doctoral is around 2,000 in the last couple of years. To reach the needed number of scientists per 1000 inhabitants this number should be doubled. Science, research and development capacities of a country are the best graduated students. That is why in each area it is necessary to have sufficient number of interested and motivated for further science and research work. The measures approved should be conducive to needed quantity in each area, which would turn into quality though the doctoral studies, and thereby the necessary science, research and university teaching youth. The additional incentives will create more favorable conditions for science research work through: innovation of infrastructure (equipment,space, etc.), continued financing of fast availability of science research information, facilitated financing of proficiency studies abroad, improved living conditions of young researchers (personal income, material costs of research, residential problems and the similar). Based on the anticipated number of students at the accredited study programs and available capacities at the faculties (mentors, equipment, etc.) it was estimated that the budget will finance 5% of graduates to take up doctoral studies within a generation in each area (the level of about 2,500 students) that will be adjusted to the determined priorities for development of science and the total economic and social development. Due to the significance of doctoral studies MSTD, shall together with the Ministry of education, adopt a document on funding the doctoral studies that would regulate more in detail this very important area for future scientific potential.

4.3 Project evaluation and career development will match national priorities

Based on the progress achieved, we will have to improve the scoring system and career promotion according to objective criteria and merits.

At the institutional level, in the forthcoming five year period at least one university in Serbia must come to the list of 500 best universities in the world. It is scarcely known to the scientific and university public that one of the main criteria for entry in the Shanghai's list is the number of scientific works published in the journals on SCI list.

At the individual level, new incentives should be introduced whereby, for instance, for each work published in the Nature and Science the Ministry would ensure corresponding award, likewise for the works published in other best world journals (the first 15% for corresponding sub-discipline). In such a way the relative effort would be more clearly recognized and the difficulties in publishing among different journals.

Further to that, the competition for a new Project cycle within fundamental research, will be published in March 2010; in addition to already clearly defined criteria which has been in force for the Project cycle 2006-2010, the said incentive measures and series of improvements of qualitative parameters (awards and acknowledgements for membership on the boards of the international scientific conference, membership on the editorial boards of international journals, editing of monographs, reviews of scientific works and projects, mentorship of master and doctoral studies, international cooperation) which will be published in the Criteria for individual and project rating in March 2010, taking into account the opinion of corresponding ministerial committees and the National council. Specific situations shall be considered: younger scientists, returnees from abroad or retirement from the administrative positions.

In the area of technological development, recent thematic wholes were introduced for the first time in proposing the projects and three categories of researcher with certain number of points earned in the previous five year period. In the forthcoming period the works will continue on

the key category of the results of TR - technical solution, its verification and valuation. Further to that the core criteria will be increased impact of science research on the economy of the country. In addition to technical solution and patents also the concrete results of scientific research and patents will be evaluated if already placed on the market.

4.4 System of financing will be more flexible and will gradually reflect the national priorities

Strategy implementation must be, first of all, financially supportedy. According to estimates almost a half of our scientific capacities have already been engaged in the proposed national priorities but changes will be necessary to increase the share. Those changes have to be quick but not destabilizing. Science needs a measure of continuity but a strong move through the system of reforms. The proposed financial reforms are as follows:

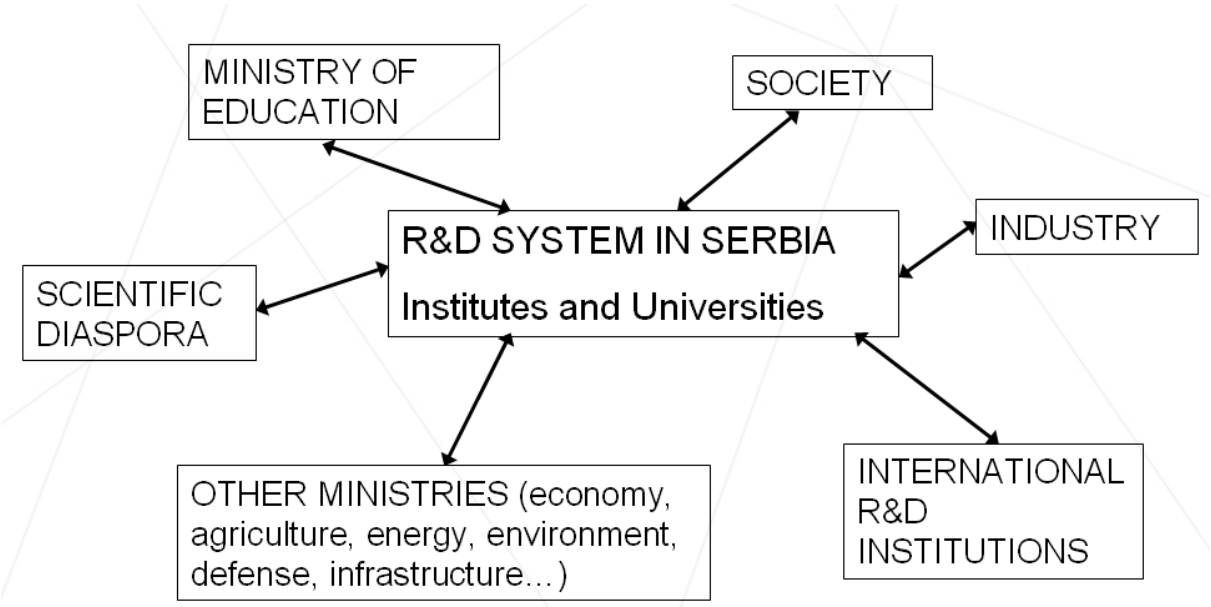
- As of 2010 the state will call the bids for national priorities
- Multi disciplinary research will be initiated under the condition of involvement of researchers from different areas and institutions
- Part of the funding will come from the economy as a partner of the academic community
- Higher flexibility will be introduced in the financing system: time frames, size of teams, duration of projects
- Material costs shall be adjusted to specific features of research areas
- The system will encourage initiative of individuals and institutions
- Priority areas will be subject to competitions, or special stimulation coefficients, provided the funds for non priority areas are not reduced, or the anticipated funding of scientists cancelled, apart from those which failed to meet the requirements for election to a position or the conditions of the competition. Depending on budgetary situation, one year projects will be introduced for the topics designated in advance. MSTD will have a reserve fund for unpredictable circumstances calling for fast reaction.

4.5 The position and results of social science and humanities will be improved

Focal attention must be devoted to this part of the Serbian science in the years to come. Quite significant potential of the scientific community must be mirrored in better state rule and its affirmation in the world. The core measures to be taken are as follows:

- Establishment of a department for social science and humanities in MSTD
- Introduction of appropriate evaluation system of science work, which will continue to affirm the international journals and lists but which will recognize specific characteristics of those two branch of science
- Funding of field work, as almost systemic precondition of publishing in the leading world journals and fitting into the international projects
- Affirmation of local journals by means of funding their break through in the international lists
- Development of the network of qualified international reviewers adequately budgeted
- Completion of the work on priority capital projects in the field of lexicography
- Rationalizations of institutions of social sciences towards building strong center devoted to the enhanced decision making at the state level: international politics, law, economy and finance
- Investments into integrated programs of affirmation of cultural heritage, like "Roads to monasteries", "Serbia Romana ", etc.Draft Strategy for public debate

THROUGH PARTNERSHIP TOWARDS A NATIONAL INNOVATION SYSTEM

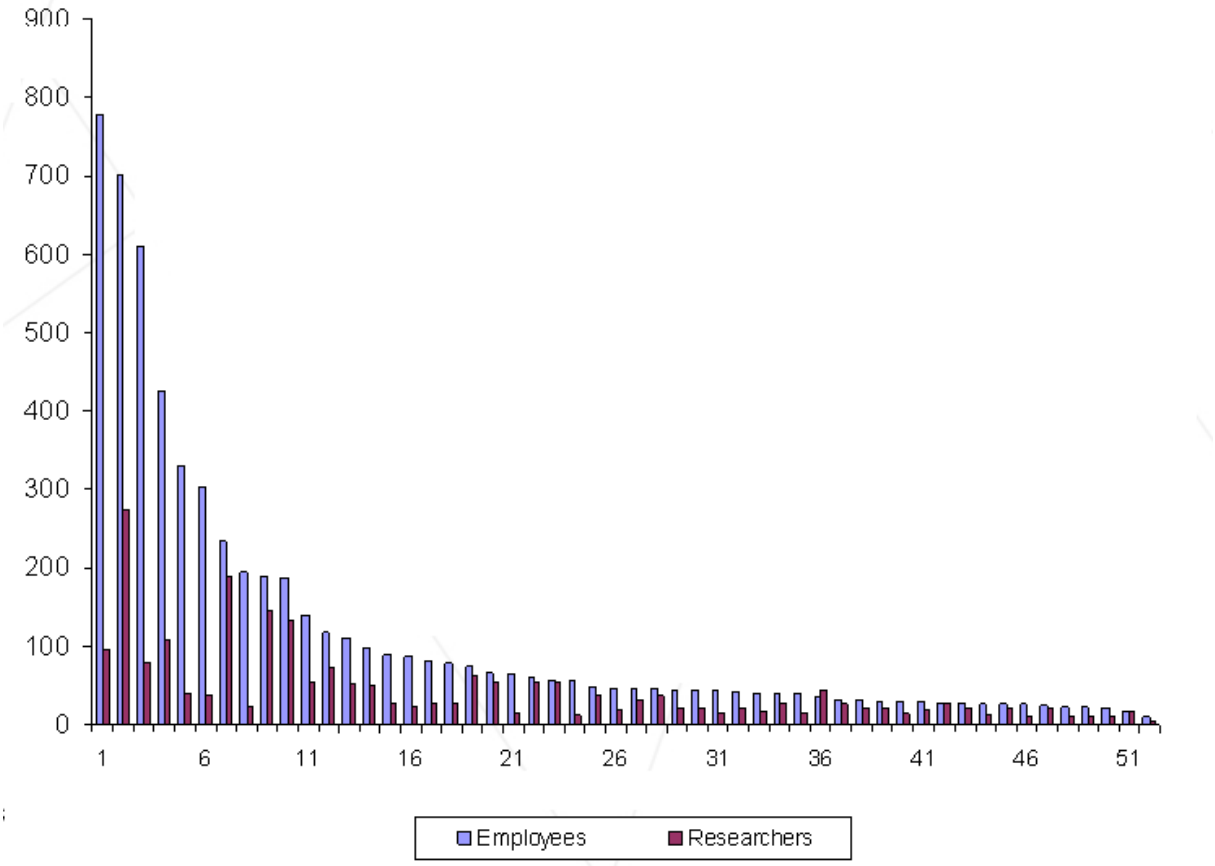


4.6 Partnership within the system through rationalization of the R&D network and close cooperation between institutes and faculties

Fragmentation of science research organizations (Graph 4.1) and too small science research programs are the main obstacles to the establishment of national science research and innovation system to drive the development and application of the existing and new knowledge and technologies, as well as the advancement of innovative products and processes necessary for international competitiveness of the Republic of Serbia.

Reorganization of science research network, including the transformation of the existing RDIs, bundling together RDIs far beyond the critical mass, and establishment of new ones, would enable rationalization and create conditions conducive to competitive and useable outcomes of research at effective cost.

On the one hand, the rationalization of the RDI network, and close linking with the faculties on the other, with the view to enhancement of the quality of study programs must result in a favorable environment for science research, the results of which have utility value, because they contribute to economic and social development of the Republic of Serbia.



Graph: 4.1: Number of employees and researchers in science institutes in Serbia (Source: Center for research in the development of science and technology)

Transformation of institutes: the existing public research institutes have to be transformed, as ownership structure must be defined, their organizational form adjusted, method of funding and work flow suited to their mission, type and program of research and functions. The following forms of research institutes or centers could be formed:

National scientific institute or center is a public institution carrying out fundamental and applied research within the long term strategic science research programs contracted with MSTD. The institute should carry doctoral studies in cooperation with other institutes and/or faculties.

- **Research-development institute or center** doing applied or developmental research, and providing professional and other non research services on the market. It could be either an institute or enterprise in the state (public) or private ownership.
- **Privatization processes should be encouraged.** The privatization process of R&D institutes if in the interest of the community and establishment of private enterprises for R&D and consultative services.
- **Cooperation between science-research organizations**: all forms of vertical and horizontal linkages need be strengthened among educational, research and manufacturing organizations towards their joint R&D work, irrespective of the type of ownership of such organizations, or the country of operation (research networks, industrial clusters, networks of the centers of excellence). The establishment and work of mediation organizations should be encouraged, as they can provide for R&D partnerships and commercialization of research outcomes, for instance, know-how transfer centers, innovation and excellence centers.
- **The status of excellence center** may be awarded to science research organization or its organizational unit with outstanding results on the national and international level,

under the international criteria. Centers of excellence should act as disseminators of excellence in their surrounding and so contribute to the development of society and economy in Serbia.

RDIs and faculties have to be integrated into one science-educational system

Quality of university education is highly dependent on the quality and intensity of their scientific work. Unity of scientific and teaching activities at the universities must be provided and science work considerably enhanced at the university: For the sake of integration of science institutes into the educational and scientific process at the university, the institutes should be allowed to become equitable members of the university, provided they shall meet the accreditation criteria for doctoral studies. In that way the Institutes would acquire the status for independent or in cooperation with other university units, organize doctoral studies and become place where the doctoral dissertations could be prepared. Due to other specific characteristics of their work and for efficient operations on the market of research and other services, the institutes should be allowed to maintain their status of legal persons. Universities and their units (faculties, departments) could become founders of science institutes, science and research centers (with or without the status of legal person), defined in the Statutes of the University. Linkage between the education and science is one of the corner stones for implementation of the present Strategy.

4.7 Partnership with society through science promotion

Science-research activity is of special importance for knowledge based development of the state. Along with higher education, it is the main actor and driver of economic and overall social development. Activities to be undertaken by relevant stakeholders contribute to education and broader knowledge requisite in the preparation of information- and knowledge-based society.

Brining science closer to the pre-school and school children affects further academic development of future generations of scientists and researchers. To that end the **Center of science and innovation** shall be formed, to inspire curiosity and interest in science at the pre-school age. Building such a center, domiciled in Belgrade but active throughout Serbia, may offer long-term learning, an ideal environment for the public at large to meet scientists, supplement the education system and contribute to cultural and economic vitality of society.

The public is insufficiently aware of the world of scientists. A series of presentations of scientific projects should be organized, debates and round tables, all over Serbia. The model of scientists playing the role of lecturers and educators of the youth should be applied in local communities. The presentations and promotions should be held in public places, accessible for all.

The scientists involved in promotion and popularization of science will receive incentives for such activities while financing of projects in that area shall continue, particularly the ones which met with good response so far as the Festival of science and many others. In addition to the competition for project in science promotion the funds will be systematically provided also within regular projects for dissemination of results, like in FP7 system of EU where each researcher on the projects of the Ministry will be obliged to present them to the public, at least to certain extent.

Science societies gathering young researchers and scientists are one of the significant factors in popularization of science, locally. More intense cooperation with science societies will affect the higher interest of the young to opt for the career of scientist and researchers.

Strengthening cooperation with the media provides for a direct contact with the local population, public polling campaigns about concrete topics, opening of discussion themes in priority scientific areas defined in the Strategy.

Creating a positive attitude by presentation of science and technological projects and social affirmation of scientists and innovators via media prompts young people to choose scientific career, increases the number of researchers and scientists.

4.8 Partnership with industry through a new law intellectual property and through incentives

MSTD shall soon draft new Law on innovative activities and amendments to the Law on intellectual property rights with the provisions concerning science research in terms of clear and more intensive linkage of science, research and innovation with economy. It would form a basis for concrete steps over the period of implementation of the present Strategy. The law stipulated among others:

- Strategic change in the method of funding, partly oriented to the entities in the economic sector as the proponents of innovation projects
- Regulation of a very important matter of the protection of the intellectual property rights under the joint projects between corporate sector and SROs, and partly financed by MSTD, that is the investment fund in the majority state ownership. The provisions on the intellectual property rights shall be fully harmonized with the international practice according to which the owner of so created intellectual property is both the employer and the client who contracted the work. On such occasion MSTD issues the document prescribing publicity and confidentiality of information relative to the realization of the innovation project, and how mutual relations are regulated among the project participants, in terms of intellectual property rights and respective financial compensation in the case of commercialization of an intellectual right. Considerable part of income would go to the innovators (not less than 30%) and institution (no less than 20%).
- Formation of joint investment funds for financing the projects.

Through the future Action plan under this Strategy and in cooperation with the Ministry of finance, taxation and budgetary incentives for investment into science and research shall be stipulated. The proposals of MSTD are as follows:

- The investment by corporations into the projects involving science research organizations, which are co-financed by MSTD shall be free of corporate profit tax (recognized as a cost)
- Employment of the young researchers registered in the projects of MSTD in the private sector enables the private sector to pay salaries for two years free of contributions and taxes (payable by the employer)
- If the enterprise would have its employer at the doctoral studies MSTD would bear up to one half of the costs
- Young researcher registered in MSTD, who would incorporate own enterprise would be released of payment of income and profit tax up to the age of 30. After that, within 5 years, progressive transition in taxation to mature to standard market conditions
- Costs of patent applications and other forms of protection of intellectual property in the Intellectual property administration under his projects co-financed by MSTD would be covered by the latter.

4.9 Partnership with scientific diaspora through joint projects

The capacities of our diaspora will have to be tapped more in the period to come. The first step is to identify our countrymen abroad and crate database, projects they are involved in, institutions they work with and model of their contribution to the development of science in Serbia. The database of our researchers abroad was started to be finalized in cooperation with the ministry of charge of diaspora.

Once we gain better insight into how many scientists in Serbia work abroad and what, numerous forms of cooperation will be implemented, starting from the inclusion of scientists into the process of reviewing projects in Serbia, as to avoid their restriction to the scientific community of Serbia and open the process towards greater number of people beyond the borders for higher objectivity.

Mechanisms for integration of scientist from diaspora in the national projects will open up while higher mobility of scientists in the country would trigger the mechanisms for employment of scientists who return from abroad to the institutes and faculties in Serbia.

The program of return of scientists will be implemented through shorter or longer study visits which will ensure necessary resources for those scientists of ours who wish to continue a part or the whole career here in Serbia. They will be enabled to gather their teams and provide necessary research equipment.

4.10 Partnership with international organizations through programs and developing databases and relevant statistical methodology

MSTD shall develop methods for closer monitoring of developments in science and research in the country, and the best experience in the world in the domain of scientific and technological policies. Only in this way, on the basis of genuine and accurate information, valid management decisions could be made. First come the completion of database of researchers in Serbia and our researchers in diaspora, and then the data on scientific projects and institutions.

In the same vein and together with the Republic statistics office, after the model of the international statistics and analyses (OECD, EuroStat, EC DG for Research Report), statistical forms will be introduced for all the companies closely ties to balance sheet. Further to that, in the next three years (till 2012), MSTD will carry out a special project and appropriate activities conducive to the diagnosis of a real situation in Serbia and indicators requisite in the process of Lisbon Agenda.

4.11 Partnership with industry through an Innovation development fund

For the projects directly related to product development, processes and services in priority areas and their placement to the national and international market a special Fund need to be formed for innovations development, on PP basis between direct and indirect beneficiaries of the budget, public enterprises, international financial institutions, banks, private commercial companies and others. The Fund would be established under the law governing incorporation and operation of investment funds, with majority state founding equity. A special rulebook would define the operations of the Fund, its financing, allocation of assets, procedures for selection of projects, form of contracts with the beneficiaries, etc..

The Fund would define its thematic framework for proposal of the projects aimed at the

development of products, processes and services on the market. Such thematic framework must be adjusted to the policies and priorities of technological development defined by MSTR and the Government. The Fund would approve criteria, under the specific rulebook for evaluation and financing of the project.

In such a way the fund for development of innovation would enable direct financing of private companies who are capable of implementing a project for development of products, processes or services, by selection of the competent science research organization.

Based on the criteria and evaluation procedures approved, the Fund shall select the best projects carried by NIO or a company with which it will sign a contract defining in details the mutual obligations. In addition to those the contract would regulate the right to the protection of intellectual property, own and of the participants.

Special part of contract will define the percentage of all parties in the case of successful commercialization of newly developed product, process or service on the market.

Since development projects are at stake, they will have to be defined at the start within much bigger budget so that the number of projects selected must serve the function of providing for successful commercialization rather than then support to all the projects. No fragmentation of the project must be allowed, leading to failure.

4.12 Partnership with international scientific community will develop according to priorities

The international scientific cooperation will be maintained and implemented through agreed strategy and priorities. Statistical data show the areas of cooperation in different programs of international cooperation, particularly in the sixth and seventh frame program where the participation of the Serbian researchers has largely been in line with the priority areas defined in this Strategy. In the meantime, the programs partly financed by national funds, the areas of cooperation will be adjusted to priorities. In the seventh framework program (70P) the Ministry will pursue the policy which will mean that within the Program committees for different areas of 70P and within other advisory committee of the European Commission, through members/experts delegated to play and active role in terms of substantive promotion and imposition of topics of interest under the Strategy and its future implementation. System of support will be developed for our institutions and individuals who shall take the leaders' roles in European projects, while at the same time they will strengthen connections with the European institutions in charge of international projects with the participation of our researchers and help our accession to the European partnership for researchers.

The Ministry will continue its active role in timely dissemination and organization of info days, training courses and workshops to get, soonest possible, broader and qualitative participation of our SROs in the programs of international cooperation. In addition, special cooperation programs will be developed in priority areas with the leading institutions in the world in the form of joint projects, exchange of researchers, etc. Also, in cooperation with the Serbian Chamber of Commerce and other competent ministries, this Ministry will support with its own activities the broader possible integration of the Serbian economy in the segments with different international programs and particularly the seventh frame program, open to them. In view of the fact that thanks to realization of certain number of projects the centers of excellence were formed in some science-research organizations, they are expected in the future to become cores of future development, both in terms of recognition of such excellence by the European institutions and further mutual cooperation within the seventh and subsequent frame programs, and in terms of attracting foreign technological companies and

realization of parts of their development programs in our NIOs. Of no lesser importance, the institutions which by participating in the framework programs advanced their resources in terms of infrastructure and human capital should be the support to the Serbian economy, specifically in the sector of innovative small and medium companies in development of their programs.

For priority areas where the number of OP7 projects is small or the success low (health care, environment) special corrective action plans will be made.

4.13 Partnership with other ministries through participation of scientific community in major infrastructural and other projects in Serbia

Enhancement of research potential in terms of human and material resources in Serbia call for its permanent involvement in major transactions important for the state. Highly justified reasons for it: financial (circulation of investment money within the state), and validated capability of R&D sector to cope with the assigned tasks. This would be also conducive to much higher engagement of the industry.

To that end, MSTD will support, in cooperation with other ministries, specific projects out of the money for large infrastructural projects appropriated to specific activities terms of reference where a part for participation of the economy would be covered from infrastructural projects and part for researchers' salaries from MSTD funds.

There is an evident need to do research connected to the infrastructural project Corridor 10 of the Ministry for infrastructure, followed by development programs of academic network and Internet corridor with the Ministry of telecommunication and information society, advancement of clusters and small and medium enterprises based on innovations with the Ministry of economy and regional development, active participation in the national program "Serbia against cancer" and the future program "Serbia against cardio vascular diseases" with the Ministry of health, infrastructural and development programs with the Ministry of defense and the Interior, continuation of the National program for energy efficiency with the Ministry of energy

as well as new capital, infrastructural and development programs in the forthcoming massive investments in energy generation, continuation of the National program of water management with the Ministry of agriculture - Waters directorate,and other infrastructural projects with the Ministry of agriculture, the action within the Environmental fund of the respective Ministry and preparations of Serbia for post-Kyoto world.

5. Increasing and diversifying R&D expenditure, as well as investing 300 million euros in infrastructure, are preconditions for the success of this strategy

5.1 The goal is to reach 1% of GDP for science by 2014, not counting infrastructure investments

A realistic plan of growth of budget appropriations for science is an annual growth rate of 0.15% GDP. At such a pace, the budget appropriations by 2014, the closing of this Strategy framework shall reach 1.05%. This is a realistic goal which we shall reach after quite a delay: the government of the Republic of Serbia approved a plan in 2003 to reach appropriation of 1% from the budget by 2007, the objective accomplished long ago by countries like Slovenia.

Still, even the growth of investment into science of 1% of GDP in the next five years will be insufficient to close the gap of the last 9 years of modest investment into science and very poor appropriations in the nineties last century. That would be the first serious step.

Such investment growth will enable funding of more costly inter disciplinary projects involving quite a number of researchers, facilitate daily functioning and procurement of consumables, greater support to young researchers, strengthening of the international cooperation but will not resolve the problem of the lack of capital equipment and poor infrastructure in the science research organizations. The infrastructure and equipment are needed not only for the projects but also for easier integration into the international projects, making our institutes more attractive partner to the economy.

5.2 Serbian R&D infrastructure investment initiative

The main sources of finance of the infrastructural projects which demonstrate and enable development of priority activities in the next five years will be international financial institutions, and particularly the European Investment Bank, European Bank of Reconstruction and Development, the World Bank, Development Bank of the Council of Europe and various international donors, specifically EU pre-accession funds. The Project of infrastructural investments, worth some 300 million Eur will start in January 2010 to last till end 2014.

The projects conducive to the development of priority disciplines were selected for this investment but also those likely to ensure successful development and identification of scientific staff, prevent brain drain and finally the projects which will make up for almost twenty years of scarce investment into scientific infrastructure.

Projects within the "Serbian R&D infrastructure investment initiative"

1. Upgrading existing capacities (~70 million Euros)
This part of the initiative is targeted at partial compensation for the lack of funding science in the last 20 years, to repair critical facilities on the infrastructure plaguing our faculties and institutes for years and bring here a laboratory of the highest research and education standards.

1.1 Adaptation of existing buildings and laboratories
Within this investment, the science research organizations will be invited to candidate their projects critical for instance for the repair of the sinking building of the Faculty

of life and mathematics sciences in Belgrade.

1.2 New capital equipment for research

Within the procurement of new capital equipment for research, apart from the general invitation to propose equipment necessary for research, part of the funds will be allocated to the equipment needed for realization of the projects falling within priorities.

2. Development of human capital (~33 million Euros)

As we witnessed, back in the 90's, some of the most educated people left Serbia. As already discussed unfavorable demographic structure of the scientific community made it clear that one of the crucial investments for the future will be human capital. Due to a very dire current situation, the development of human resources for science will have to ramify into several directions. The first is the program for return of researchers from the diaspora via complex project of shorter and longer visits, joint projects and networking of researchers. Another direction is an early identification and work with talented young researchers and the third a long-term route is to promote science among the youngest and disseminate science among the public and large, particularly the children. The third measure will ensure not only wider support to the scientific community in Serbia but the best way of motivating children for learning and science.

2.1 Human resources program (program of return of Serbian researchers from diaspora)

One of the main causes of poor demographic structure of scientific community is considerable brain drain in the 90's which slowed down but not was not halted till the present day. Many who left are highly educated and scientific staff. They constitute a broad base of our researchers in diaspora who should be integrated in concrete projects. One of the projects to have the researchers back for a period of time is to provide them with working conditions, means, necessary equipment and adequate accommodation. Networking of researchers in Serbia with their colleagues in diaspora has also been planned, visits of the eminent Serbian researchers and incentives for researchers in the diaspora to establish own enterprises in Serbia.

2.2. "Petnica" research center

The "Petnica" esearch center is a unique institution with a history of 26 years and about 14,000 young trainees, many of whom are proponents of science research in Serbia today. In the next three years the works on additional capacities of "Petnica" should be completed for both accommodation and modern laboratories.

2.3. Mathematical high school campus

Mathematical high school in Belgrade is a specialized secondary school which enrolls, under special selection criteria, the most talented young mathematicians and others interested in natural sciences from entire Serbia. Due to the limited accommodation and conditions in dormitories in Belgrade, many schoolchildren in Serbia cannot access this institution. That is why it was planned to build a campus for accommodation during the school year but also organize preparations for international scientific competitions and many other activities.

2.4. New Science and innovation center in Belgrade (for popularization of science among the youth and public at large)

One of the core projects within the initiative to build a new scientific infrastructure is the Center for promotion and popularization of science in Belgrade. The capital of Serbia is one of the last capitals of Europe that cannot offer its youth interesting and

educative pastime every day. Great popularity of the Festival of science reveals that there is interest in such manifestations. Hence, the construction of new, modern, interactive center has been planned, where children, school children but also their parents, will gain knowledge about topical issues in the domain of science. The center will be active throughout Serbia.

3. Development of Excellence center and academic research centers (~60 million Euros)

With the view to establishing stronger links among science research organizations in Serbia and building capacities for joint approach to the European Union and other sources of funding of science projects, it has been planned to form Excellence center in priority areas. Depending on the character of individual areas and the existing capacities, the establishment of such centers would require a combination of construction of new facilities and networking of old ones.

- Energy and environment (National institute of energy generation and national laboratory for water quality, soil and air)
- New materials and nanosciences (National laboratory of physics, materials and nano technology)
- Agriculture and food (Network f institutes and faculties with a hub in Novi Sad: Institute of plants and vegetables, Institute of food technology)
- Biomedicine (campus for bio medical research and bio technical companies using the infrastructure of the Institute for molecular genetics and genetic engineering, Vaccine and serum institute "Torlak" and Pharmaceutical faculty)

4. Development of information and communication technology infrastructure (30 to 80 million Euros)

As one of the defined priorities of Serbia, the development of information and communication technologies require advanced infrastructure and new human resources in this area. This is of importance not only for ICT but other scientific disciplines involving complex calculations and modeling of complex systems. Successful development of human resources in information and communication technologies is one of the best ways of attraction of technological firms worldwide to shift their development capacities to Serbia.

4.1. Campus for faculties of technical sciences of the University in Belgrade

The present status of infrastructure at the engineering faculties of the University of Belgrade is inadequate. Those faculties, educating strong engineering resources, have no sufficient space currently in use and are in a very poor condition. The redress to this problem is either construction of new facility in the already existing campus downtown Belgrade, or construction of a new campus for all the faculties of the University in Belgrade dealing with these topics such as the Faculty of physics and the Faculty of organizational sciences. Such networking will enable more efficient teaching and easier linkage within science research projects.

4.2. Infrastructure for supercomputing initiative "Blue Danube"

One of the capacities indispensable to the researchers in Serbia for studying various complex phenomena is the possibility of computing on powerful processors. That is why a supercomputing initiative "Blue Danube" has been launched anticipating a network of processors in all university centers in Serbia based at the Institute of physics in Belgrade. As part of the initiative, Serbia was admitted to membership of European partnership of supercomputing, in November 2008. Strengthening of infrastructure in that domain will enable realization of complex research in climate changes, bioinformatics, and synthesis of new material, physics and many others.

5. Creation of a knowledge-based economy through the construction of science parks in Belgrade, Novi Sad, Nis and Kragujevac (~ 30 million Euros)

One of the key elements of this Strategy will be the diversification of sources of finance for scientific projects through better cooperation with the economy. To translate this generally upheld idea into reality it will be necessary to strengthen the capacities of scientific community for implementation of the results of applied research. Establishment of science-technical parks closely related with the university and the rest of scientific community opens the possibility of incorporating innovation based companies originating from science research and providing infrastructural support to the achievement of joint projects or scientists and interested companies.

6. Basic infrastructure projects (~80 million Euros)

6.1 Apartment buildings for researchers in Belgrade, Novi Sad, Nis and Kragujevac

Within the resolution of the problem of brain drain and strengthening of human resources of our science community, the key project is the construction of houses for researchers. The project has been started; two of seven were successfully completed in Belgrade and a couple of them in Nis and Novi Sad. Because of the lack of finance the dynamics of realization was slowed down and than halted. The completion of works on another five buildings in Belgrade, construction of housing units in Kragujevac and more in Novi Sad and Nis was anticipated. Part of the flats will be rented out under non commercial conditions to the researchers starting their careers, while the rest will be offered to them for purchase, at the construction cost and very favorable credit terms.

6.2. Infrastructure for the Ministry of science and technological development

MSTD is currently located on four different locations in the city. Apart from the fact that this situation hampers the efficiency of the Ministry it is a problem for the researchers too, who have to change several locations to go through an administrative obligation. The Ministry got a building at the corner of Krunska and Svetozara Markovica Street of sufficient area to accommodate all the sectors and services of the Ministry but the building is dilapidated. The reconstruction of the building for not only the Ministry but a meeting point for scientific community and organization of numerous activities is among the projects planned in the next three years.

6. A strict implementation tracking system will be established

The implementation shall be monitored by the Ministry for science and technology development with the Ministry of education, Ministry of economy and other ministries, the National Council of science and technology, National council of higher education, Serbian Academy of Arts and Sciences, other advisory bodies and representatives of local and international companies.

Implementation instruments
The following programs call for definition and planning:

Integrated R&D programs, which favor targeted unification in the long-run of the fundamental and developmental research and are targeted at redressing topical and long-term development problems in Serbia in line with its development priorities. Conditions should be created for high quality fundamental research directed towards knowledge needed in fundamental research, whose results should be applied to the greatest extent towards developing original and innovative technological solutions and products. The integrated R&D programs are financed and implemented under a special term sheets. The most part of the fundamental and applied research should be financed within Integrated R&D programs.

Public invitations for project application within fundamental and applied research should be annually published, largely within the Integrated R&D programs. The applied projects should go though a clear and transparent scoring procedures, with the application of usual international criteria and engagement of independent reviewers from the country and abroad.
The National council shall establish at the proposal of the Ministry the rate of fundamental to applied research, and integrated R&D programs in the chapter of the budget appropriations to science research, provided the obligations already taken shall be respected.

Program of technological development should enable development of new technologies, development of all the products and enhancement manufacturing and business relations. A precondition is strict selection of technical projects to be financed in compliance with strategic priorities.

Program of incentives for development of innovations, to be made possible by financing of innovative projects within NIO and industry, establishment, development and activity of innovation centers, assistance in commercialization of products and intellectual property rights.

Program of knowledge transfer, which should make possible the development and operation of centers for transfer of know-how and networking, organization of training courses for new technologies, incentives for feasibility studies of introduction in our industry (in cooperation with the Fund for research and technology, banks and the Fund for development).

Program of establishment of risk capital funds, which should spur up the establishment of private funds of risk capital: Fund for innovation development (4.11).

In addition to the program, new legislation will be necessary, or changes and amendments to the existing one, which regulate science research and innovation activities, higher education, establishment and operations of enterprises, taxation system, Budget law, etc.

The Government should approve a separate Action plan to define implementation schedule of

such products and identify their proponents.

SUCCESS CRITERIA (initial list):

- Target defined and applicable science research programs
- Application of research results
- Enhancement of higher education
- Improved efficiency of allocation and use of all science research and development resources
- More efficient distribution of funds to science
- Enhancement of applied technology as a result of own development
- Development of national innovation system ensuring international competitiveness of Serbia
- Development of small and medium enterprises based on innovations

NEXT STEPS:

- Public debate will take place until the end of Septembr. Comments can be given through www.forum.nauka.gov.rs or strategija@nauka.gov.rs
- An actional plan will be formulated by the end of the year

- By the end of 2009. a new legal framework will be adopted:
  - Changes to the Law on research
  - Law on innovation
  - Law on intelectual property
  - Law on Serbian Academy of Sciences and Arts

- Joint work with the Ministry of education on the new Law on higher education by the end of the year
- Detailed joint action plans with other ministries and industry
- Finilizing 2010 budget and negotiations with EIB in the last quarter of 2009
- Finished framework for new project cycle and adoption in the first quarter of 2010