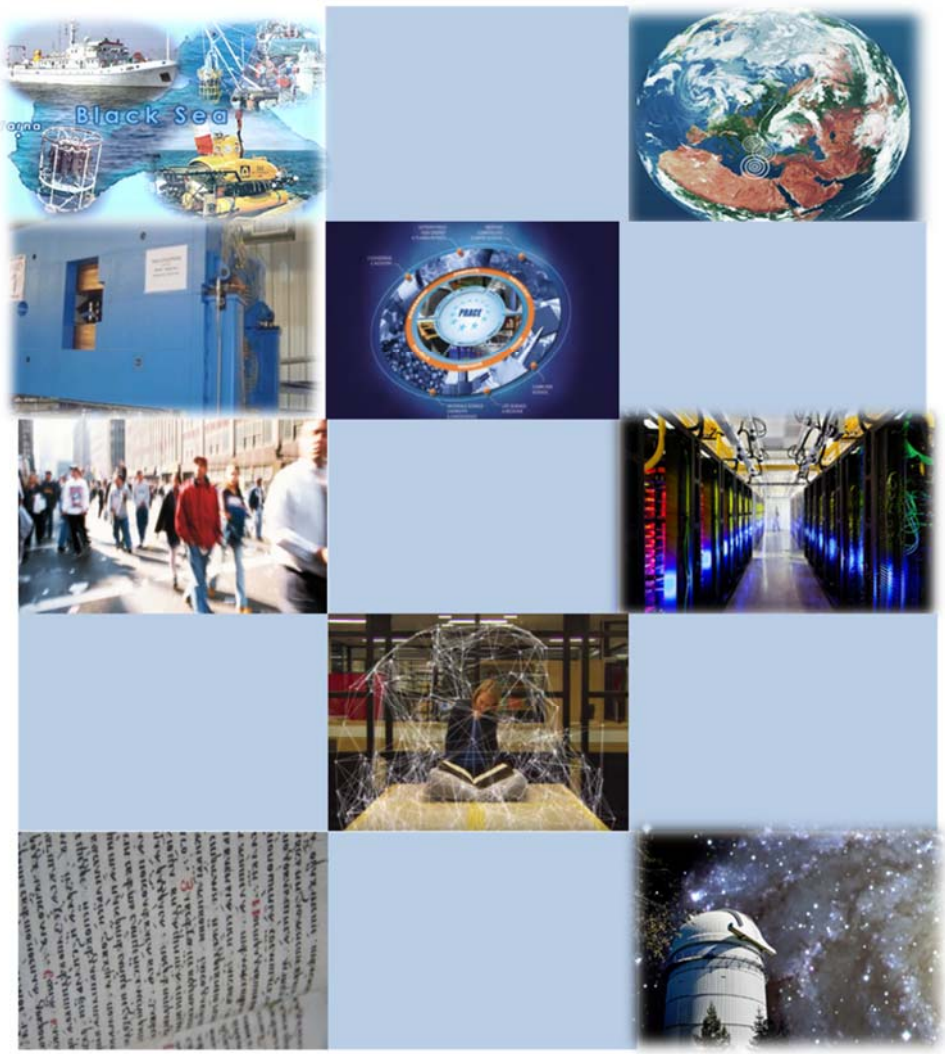
Ministry of Education and Science

Republic of Bulgaria

DIAGNOSTIC REVIEW

MAPPING OF RESEARCH INFRASTRUCTURES AND EQUIPMENT IN BULGARIA



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Contents

Abbreviations and Acronyms

AA	Agricultural Academy
BAS	Bulgarian Academy of Sciences
BERD	Business Expenditure on Research and Development
CoC	Center of Competence
CoE	Center of Excellence
DG	Directorate-General
EC	European Commission
EPO	European Patent Office
ERDF	European Regional Development Fund
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
EUR	Euro
GERD	Gross Expenditure on Research and Development
GDP	Gross Domestic Product
ICT	Information and Communication Technologies
KSP	Knowledge Sharing Program
MES	Ministry of Education and Science
M&E	Monitoring and Evaluation
NCPs	National Contact Points
NSI	National Statistical Institute
OP	Operational Program
PM	Prime Minister
PME	Physics, Material Science and Engineering
RIS 3	Research and Innovation Strategy of Smart Specialization
R&D	Research and Development
SWOT	Strength, Weakness, Opportunities and Threats
TTO	Technology Transfer Office
USPTO	United States Patent and Trade Mark Office

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The team involves key external experts, who carried out the verification of research infrastructures and research equipment and prepared in-depth analysis as per respective research areas, namely: Prof. Dimitar Tcharaktchiev (medicine), Prof. Dr. Sc. Ivan Atanassov (agro-bio science), Prof. Dimitar Karastoyanov (social science and humanities), Assoc. Prof. Eng. Tihomir Tyankov (physics, material science and engineering), and Dr. Boyan Zhekov (e-infrastructure for multidisciplinary research).

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EXECUTIVE SUMMARY

Research infrastructures are an integral part of any national scientific and research system. Their presence ensures acquiring new knowledge by serving fundamental and applied research. On the one hand, they are used to solve complex interdisciplinary scientific matters, whereas on the other, they help to commercialize research results, which introduce new innovative products and services that improve country competitiveness. Access to modern scientific infrastructure ensures the framework for the development of scientists and science and it is a prerequisite for technology and knowledge transfer to and from industry. Research infrastructures are the center of the **knowledge triangle**: education, research and business.

The Ministry of Education and Science (MES) of the Republic of Bulgaria undertook a mapping of research infrastructures, equipment and apparatus, throughout the country between December 2015 and February 2016. Academic institutions were invited to provide information about present research infrastructures and research equipment, their location and area of impact. Then, the universities and research institutes were visited by a relevant independent expert, assigned by MES, who verified the existing research infrastructures, human resources, exploitation life of the research equipment, project financing and the availability of key partners.

In partnership with the Ministry of Economy, MES undertook consultations with relevant stakeholders at national and regional levels in the past couple of years in order to discuss the state of the research infrastructures. In October 2016, senior government officials from MES met with senior officials from the European Commission - EC (DG Regional and Urban Policy and DG Research and Innovation) to discuss the update of the National Roadmap for Research Infrastructures. Follow up discussions were organized in December 2016 which required that a Diagnostic Review *Mapping of Research Infrastructures and Research Equipment in Bulgaria* is undertaken by MES.

As a result, the same experts (including a separate expert on agro-bio science, who was attracted), contracted by the Ministry of Education and Science, undertook a second review of the research infrastructures and research equipment between December 2016 and February 2017 in four broad research fields. As a result, the following **161 research infrastructures** were identified: 57 in the Physical, Material Science and Engineering; 61 in the medical and agro-bio sciences field; 29 in the social science and humanities, and 14 infrastructures in the E-infrastructure for multidisciplinary research field.

This report aims to contribute to the vision for Bulgaria to have modern and sustainable research infrastructure for the development of high quality scientific research and training.

The challenge today

Bulgaria is facing challenges today. As a member of the European Union (EU) since 2007, it has been influenced by high pressure from competition in the EU market. The impact of the global financial crisis has conveyed a trajectory of slow economic growth, unemployment, insufficient public and private investment. The political instability in the past few years has also delayed some key structural reforms. The Bulgarian population is shrinking and getting older.

In order to catch up with the EU average, Bulgaria needs to improve its research capacity in order to boost the innovation eco-system and achieve economic growth, based on knowledge-intensive sectors with new and qualified jobs.

Increasing the performance of research institutes and universities and integrating more domestic research partners in the European Research Area (ERA) would raise the potential of the national research system.

Through its European Union (EU) membership, Bulgaria relies on the European research solidarity which has yielded results mainly through the EU Framework Programs on Research and the European Structural and Investment Funds, and currently – through Horizon 2020 and the Operational Programs (OPs) on innovations, competitiveness, research competence and education.

In some major research areas, Bulgarian science has won firm positions in the global research community, which has led the research sector becoming part of ERA. In many other areas, however, scientific research does fail to meet relevant criteria for excellence.

National research system

The Bulgarian Academy of Sciences, the Agricultural Academy and key Bulgarian universities (Sofia University "St. Kl. Ohridski", Sofia Medical University, Plovdiv University, and the Technical University in Sofia) represent the major public research performing institutions in Bulgaria. The private performers are private universities, private research organizations, and enterprises involved in R&D.

Although a relatively new phenomenon (mainly due to OP "Development of the Competitiveness of the Bulgarian Economy", co-financed by ERDF during programming period 2007-2013), clusters, Technology Transfer Offices (TTOs), Sofia Tech Park, networks and platforms in Bulgaria, are the organizations responsible for the dissemination of information and research results as well as they facilitate the search for partners in Bulgaria and EU for joint innovative and research projects, promote cooperation and the development of scientific, technological and business collaborations.

R&D Funding

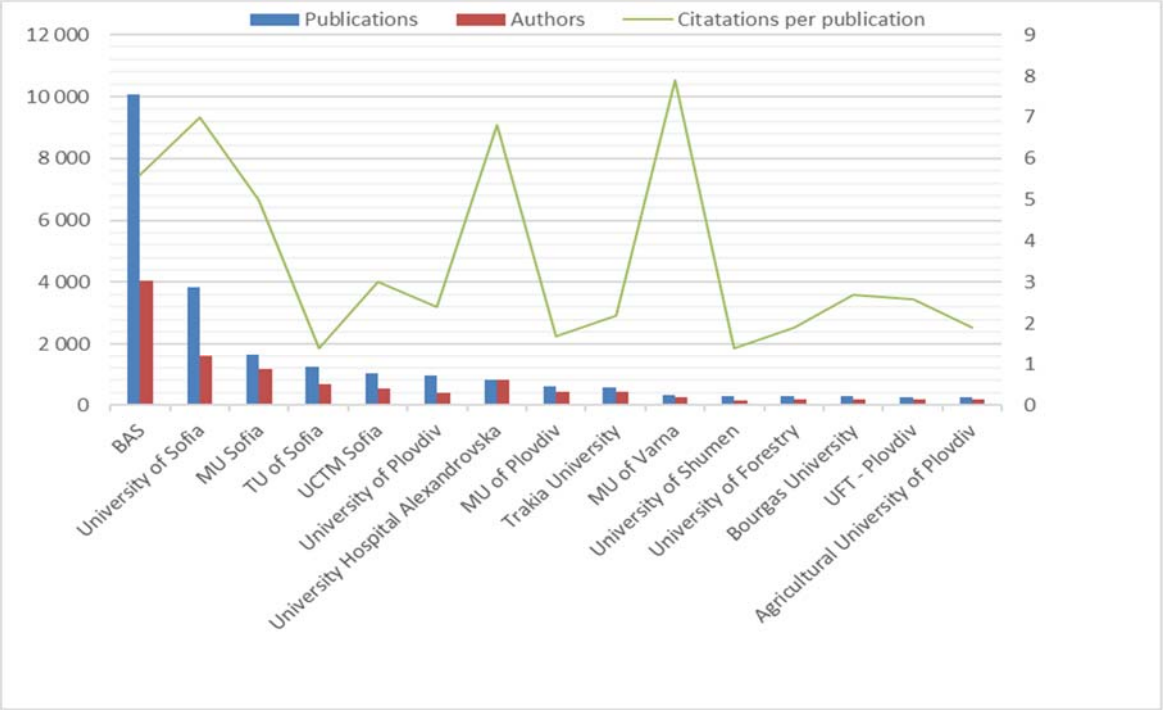
The total gross domestic expenditure on R&D (GERD) in Bulgaria for 2015 reached €430.4 m, increasing by 20% compared to 2014. Three main sources channeled R&D funding in 2015, namely: the business sector (25%), the government (30%), and foreign funding (45%). The total GERD follows an upward trend from 2005 onwards. On the other hand, starting in 2010, the direct support from the government declined. Support from EU, remained almost stable in size. Yet, it is very low in comparison to the other sources of R&D financing.

Publications

There have been 23,396 publications that were generated between 2011 and 2016 by 15,066 authors in Bulgaria as per SciVal platform. A total of 103,272 citations are estimated, which is equivalent to 4.4 citations per publication. Most of the publications are published in the area of physics and astronomy (13.1% of total), Medicine (12.4%), Chemistry (7.3%) and Agricultural and Biological Science (7.2%). Based on the metrics in the SciVal analytical platform the output of the country is mainly in the field of Physics, Chemistry, Biological Science and Engineering. Despite the observed low share of publications in the field of Environmental Science, Social Science and Humanities, their citation impact is quite high, compared to that of leading scientific fields.

The lead research organization is the Bulgarian Academy of Science, followed by Sofia University, Sofia Medical University, Technical University, the University of Chemical Technology and Metallurgy, and Plovdiv University, among others.

Top 15 best performing research organizations in Bulgaria, 2011-2016



Source: SciVal, January 2017.

Overall, physics and astronomy top the list of top 10% most cited publications worldwide with 21% share, while medicine takes second position with 16 %, followed by biochemistry, genetics and molecular biology (10%) and chemistry (10%). In terms of relative strength (the quality of the output of research in Bulgaria compared to the rest of the world) three out of this five subject areas in the group of Natural science (including Physics, Chemistry etc.) and Engineering seem to have an upward trend in regard with the Citation impact and reaching the level higher than the global average.

Patents

Bulgarian patent activity at USPTO in the period 2000-2014 is higher compared to patent activity at the EPO. There are overall 903 patent applicants and 303 registered patents at USPTO and overall, there is a positive trend since 2012.

Human Resources

As per 2015 NSI data, 53 % of the researchers in the country are women, while 47% are men. The age groups are distributed almost equally - 21 % of all researchers are in the age group of up to 34, whereas 27 % of all are in the age group between 35 and 44. Scientists between 45 and 54 and between 55 and 64 are 23 % and 24 %, respectively. Insignificant percentage of all scientists falls in the group of 65 or over – 5 %. Yet, the scientific community does require that every year there is a cohort of young scientists to enter in order to reach the EU-average levels.

Bulgarian Participation in Horizon 2020

The participation of Bulgarian researchers in European competitive calls for funding research is essential. However, the data show that Bulgaria's participation is to a large extent limited and comparatively lower to neighboring countries. There are between 160-180 publications per year (per 1 m. inhabitants) which have been published in co-authorship with foreign researchers in international refereed journals and the increase is by less than 10 % on an annual basis. Romania and Serbia do have much higher increase of common

publications, which means that Bulgarian scientists do lose significantly their positions in the international scientific ranking. Bulgaria has attracted 12.8 EUR per capita in the 7th framework program, which precedes Horizon 2020. This is six times less than the EU average of 78.9 EUR per capita. The success rate of projects with Bulgarian participation is 15.4 %, which is also lower compared to EU average of 20.4%.

Between 2014 and 2016, most of the Bulgarian research institutes and universities have applied through the Societal Challenges (97 projects), followed by Excellent Science (43) and Industrial leadership (40).

In fact, Bulgaria ranks last in the EU-28 context in terms of received Horizon 2020 funds per capita in the first two years of the program. Therefore, the trend in Horizon 2020 does demonstrate even lower outcomes compared to the 7th Framework program as Bulgarian participants have attracted 1.55 EUR per capita on an annual basis, whereas the EU average is 14.60 EUR.

There are 21 projects under Horizon 2020, identified to support the preparatory phase for ESFRI infrastructure consortiums. Overall, they have generated €1.9 m for Bulgarian research institutions since 2015, which is highly unsatisfactory and it demonstrates the weakness of the national research system.

Technological pull

There are competences in the respective priority areas of Bulgaria's RIS 3, which require highly qualified researchers, as follows.

Mechatronics and clean technologies

- ✓ Technologies for big data management in real time
- ✓ Sensor interfaces and systems for human-machine interaction
- ✓ Specialized technologies for production of micro products, incl. robotized production and technology operations
- ✓ Specialized apparatuses and systems with integrated software
- ✓ Development and production of high tech electronic and electro mechanic and mechatronic products for large manufacturing companies
- ✓ Fine mechanics, using the newest CNC equipment in the production of complex mechanic parts and components for electronics, robotics, automobile industry, medical, optical, semiconductor and other industries.

Health industries and agro-bio research areas

- ✓ Improved fermentation technologies for bio products
- ✓ Agro-bio technologies
- ✓ Medical nano diagnostics
- ✓ Technologies for better use of big data and supply of personalized medical information.

Cultural and creative industries

- ✓ Design and production of climbing walls
- ✓ Design and production of bicycles and ski
- ✓ Design and production of online video games
- ✓ Technologies for visual effects and virtual reality.

E-Infrastructure

- ✓ New technologies for management of business, finance, health and administration
- ✓ Cloud technologies, virtualization (NaaS)
- ✓ Big data, Artificial Intelligence, Automated analytical services
- ✓ Semantic technologies for text and web analysis
- ✓ Technologies for mobile apps
- ✓ Technologies for E-Commerce
- ✓ CAD, CAM, GIS Technologies

Technological Push

The mapping review of the four priority research areas develops understanding about the key actors, available research infrastructures and research equipment with the universities and research institutes in Bulgaria, as well as it talks about financing and human resource capacity. It presents also SWOT analysis. Regional specialization of the available research infrastructures in the four research areas is also in the focus of this section.

The report finds that there are 12 research infrastructures with European significance, 84 research infrastructures with national significance and 65 research infrastructures with regional significance. About 40 % of the research infrastructures have attracted less than 100,000 EUR per year over the past five years. It seems that the main source of funding for new purchases of equipment for research institutes and universities is EU project financing. About 30 % of all infrastructures are less than 15 years old or more and attracted funding comes to less than 25,000 EUR per year for 30 % of all infrastructures. There is a substantial gap in all research areas, except medical and agro-bio sciences in terms of available research infrastructures at the regional level. This requires substantial financial support for establishing new regional centers or strengthening existing regional centers of knowledge. The untapped potential seems to exist with the South-East, South Central, Northeast and Northwestern economic regions. Key finding from the in-depth analysis of all research areas is the human resource potential, which has been downgrading due to low payment for researchers and limited prestige for the research community which is losing the young generation of talented researchers who leave the country. Therefore, there is a need to further channel funding for support of soft skills and also increase the pay of researchers. It is recommended that there are special provisions to support young researchers who are either attracted by the domestic private sector or by research institutes and universities from abroad.

Key common findings are as follows:

- Not enough modern research infrastructures are available in Bulgaria, which respond to contemporary conditions for research infrastructure
- Not enough adequate management of existing research facilities and infrastructures, which are inefficiently utilized and maintained
- Imbalanced distribution of the research infrastructures in Bulgaria
- Not enough qualified researchers for maintenance of the research infrastructure.
- Financial dependence and limited cooperation with businesses
- Regional specialization is needed which is linked to district and municipal priorities
- Development of regional smart specialization strategies is needed.

Key findings per research area:

- ✓ **E-infrastructure** for multi-disciplinary research has the highest number of infrastructures with European significance, compared to other research areas, although it has also the lowest number of infrastructures, which is mainly concentrated in the capital. This is the research area with the highest number of infrastructures which are funded well over the past five years. It is recommended that new purchases of research infrastructure are maintained periodically in order to keep up with the dynamics of new trends every year. It is also advisable that new equipment is purchased by research facilities that are situated outside the capital.
- ✓ Majority of the **Physics, Material Science and Engineering** infrastructure has national significance. This is the research area with the highest percentage of obsolete infrastructure, whereas it has also the highest percentage of most modernized infrastructure in the past three years. Yet,

in order to maintain stable PME research infrastructures, there is a need to stimulate research infrastructures in this area to expand their contacts with European research partners in order to upgrade their research infrastructures from national to European significance. Therefore, there is a need to continue to invest in PME research infrastructures so that scientists keep up with the level of research excellence in Europe.

- ✓ **Medical and Agro-bio Science** research area has the highest number of infrastructures with regional significance. Hence, this is the research area which offers the highest degree of decentralization. This is the research area with the lowest funding over the past five years due to the agro-bio science research area, while it has also the highest share of new research, equipment and apparatuses, which is due to the medical research area. Therefore, it is recommended that more funding is available for this research area. It is also advisable that regional hubs of agro-bio science facilities are strengthened through new purchases of equipment and apparatuses.
- ✓ Research infrastructure in the **Social Science and Humanities** is the most equally distributed throughout the country, while at the same time it has the lowest percentage of attracted competitive funding over the past five years. Moreover, it is the research area with the most outdated research infrastructure. Therefore, it is recommended that investments are channeled for new purchases of equipment and apparatuses.

Thematic Specialization

Physics, Material Science and Engineering

There are 57 research infrastructures in the Physics, Material Science and Engineering (PME) research area that are located in 15 scientific organizations in Bulgaria. Most of the scientific organizations are situated in Sofia, the capital of Bulgaria (10 scientific organizations), which falls in the **Southwestern economic region**. The other five organizations are situated in the **North-eastern region**, (TU - Varna), **North-Central region** (TU - Gabrovo), **South-central region** (Central laboratory of applied physics – Plovdiv - BAS), **South-Western region** (Blagoevgrad), and **South-eastern region** (University "Prof. A. Zlatarov" - Burgas) of the country. Thus, they cover the whole territory of the country, except **North-western region** where there is no research infrastructure identified. Overall, 66 % of the research infrastructures are located in the capital of Bulgaria, while 34 % are in the rest of the country. This is too much of a concentration of the PME research infrastructures and there is a need to channel more funding in this area to other economic regions.

Medicine and Agro-Bio Science

Leading organization in the field are the Bulgarian Academy of Science and the Medical Universities. There are overall 61 research infrastructures in this research area, 20 being in medical science. In terms of **regional specialization**, 42 % of the infrastructures are situated in Sofia, while 58% in the rest of the country. Majority of the research infrastructures in the medical sciences are situated in the **South-western region**. For example, the Medical University - Sofia (3 Infrastructures, one of them together with Medical University - Plovdiv), Sofia University "St. Kliment Ohridski" (1 infrastructure registered as "Allianz for Cell Technology" together with associations (NGOs) and private companies), Bulgarian Academy of Sciences (3 infrastructures, two of them are situated in the Institute of Molecular Biology), and South-West University "Neofit Rilski" (2 infrastructures). As far as research infrastructures of the agro-bio sciences research area is concerned, they are located throughout the country (institutes of the Agricultural Academy). In **South-Western region** and mainly in the capital of Bulgaria – 8 research institutes one university and Sofia Tech Park

are found. Three institute and three universities are located in Plovdiv – **South Central region**. In the **South Eastern region** we found 3 institutes and one university. In **North Eastern region** we found 2 institutes. In **North Central region** we have four institutes. **North-western region** has no representatives of these research areas. Therefore, there is a need to further strengthen the regional specialization in both, the medicine and agro-bio science research areas.

Social Sciences and Humanities

There are 29 research infrastructures in the social science and humanities field, located in 20 key research institutions and universities. The **regional specialization** is structured as follows. The infrastructure of these research institutes and universities are situated mostly in Sofia (8 institutions), **South-Western region**. Three of them are situated in the **North-Central Region** (Gabrovo, V. Turnovo, Rouse), two Organizations are situated in the **South-Western Region** (Blagoevgrad), three organizations are situated in the **South-Central Region** (Plovdiv), two organizations are situated in the **South-Eastern Region** (Stara Zagora, Bourgas) and two Organizations are situated in the **North-Eastern Region** (Varna). No research infrastructures are declared in the **North-Western Region**. Overall, 62 % of the available infrastructures are present in the capital of Bulgaria and 38 % are found in the rest of the country (Plovdiv, Blagoevgrad, Varna, Russe, V.Tarnovo, St.Zagora and Gabrovo). Therefore, there is a large concentration of the social sciences and humanities research infrastructures in the capital of Bulgaria and more funds need to be distributed at the regional levels.

E-infrastructures for multidisciplinary research

There are only five universities, one institute of the Bulgarian Academy of Sciences and Sofia Tech Park which are active in the e-infrastructures field. Overall, there are **14 Infrastructures** available and the infrastructure is very concentrated in the capital of Bulgaria (86 % of all) with some presence in North-Central, North-Eastern and South-eastern regions. Too much concentration in the capital of Bulgaria for e-infrastructures does require a policy for strengthening regional actors to establish new e-infrastructures throughout the country.

Diagnostic analyses –mapping, % Overlap

ISSS / Science Research Areas	Information and Communication Technologies and Informatics;	Mechatronics and Clean Technologies	Healthy lifestyle and Biotechnology Industries	New Technologies in the Creative and Recreatitional Industries.
E-infrastructure for multidisciplinary research.	100 %	60%	50%	40%
Physics, Material Sciences and Engineering;	60%	100%	35%	25%
Medical and Agro-Bio Sciences;	25%	25%	100%	20%
Social and Humanitarian Science;	40%	10%	20%	80%

Regional Specialization

North-Western

There is only one unique infrastructure that is located in the medicine research area. This is the telecommunications endoscopy center (TELEC), which is unique infrastructure in Bulgaria, placed at the Medicine University in Plevel and second in Southeast Europe. It provides access to robotic system "Da Vinci S" and "Da Vinci Si" which allows the performing of robotic surgery in the field of onco-gynecology, urology, general surgery and cardiac surgery. There is a need for national support in order to maintain and further develop this research infrastructure.

The Vine and Wine Institute in Pleven is a regional lab in the Agro-bio science research area. The only available Grain Institute of the Agricultural Academy is placed in this region. It has, however, very obsolete research equipment, which requires modernization as this institute has a great value. The scientific center requires also upgrade of the human capital.

The bicycle industry and the rechargeable battery industry are well developed in this region, which requires that the necessary researchers are needed to help the local industry grow.

North-Central

There are 14 unique research infrastructures that are located in this region. One e-infrastructure is available, called Research and educational Development Laboratory (REDL) "CNC technology, CAD / CAM design and prototyping". It is located at the Technical University in Gabrovo. In the physics, material science and engineering, there are six infrastructures – 5 of them being regional and one European. Most of these infrastructures are available at the Technical University in Gabrovo, namely:

- ✓ Research, training and production laboratory (RTPL) “Microelectronic systems”;
- ✓ Laboratory of automation devices SIEMENS
- ✓ Laboratory of Industrial automation BECKHOFF:
- ✓ Laboratory of programmable controllers UNITRONICS
- ✓ Laboratory of operating equipment AMK

It is therefore recommended that there is a need to increase funding in the space of physics, material science and engineering.

There are three regional labs of the Agricultural Academy in this region, which requires that more investments are channeled to the bio-agro science research area. Social sciences and humanities are represented by two regional and one European infrastructure. There are laboratories that deal with national security, but its research infrastructures are outdated. Therefore, there is a need to channel more funds to this region in order to develop unique research infrastructure in the security space with pan-european significance.

North-Eastern

In the North East region there are 14 infrastructures and laboratories. One is available in the e-infrastructure; 8 in the Physical, Material Science and Engineering; 3 in the Medical and Agro-Bio Science and 2 in the Social Sciences and Humanities. The infrastructure for Marine Studies is considered a leader, as it includes Research ship “Akademik”; research submarine PC-8B; Analytical laboratory complex; National operative marine observation system; BulARGO; Bulgarian National Oceanographic Data Centre. 11 infrastructures have regional importance. The most notable are the lab for Renewable energy and the

Agroecological lab for quality analysis of plants and foods and assessment of the components of environment, Accredited lab for structural analysis (Technical University – Varna) and the Center for Translational Medicine and Cell Therapy at the Medical University in Varna. Two infrastructures with national significance are available in the field of e-infrastructure, including "Marine science and technologies at the Naval Academy in Varna and the Laboratory "Combating disasters and accidents" at the Technical University – Varna. There is a need to support the unique research infrastructures in the marine studies and the regional hubs of agro-bio sciences, which need to provide high quality of research.

South-Eastern

There are 20 infrastructures and equipped labs in this region. There is one e-infrastructure for multidisciplinary research, while the physics, material science and engineering has 7 infrastructures; medical and agro-bio science has 12 available infrastructures and the social sciences and humanities has 2 infrastructures. There are 18 regional infrastructures in all four categories, including the Labs "Analysis for water/innovative technologies for water purification with the Prof. Assen Zlatarov – Bourgas. There are two infrastructures with national significance in the medical and agro-bio sciences – Genetic Lab at the Trakia University in St.Zagora and Cisco Academy and Pearson Vue – Testing Center at the Prof. Assen Zlatarov University in Bourgas.

The development of national priority for bio production does have a huge impact on this region, which is traditionally strong in food, cosmetics and medicine, based on natural Bulgarian sources. Large infrastructure complexes of Trakia University and Assen Zlatarev University represent the region in the "Medical and Agro-Bio Sciences"- 12 research infrastructures, which translates into the necessity to further maintain these infrastructures and provide a modern equipment to maintain the facilities. It is recommended that more investments are channeled to infrastructures that operate in the space of purification and water management, as well as marine science and technologies.

South-Central

There is no e-infrastructures identified in the South Central region. One lab in the field of Physical, Material Science and Engineering, called Central laboratory of applied physics – Plovdiv (Bulgarian Academy of Sciences) is available and one for Astronomy and Space Science (Regional Center for Astronomical Research and Education). The Regional Center for Astronomical Research and Education partners with the European Space Agency (RACIO). This region has 12 labs in the medical and agro-bio sciences research area. Nine of these labs are in fact in the area of agro-bio sciences.

South-Western

Most of the infrastructures in the e-infrastructure are located in this region - 11 infrastructures are found in the capital of Bulgaria. 3 of the infrastructures are partners in 4 ESFRI ERICs, namely EGI; PRACE, CLARIN and GEANT – through Bulgarian Research & Education Network (BREN), which is a consortium of science, academy and government institutions. 26 laboratories are identified in the region in the research area of Physical, Material and Engineering Sciences. Most of them are situated in research institutions in Sofia (10 scientific organisations). Leaders is the field of mechatronics and micro/nano manipulation systems are Technical University – Sofia with its two infrastructures: Laboratory "CAD/CAM/CAE in industry" and Faculty of Mechatronics lab; and one Laboratory for robotization of micro/nano manipulations with biological cells and micro-objects at the Institute of Mechanics of the Bulgarian Academy of Sciences. In the field of Renewable energy one infrastructure exists; Experimental platform for technology investigations for energy from renewable sources (Technical University - Sofia).

There are three leaders in the Energy storage and hydrogen based technologies - Institute of electrochemistry and energy systems "Acad. E. Budevski" - BAS (IEES), Radiophysics and electronics department– Sofia University, Innovation Center for Eco-Energy Technologies - South-West University "Neofit Rilski"- Blagoevgrad. 12 labs are equipped in the field of advanced nanomaterials (Institute of Physical Chemistry, Institute of Catalysis , Institute of organic chemistry with center of phytochemistry – BAS (INFRAMAT), Faculty of chemistry and pharmacy – Sofia University (INFRAMAT), Laboratory "Spectroscopy of crystals and biological objects" – Sofia University (INFRAMAT), Laboratory "Electronic and phonon properties of solid state materials and structures" – Sofia University (INFRAMAT), Laboratory "Materials technology" – Sofia University, Laboratory "Electroacoustic interactions" – Sofia University, Acoustic waves Department – Sofia University (INFRAMAT), Institute of mineralogy and crystallography "Acad. Ivan Kostov" – BAS, Laboratory for experimental micro and nano-mechanics (Institute of Mechanics – BAS), Sofia TechPark. The extended possibilities from the participation of INFRAMAT unique infrastructure in ESFRI CERIC-ERIC will improve the service qualities offered to the industry.

One non-waste technologies and sustainable control and water utilization lab in the Faculty of Biology at Sofia University is identified in this region, as well as three laboratories, clustered in laser optics (Laboratory Laser physics and applications; Laboratory Femtosecond photonics, Quantum electronics Department - Sofia University). There are also 2 labs in the Micro-electronic engineering which prove significant research and scientific investigations but have no so significant infrastructure (Laboratory "Automated design in the electronics and micro-electronics" (Technical University - Sofia), Laboratory "Ionising radiation detectors" (Sofia University).

The region in the area of Medical and Agricultural Sciences is represented by 16 Labs. There are 9 infrastructures in the medical research area are as follows: Medical University - Sofia; Sofia University "St. Kliment Ohridski" (1 infrastructure registered as "Allianz for Cell Technology" together with associations (NGOs) and private companies); Bulgarian Academy of Sciences (3 infrastructures, two of them are situated in the Institute of Molecular Biology); and two infrastructures with the South-West University "Neofit Rilski".

There are 7 infrastructures in the agro-bio science research area as follows: The Faculty of Chemistry and Pharmacy (FCP-SU) and Faculty of Biology (FB-SU) possess well-equipped laboratory complex for basic and applied research in Microbiology, Plant Biotechnology, Genetics, Biophysics equipped with basic and specialized 2 labs and and infrastructure of Joint Genomic Center for Molecular Biology and Metabolite analysis lab for applied research. The main two laboratories of Agricultural academy are AgroBioInstitute, Sofia and Institute of Cryobiology and Food Technology, Sofia. The Institute of Organic Chemistry with Center for Phytochemistry – Sofia, /IOCCP/ is leading in the country and well-recognized abroad institute for research in the field of phytochemistry, extraction and characterization of natural bioactive compounds with 2 main infrastructures.

There are 10 infrastructures in the Social Sciences and Humanities field. 3 Multimedia centers are found at Sofia University "Kliment Ochridski" (Video Conference System and Repository), whereas the South-Western University in Blagoevgrad has a Multi Media Center of computerized Archives, and the Academy of Ministry of Internal Affairs has Schengen Information System – Education version). Furthermore, web-based platforms are available in three Research Infrastructures at the University of National and World Economy-Sofia, Sofia University "St. Kl. Ochridski" (web platform for online control of research communication). Four research infrastructures are available with databases and other social sciences and humanities repositories.

Overall, the South-western economic region is the best performer in the country and its role for strengthening partnerships between Bulgarian research infrastructures and Pan-European research infrastructures is crucial. Beyond that, research institutes from this region need to increase the transfer of know-how to research institutes and universities

throughout the country in order to improve the regional strength in respective research areas. In this respect, special funding should be directed towards improving partnerships of this kind.

Regional Specialization per Research Area in Bulgaria

Region/research area	PME	Medicine & Agro-Bio Science	Social Science and Humanities	E-Infrastructures for multidisciplinary research
North-Western	n/a	*	n/a	n/a
North-Central	**	**	*	*
North-Eastern	***	**	**	*
South-Western	***	***	***	***
South-Central	*	***	***	n/a
South-Eastern	***	***	*	*

Note: *** (high level of presence of research infrastructure); ** (mid-level); *(low- level); n/a – not available.

Given the specialization of Bulgaria's RIS 3, which prioritizes certain sectors of the economy in the six economic regions of the country[1], we could summarize the following gaps at the regional level, which require specific policy action.

North-West has a huge gap compared to all other regions as infrastructure is available only in the Medicine and Agro-Bio Science research area. At the same time, it does prioritize in OP Innovation and Competitiveness all sectors, except ICT. It is crucial that this region is supported through European and national funding in the areas that have already demonstrated research potential. Yet, government policies need to incentivize businesses and researchers to cooperate in areas which are new to the region.	**North-Central** does have a potential to specialize more in ICT, but the potential of using and further strengthening the research infrastructure in PME and Medicine and Agro-Bio Science is there. Therefore, there is a need to channel funding for new equipment in all three priority areas.	**North-Eastern** does have a high specialization in the mechatronics and clean technologies field but it could strengthen its potential also in the healthy life industries and biotech, as well as in the creative and recreational industries, where there is a priority under Bulgaria's RIS 3.
South-Western stands far away from other regions in terms of presence of research infrastructure in all four areas. Moreover, Bulgarian research infrastructures which are integrated in Pan-European partnerships are exclusively coordinated by research institutes and universities, which	**South-Central** faces the highest gap in terms of available research infrastructure and priorities under Bulgaria's RIS 3. Creational and recreational industries will not be supported, although there is strong research infrastructure in the field of	**South-Eastern** does have available strong research infrastructure in the mechatronics and clean technologies, as well as in the health life industries and biotech areas, which are also priorities in the RIS 3. Limited research infrastructure in the social

[1] The ICT industry is present in North-Central, South-western and South-Central region; Mechatronics and clean technologies is missing in the South-Western region, but present in all others; health industries and biotechnologies is present in all regions; and New Technologies in creative an recreational industries is present in all economic regions but North-Central and South-Central regions.

are located in the capital of Bulgaria. It stands out clearly that its highly sophisticated presence of research infrastructure in the PME area does not match the lack of priority in the OP Innovation and Competitiveness, guided by Bulgaria's RIS 3, for projects that support the mechatronics and clean technologies production.	social sciences and humanities. Moreover, there is no capacity in e-infrastructures, whereas the ICT industry will be supported through OP Innovation and Competitiveness. Finally, there is limited research infrastructure in PME area, although mechatronics and clean technologies are supported by OP Innovation and Competitiveness.	sciences and humanities would need to be improved through support under OP Innovation and Competi-tiveness for creative and recreational industries.

Mid-Term Financial Strategy

In terms of regional distribution of R&D financing, the South-Western economic region is far ahead. It generates about 75 % of all R&D financing, whereas the second largest R&D contributor (South-Central economic region), generates only 7.7 % of all R&D financing in 2015. There is a need to channel public R&D funding through EU and national financing to the other economic regions. Given the target of 1.5 % of GDP in R&D financing by 2020, this report estimates 0.7% of GDP in R&D financing (public and private) for all regions, except South-western region, which will generate 2%. Overall, this represents a contribution of 66% of all R&D in 2020.

The mid-term financial strategy for 2018-2020 should incorporate a substantial increase of public funding and the thresholds are indicated below.

Distribution of R&D public funding for 2018-2020, in M. EUR

	2018	**2019**	**2020**
Operational Program Science and Education for Smart Growth	70	70	45
- EU funds for CoE, CoC, Unique infrastructures	59.5	59.5	38.25
- National co-financing	10.5	10.5	6.75
National Funding for RIs	10.5	11	14
- National Roadmap for RI	8	8	10.5
- Non-competitive funding through National Science Fund	2.5	3	3.5
Horizon 2020 and other EU competitive programs	39.5	49	81
Overall:	120	130	140

Source: Authors.

National co-financing for R&D projects, funded by Operational Programs, like the OP for Education and Science for Smart Growth is estimated at 27.75 m. EUR for 2018-2020, whereas EU funding for the same period is estimated at close to 157.25 m. EUR. Dedicated funding for the National Roadmap for Research Infrastructures is estimated at a total of 35.5 m. EUR for the same period, given that the EU funds for Centers of Excellence and Centers of Competence will fund the budget gaps of research infrastructures in the National Roadmap.

Non-competitive funding from the National Science Fund will provide 9 m. EUR for national research infrastructures.

Provided that CoCs and CoEs will launch full operation in 2018, it is expected that the number of successful project applications by Bulgarian partners (Bulgarian research institutes, universities, and companies) to Horizon 2020 Programs and other competitive EU calls will reach EUR 170 M. in 2018-2020.

DIAGNOSTIC REVIEW

MAPPING OF RESEARCH INFRASTRUCTURES AND EQUIPMENT IN BULGARIA

Introduction

The research infrastructures are an integral part of any national scientific and research system. Their presence ensures acquiring new knowledge by serving fundamental and applied research. On the one hand, they are used to solve complex interdisciplinary scientific matters, whereas on the other, they help to commercialize research results, which introduce new innovative products and services that improve country competitiveness. Access to modern scientific infrastructure ensures the framework for the development of scientists and science and it is a prerequisite for technology and knowledge transfer to and from industry. Research infrastructures are the center of the **knowledge triangle**: education, research and business.

The National Roadmap for Bulgaria's Research Infrastructures is essential for achieving these aims and it is one of the most successful European initiatives that attract European and international scientific organizations in the implementation processes of scientific research. It is of great importance also for increasing the level of R&D funding. The inclusion of research infrastructures in the agenda of a number of strategic documents for science and development, as for instance the Europe 2020 Strategy, is a proof for this. The development of research infrastructures is one of the five pillars of the **European Research Area** and this is a leading motive in the provision of the National Roadmap of Research Infrastructures for Bulgaria.[2]

A prerequisite for defining a relevant National Roadmap of Research Infrastructures is the process of **mapping of research infrastructures** and **research equipment** which identifies all key actors in the scientific field and specifies key characteristics of research

[2] The first National Roadmap of Research Infrastructures for Bulgaria was adopted in 2010 with Council of Ministers' Decisions № 692 and it served as a base for defining national needs in the field of scientific infrastructure. It is linked to the priorities of ESFRI. An update of the National Roadmap was adopted with Council of Ministers' Decision № 569/31 in July 2014 for review and assessment of existing and new research infrastructures to identify those that fit into the European priorities and frame priority areas for modernization and/or development of new scientific facilities. The assessment has been conducted at two levels - national and international. At the national level, the assessment has been carried out by an interdisciplinary Working Group with representatives of the Bulgarian Academy of Sciences (BAS), universities, NGOs and ministries. The national Working Group has reviewed, evaluated and selected proposals received by research areas.

infrastructure of research institutes and universities, including human resource, exploitation period of the scientific infrastructure, financing, among others.

The Ministry of Education and Science (MES) of the Republic of Bulgaria undertook a mapping of research infrastructures, equipment and apparatuses throughout the country between December 2015 and February 2016.[3] Academic institutions were invited to provide information about present research infrastructures and research equipment, their location and area of impact. Then, the universities and research institutes were visited by a relevant independent expert[4], assigned by MES, who verified the existing research infrastructures, human resources, exploitation life of research equipment, project financing and the availability of key partners.

In partnership with the Ministry of Economy, MES undertook consultations with relevant stakeholders (academics, business associations and representatives of government institutions) at national and regional levels in the past couple of years in order to discuss the state of the research infrastructures and the National Roadmap of Research Infrastructures. These consultations reflected the state of preparedness of research infrastructures in the Roadmap to take an active part in ESFRI (See, Appendix 1, List of meetings).

In October 2016, senior government officials from MES met with senior officials from the European Commission - EC (DG Regional and Urban Policy and DG Research and Innovation) to discuss the update of the National Roadmap for Research Infrastructures. Follow up discussions were organized in December 2016 which required that a Diagnostic Review *Mapping of Research Infrastructures and Equipment in Bulgaria* is undertaken by MES.

The present document reflects the discussions with EC and it is structured as follows. *Section 2* discusses the policy domain and provides a snapshot of the research performance. *Section 3* develops analysis of four broad research areas, based on available research infrastructure, human resources, financing, as well as SWOT analysis. *Section 4* provides mid-term financial strategy (2018-2020) for support of science in Bulgaria and discusses changes in the institution building. It also incorporates a monitoring & evaluation aspect. Finally, the document concludes.

[3] The first mapping of the research infrastructures in Bulgaria was carried out by MES in 2008.

[4] The following experts were selected by MES to verify existing research infrastructures: Prof. Dimitar Tcharukchiev, Prof. Dimitar Karastoyanov, Assoc. Prof. Eng. Tihomir Tyankov, and Dr. Boyan Zhekov. Prof. Dr. Sc. Ivan Atanassov joined the team at a later stage.

Landscape Analysis of the Research System

Policy domain

Through its European Union (EU) membership, Bulgaria relies on the European research solidarity which has yielded results mainly through the EU Framework Programs on Research and the European Structural and Investment Funds, and currently – through Horizon 2020 and the Operational Programs (OPs) on innovations, competitiveness, research competence and education.

In terms of institutional support, the national policy for research and innovations is conducted by the Ministry of Education and Science (MES) and the Ministry of Economy (ME), but an active role in the development of research and innovation policy is played also by the Ministry of Agriculture and Foods, the Ministry of Transport, Information Technology and Communications, the Ministry of Health, the Ministry of Defense and the Ministry of the Interior. The Ministry of Finance, which is the budget holder, is also a key counterpart in identifying areas for financing of the national research priorities, including a 3-year budget forecast.

MES designs and carries the national education and research system and oversees the functioning of the main public research funding instrument – the National Science Fund. MES coordinates also the Managing Authority of OP "Science and Education for Smart Growth 2014-2020" (General Directorate "Structural Funds and International Educational Programs") and the network of National Contact Points (NCP) for the EU framework programs for research and innovation (within the "Science" Directorate).

A **game changer** for the national research system has become Bulgaria's RIS 3, which has been developed between 2012 and 2015 with the support of an international expert team of the World Bank.[5] The strategy document was eventually adopted on November 3, 2015 by the Council of Ministers' (COM) Decision No.857. An Action Plan for Bulgaria's RIS 3 was approved in end- 2016.

Bulgaria's RIS3 puts four sectors of the economy in priority, namely **Information and Communication Technologies (**

Research studies in 51 universities throughout the country are implemented under the Law on Higher Education and Ordinance of the terms and procedure for planning,

[5] The World Bank signed a partnership agreement for reimbursable advisory services with the Ministry of Economy, Energy and Tourism in July 2012, which paved the way for developing a series of documents which supported analytically the RIS 3 strategy and the proposed governance mechanism of the national innovation eco-system. Relevant World Bank documents are available: http://www.mi.government.bg/bg/themes/inovacionna-strategiya-za-inteligentna-specializaciya-1193-287.html [21 March 2017].

[6] The mayor of Sofia launched the work on RIS3 for Sofia in December 2014 by setting up an expert group, which met between January and November 2015 with businesses, academics, public officials and experts to develop the RIS3 analyses and the strategic vision. In overall 30 events, the living document was discussed and further elaborated. Outcomes of the report were presented to consultative councils of the Sofia Municipality – Expert Council for Science, Technology and Innovation and the Business Consultative Council which provided comments and advice.

[7] Information about the RIS3 data and process is available at: http://s3platform.jrc.ec.europa.eu/home. [21 March 2017].

allocating and spending budget funds earmarked for the relevant research or creative and artistic activities at higher education institutions, as well as the participations of higher education institutions or their units in R&D on a project principle with public and/or private funding.

The Bulgarian Academy of Sciences (BAS), the Agricultural Academy (AA) and key Bulgarian universities (i.e. Sofia University, Plovdiv University and the Technical University in Sofia) represent the major public research performing institutions in Bulgaria. The private performers are private universities, private research organizations, and enterprises involved in R&D.

Although a relatively new phenomenon (mainly due to OP "Development of the Competitiveness of the Bulgarian Economy", co-financed by ERDF during programming period 2007-2013), clusters, Technology Transfer Offices (TTOs), Sofia Tech Park, networks and platforms in Bulgaria, are the organizations responsible for the dissemination of information and research results as well as they facilitate the search for partners in Bulgaria and EU for joint innovative and research projects, promote cooperation and the development of scientific, technological and business collaborations.

In July 2016, *"Technological Road Maps for the Four Priority Sectors of the Economy under Bulgaria's RIS 3"* was completed, which provided detailed analysis of global trends and local capacity for production of products and services, identified as great potential for technological development.[8]

A renewed Bulgarian research strategy 2025 was adopted by the Council of Ministers in October 2016. Yet, it underwent another revision in order to achieve maximal impact on Bulgaria's society. The renewed strategy was placed for public consultation in March 2017 and it awaits Council of Ministers decision. The new strategy covers the period until 2030 and it offers a fast, scalable and long-term development of the research system in order to raise the international prestige of Bulgaria as an attractive center for modern scientific research and development of new technologies to keep young talents in the country and achieve economic growth.

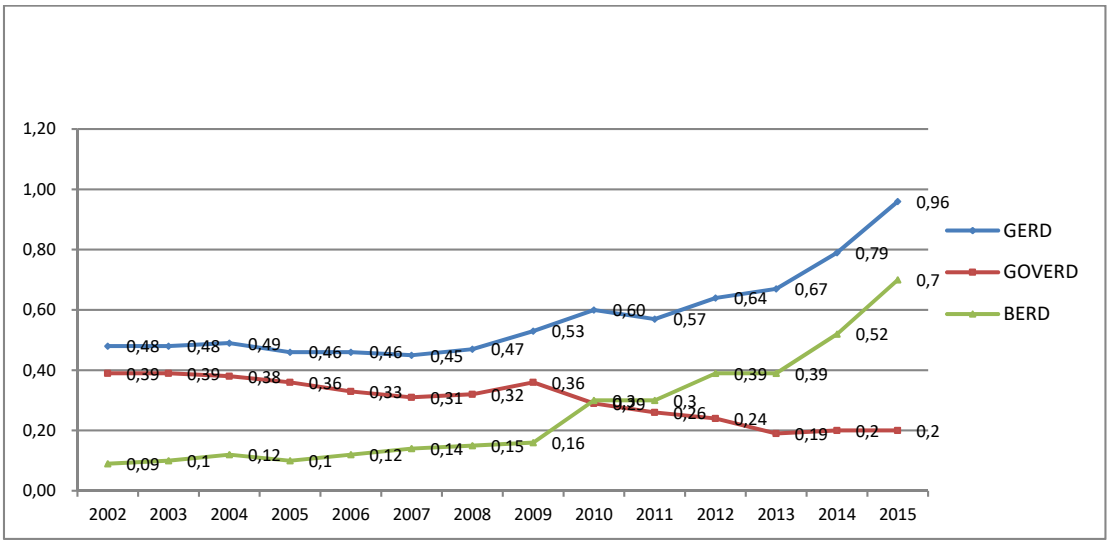
[8] The document was prepared by Strategma for the Ministry of Economy.

Snapshot of Bulgaria's research performance

R&D Funding

The total gross domestic expenditure on R&D (GERD) in Bulgaria for 2015 reached €430.4 m, increasing by 20% compared to 2014. Three main sources channeled R&D funding in 2015, namely: the business sector (25%), the government (30%), and foreign funding (45%). The total GERD follows an upward trend from 2005 onwards. On the other hand, starting in 2010, the direct support from the government declined. Support from EU, remains almost stable in size and it is very low in comparison to the other sources of R&D financing (See, fig.1).

Figure 1: Government funding of the total GERD



Source: Eurostat (Jan. 2017).

The public sector is almost exclusively the recipient of government funded GERD. The share of direct public funding going into the business sector is negligible until 2007, then increases in 2008, before decreasing again in 2009.

In Bulgaria, the intensity of the business enterprise expenditure on R&D (BERD) is modest (0.7% of the GDP in 2015), but it has been on the rise since 2009. The rise is most probably related to the increased role of financing inflows from abroad. However, restricted data availability due to confidentiality limits any detailed analysis of the degree of internationalization or inward R&D penetration. Services and manufacture together account for more than 95% of the BERD expenditure in the period under focus. It is worth mentioning that the services clearly take the lion's share of the BERD (whereas the intensity of the manufacture stagnates in the period 2006-2014) and they are strongly correlated to the total BERD intensity.

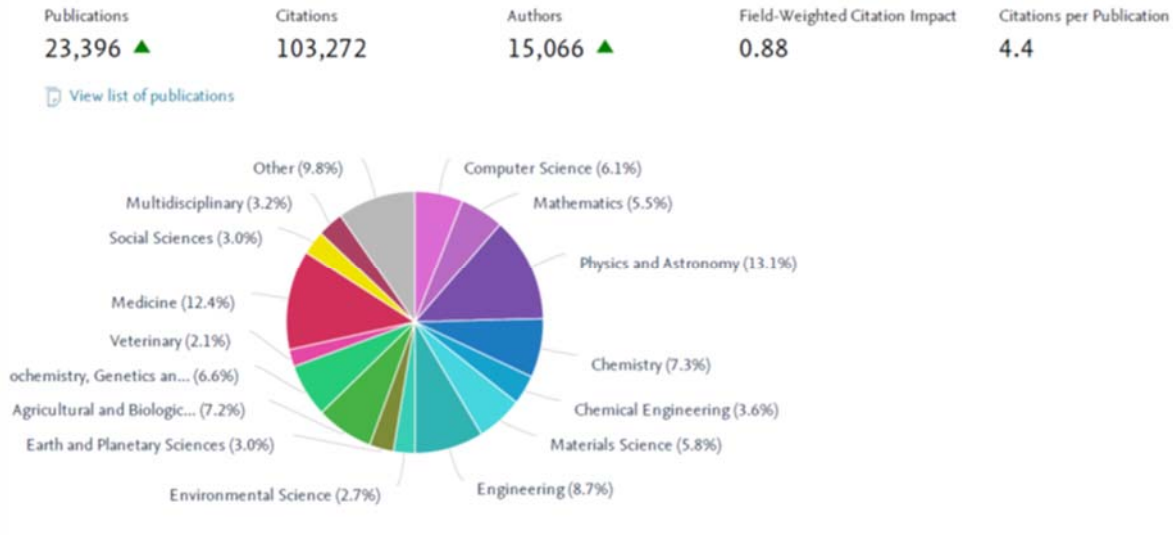
The business expenditure on R&D in the top manufacturing sectors in Bulgaria experienced strong fluctuations in the period 2006-2013. In spite of this, there is a growing trend in 2009-2013 in the manufacturing of machinery and equipment. The pharmaceutical industry is another leading manufacturing sector in Bulgaria, and so is (although at lower levels of BERD expenditure) the manufacturing in electronics.

The regional R&D distribution is to a very large extent concentrated in Southwest Bulgaria (over €250 m.) and North and South East Bulgaria (over €150 m.) in 2014.

Publications

A total of 23,396 publications were generated between 2011 and 2016 by 15,066 authors in Bulgaria. A total of 103,272 citations are estimated, which is equivalent to 4.4 citations per publication. As seen from Figure 2, most of the publications are published in the area of Physics and Astronomy (13.1% of total), Medicine (12.4%) and Agricultural and Biological Science (7.2%).

Figure 2: Overall research performance of Bulgaria, 2011-2016



Source: SciVal

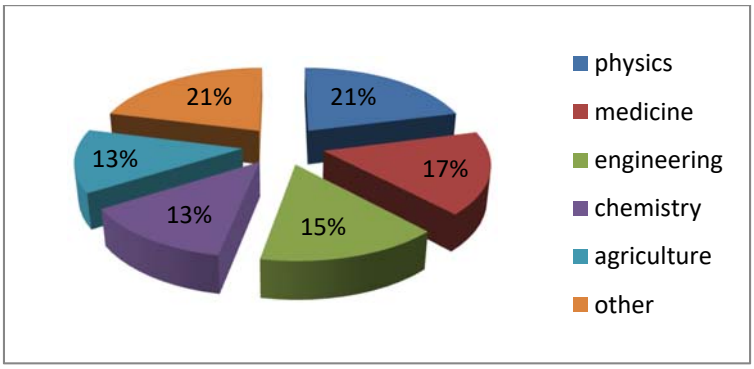
Based on the metrics in the SciVal analytical platform the research output of the country is mainly in the field of Physics, Chemistry, Biological Science and Engineering. Despite the observed low share of publications in the field of Environmental Science, Social Science and Humanities, their citation impact is quite high, compared to that of leading scientific fields (See, Fig.3).

Figure 3: Research output of Bulgaria in the scientific arears and Citation impact, 2011-2016

Source: *SciVal, 2011-2016.*

The total number of publications in Bulgaria for the period between 2011 and 2016 came to 23,740. The number of publications (indexed in SCOPUS) in Bulgaria in 2015 was 3,960, which is an increase by 40% compared to published articles in 2011.

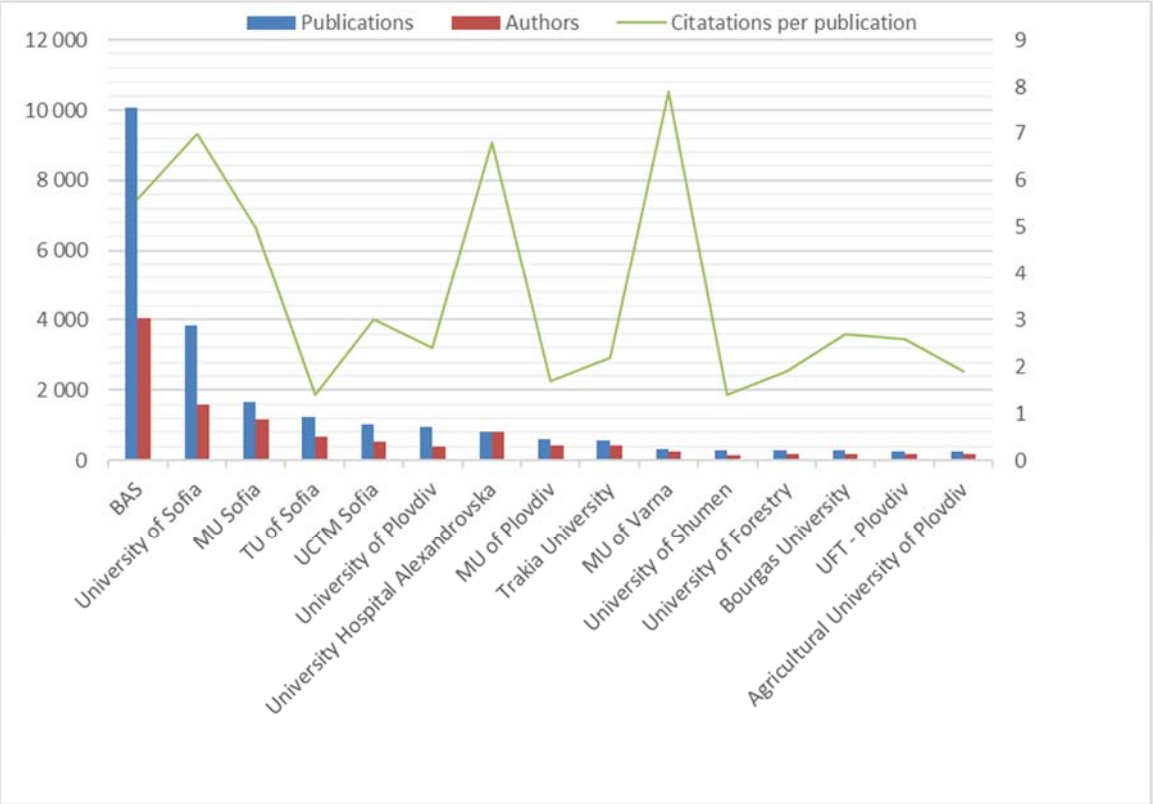
Figure 4: % of overall Bulgarian publications indexed in Scopus, 2011-2016



Source: SCOPUS.

The lead research organization is the Bulgarian Academy of Science, which is composed of 47 research institutes, followed by Sofia University, Sofia Medical University, Technical University, the University of Chemical Technology and Metallurgy, and Plovdiv University, among others (See, Fig.5).

Figure 5: Top 15 best performing research organizations in Bulgaria, 2011-2016



Source: SciVal, January 2017.

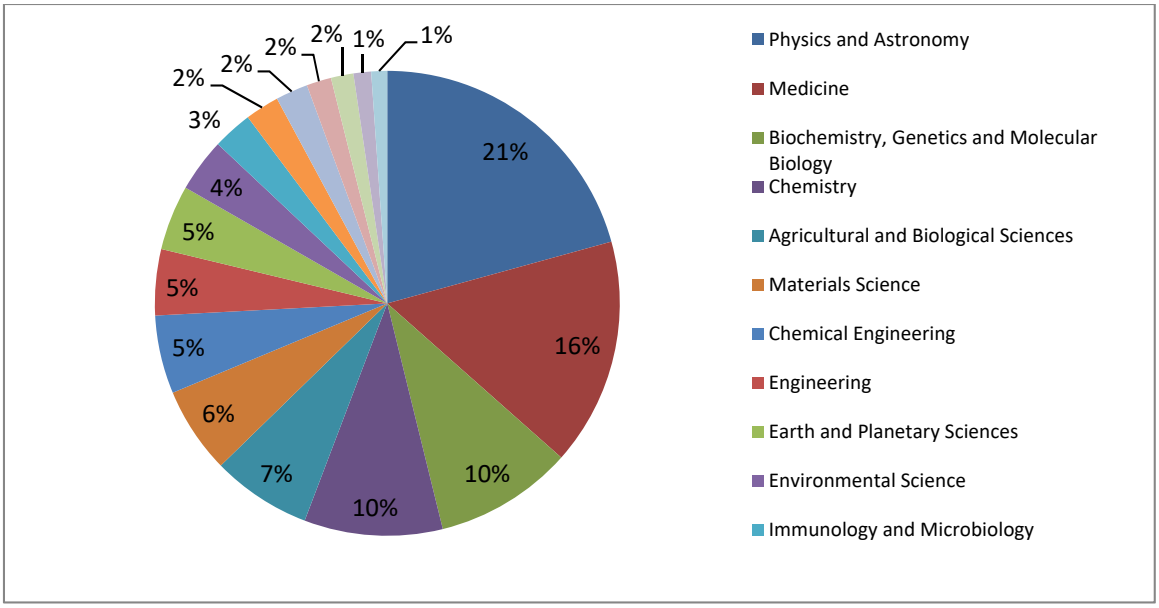
Varna Medical University, Sofia University, University Hospital Alexandrovska, BAS, Sofia Medical University demonstrate publications with the highest citation impact.

Figure 6: Physics and Astronomy, Chemistry, Engineering and Material sciences top the list of publications with high citation impact in the Bulgarian Academy of Sciences

Source: SciVal, 2011-2016.

By far, the leading research areas at the Bulgarian Academy of Sciences (BAS) are physics and astronomy, chemistry, engineering and material sciences, which also have high citation impact. It is interesting to note that areas like Medicine, Environment Science, Pharmacology, Toxicology and Pharmaceutics and Decision Sciences, performed by BAS research institutes, have much lower number of publications, yet their citation impact is among the highest in the ranking.

Figure 7: Publications within the top 10% most cited publications worldwide within BAS research institutes

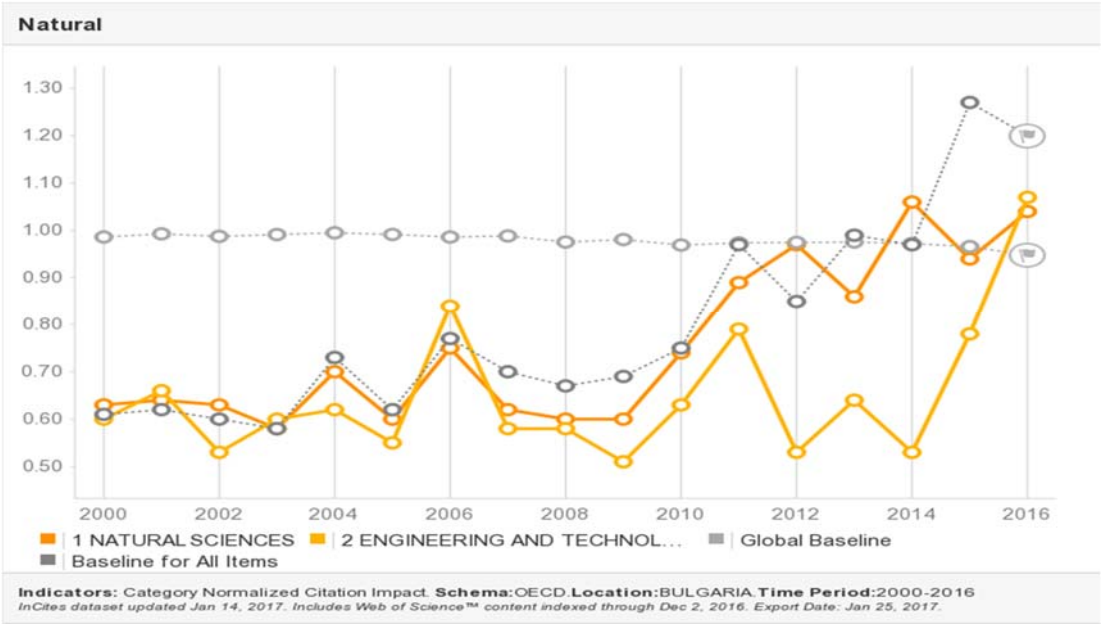


Source: SciVal, 2011-2016

Physics and astronomy lead the list of top 10% most cited publications worldwide for research institutes of BAS with 21% share, while medicine takes second position with 16 %, followed by biochemistry, genetics and molecular biology (10%) and chemistry (10%).

In terms of relative strength (the quality of the output of research in Bulgaria compared to the rest of the world) three out of this five subject areas in the group of Natural science (including Physics, Chemistry etc.) and Engineering seem to have an upward trend in regard with the citation impact and reaching the level higher than the global average.

Figure 8: Bulgarian Natural Sciences, Engineering and Technologies: Citation Impact, 2000-2016.



Source: InCites dataset, exported: 24 JAN 2017.

Based on analysis of the publications over the period 2011-2015, the competencies of BAS in 2015 are identified. As a result, the Natural and Engineering science is positioned as No.1 competence. Similarly, Sofia University does exhibit the same No.1 competence. For instance, standard model (particle physics); mass pulses; quantum optics; foams, surface active agents, surfactants; neutrons and so forth.

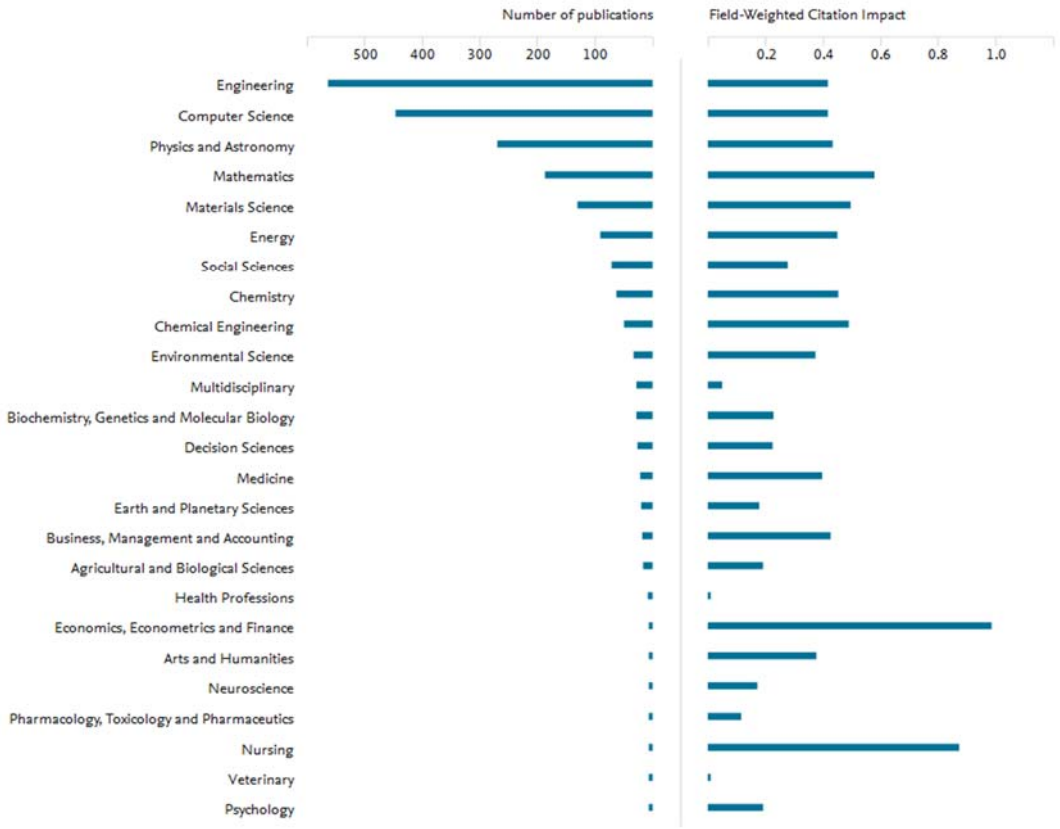
The University of Sofia does have the highest impact of citations in the natural sciences (physics and astronomy, chemistry, material science, engineering, chemical engineering), among others.

Figure 9: Sofia University "St. Kl. Ohridski": Publications and Field-Weighted Citation Impact

Source: *SciVal, 2011-2016*

The Technical University of Sofia does exhibit very strong research capacity in the engineering fields as seen from Figure 10.

Figure 10: Technical University of Sofia: Publications and Field-Weighted Citation Impact



Source: SciVal, 2011-2016

Patents

Bulgarian patent activity at USPTO in the period 2000-2014 is higher compared to patent activity at the EPO. There are overall 903 patent applicants and 303 registered patents at USPTO and we note a positive trend since 2012.

Figure 11: Bulgarian patent applications/registrations at EPO per 1 m. inhabitants

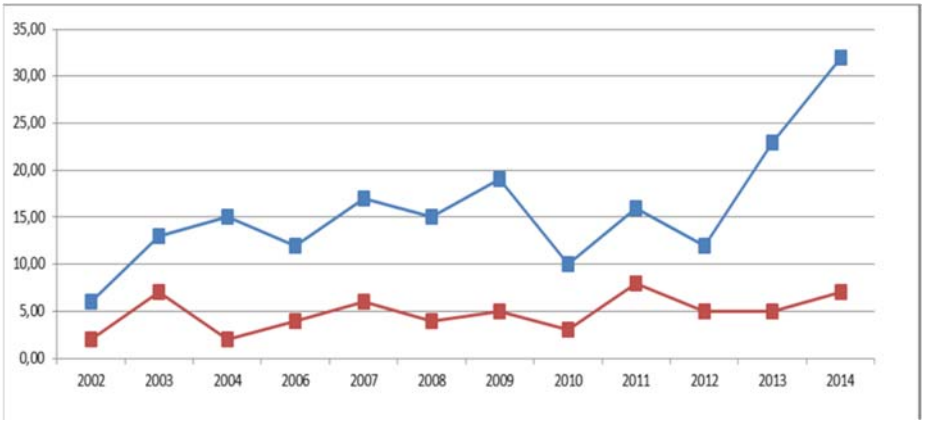
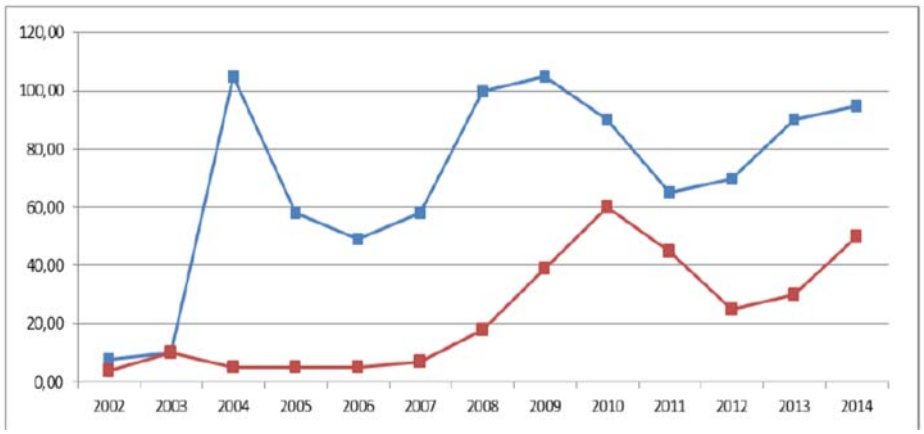


Figure 12: Bulgarian patent applications/registrations at USPTO per 1 m. inhabitants



Source: EPO 2016, USPTO 2016.

Note:

Patent applications

Patent registrations

Human Resources

As per 2015 NSI data, 53 % of the researchers in the country are women, while 47% are men. The age groups are distributed almost equally - 21 % of all researchers are in the age group of up to 34, whereas 27 % of all are in the age group between 35 and 44. Scientists between 45 and 54 and between 55 and 64 are 23 % and 24 %, respectively. Insignificant % of all scientists fall in the group of 65 or over – 5 %. Yet, the scientific community does require that every year there is a cohort of young scientists to enter in order to reach the EU-average levels.

Table 1. Distribution of scientists in Bulgaria as per age groups and gender, 2015.

Age groups	Men	Women	Total	% of age groups
Up to 34	1	1 434	2	21 %
35 – 44	1	2 034	3	27 %
45 – 54	1	1 582	2	23 %
55 – 64	1	1 493	3	24 %
65 and over	423	232	655	5 %
Total	5	6 775	12	

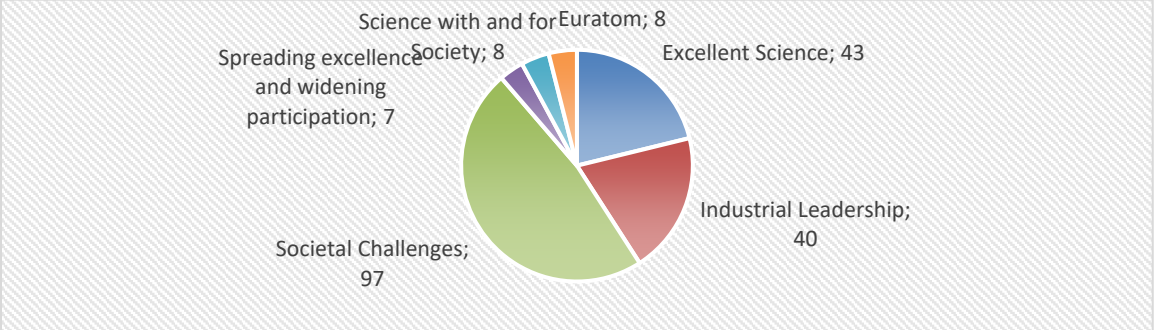
Source: NSI, 2016.

Bulgarian participation in Horizon 2020

The participation of Bulgarian researchers in European competitive calls for funding research is essential for development of the research system. However, the data show that Bulgaria's participation is to a large extent limited and comparatively lower to neighboring countries. There are between 160-180 publications per year (per 1 m. inhabitants) which have been published in co-authorship with foreign researchers in international refereed journals and the increase is by less than 10 % on an annual basis. Romania and Serbia do have much higher increase of common publications, which means that Bulgarian scientists do lose significantly their positions in the international scientific ranking. Bulgaria has attracted 12.8 EUR per capita in the 7th framework program, which precedes Horizon 2020. This is six times less than the EU average of 78.9 EUR per capita.[9] The success rate of projects with Bulgarian participation is 15.4 %, which is also lower compared to EU average of 20.4%.

Between 2014 and 2016, most of the Bulgarian research institutes and universities have applied through the Societal Challenges (97 projects), followed by Excellent Science (43) and Industrial leadership (40).

Figure 13: Bulgarian Projects by Priority Pillars of H2020

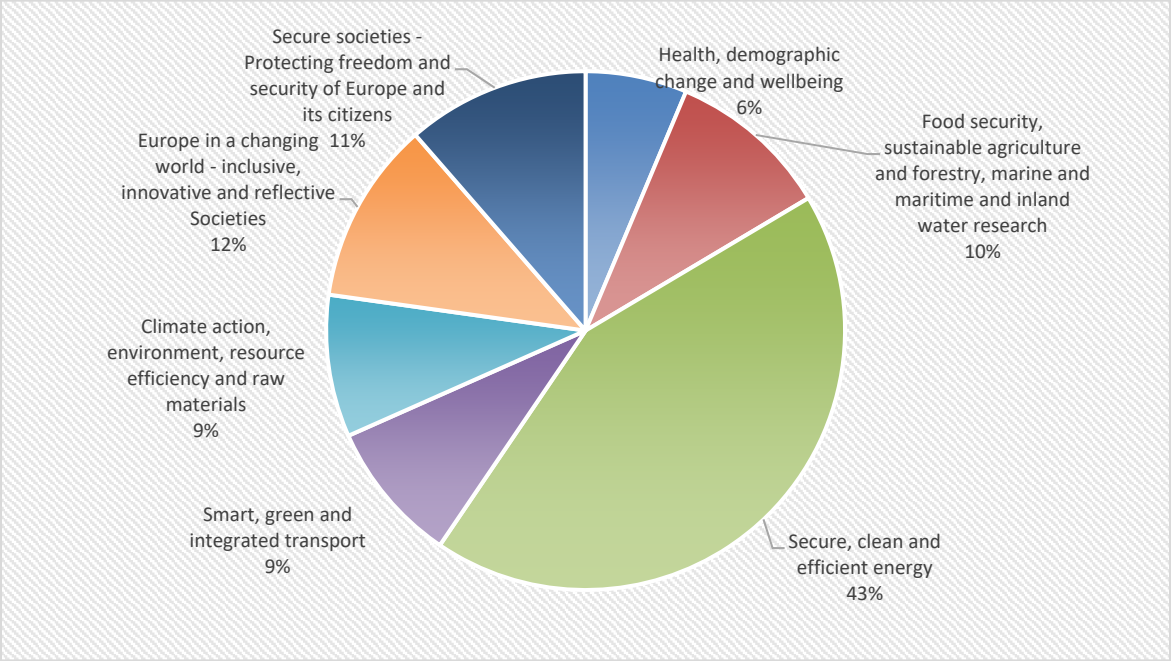


Source: CORDIS, November 2016

Within the societal challenges pillar, mainly partners in the secure, clean and efficient energy have applied with projects.

[9] European Commission, JRC-IPTS (2015), Stairway to Excellence Facts and Figures: Bulgaria.

Figure 14: Bulgarian Participations data within the Societal Challenges



Source: CORDIS, November 2016.

In fact, Bulgaria ranks last in the EU-28 context in terms of received Horizon 2020 funds per capita in the first two years of the program. Therefore, the trend in Horizon 2020 does demonstrate even lower outcomes compared to the 7th Framework program as Bulgarian participants have attracted 1.55 EUR per capita on an annual basis, whereas the EU average is 14.60 EUR.[10]

Figure15: Horizon 2020 funding per capita in 2014-2015, in EUR

Source: Report Horizon 2020, Two Years On, 2016.

[10] Report Horizon 2020 Two years on, 2016.

There are 21 projects, financed under Horizon 2020. Overall, they have generated €1.92 m for Bulgarian research institutions since 2015.

Table 2: EU Financial Contributions for Bulgarian research institutes as project partners

INSTITUTE OF MATHEMATICS AND INFORMATICS AT THE BULGARIAN ACADEMY OF SCIENCE	70500
ASSOCIATION "NATIONAL CENTRE FOR SUPERCOMPUTING APPLICATIONS	261298
INSTITUTE OF NUCLEAR RESEARCH AND NUCLEAR ENERGY - BULGARIAN ACADEMY OF SCIENCES	46000
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES	27019
ONTOTEXT AD	328650
INSTITUTE OF NUCLEAR RESEARCH AND NUCLEAR ENERGY - BULGARIAN ACADEMY OF SCIENCES	45000
INSTITUT PO BIORAZNOOBRAZIE I EKOSISTEMNI IZSLEDVANIYA BALGARSKA AKADEMIYA NA NAUKITE	32479
INSTITUTE OF OCEANOLOGY - BULGARIAN ACADEMY OF SCIENCES	75858
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES	95642
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES	343813
ROUMEN TSANEV INSTITUTE OF MOLECULAR BIOLOGY BULGARIAN ACADEMY OF SCIENCES	1500
BULGARIAN RESEARCH AND EDUCATION NETWORK	18576
ASSOCIATION "NATIONAL CENTRE FOR SUPERCOMPUTING APPLICATIONS	203074
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES	44400
INSTITUTE OF OCEANOLOGY - BULGARIAN ACADEMY OF SCIENCES	41125
Pensoft Publishers Ltd	192500
BULGARIAN RESEARCH AND EDUCATION NETWORK	22089
BULGARIAN RESEARCH AND EDUCATION NETWORK	0
INSTITUTE OF NUCLEAR RESEARCH AND NUCLEAR ENERGY - BULGARIAN ACADEMY OF SCIENCES	27250

INSTITUT PO BIORAZNOOBRAZIE I EKOSISTEMNI IZSLEDVANIYA BALGARSKA AKADEMIYA NA NAUKITE	4438
Bulgarian Academy of Sciences	46875
TOTAL	1928086

Source: CORDIS, March, 2017.

Bulgarian partners, who take part in large consortiums (sometimes participants go over 40 in a project consortium) managed to attract significantly low amounts compared to overall project cost. For example, R. Tsanev Institute of Molecular Biology at the BAS attracted €1,500 in a €1.5 m project under H2020-INFRADEF-1-2015-2. Similarly, the Institute of Information and Communication Technologies, which is among lead research institutes in Bulgaria, managed to attract around €27,000, which is quite insignificant compared to overall budget of €8 m under H2020-EINFRA-2014-2 in a recent procedure under Horizon 2020. At the same time, the same Institute at BAS attracted over €340,000 (about 10 % of overall cost) for another project. None of the 21 projects, funded under recent Horizon 2020 calls, with Bulgarian participations, has Bulgarian project coordinator.

Mapping Review of Priority Research Areas

This section looks at four broad research areas. It develops understanding about the key actors, regional specialization, available research infrastructures and research equipment with the universities and research institutes in Bulgaria, as well as talks about funding and human resources. SWOT analyses for research infrastructures in each research area are presented.

Physical, Material Science and Engineering

There are 57 research infrastructures in the Physical, Material Science and Engineering (PME) research area that are located in 15 scientific organizations in Bulgaria namely:

1. Technical University – Sofia (TU - Sofia)
2. Technical University – Gabrovo (TU - Gabrovo)
3. Technical University – Varna (TU - Varna)
4. Institute of Astronomy and National Astronomical Observatory - BAS
5. Institute of Catalysis – BAS
6. Institute of electrochemistry and energy systems "Acad. E. Budevski" - BAS
7. Institute of mineralogy and crystallography "Acad. Ivan Kostov" - BAS
8. Institute of organic chemistry with centre of phytochemistry - BAS
9. Central laboratory of applied physics – Plovdiv - BAS
10. Institute of General and Inorganic Chemistry BAS
11. Institute of Mechanics - BAS
12. Institute of Physical Chemistry - BAS
13. South-West University "Neofit Rilski"- Blagoevgrad
14. Sofia University "St. Kliment Ohridski"
15. University "Prof. A. Zlatarov" - Burgas

In terms of **regional specialization**, most of the scientific organizations mentioned above are situated in Sofia, the capital of Bulgaria (10 scientific organizations). The other 5 organizations are situated in the Northeast region, (TU - Varna), Northcentral region (TU - Gabrovo), Southcentral region (Central laboratory of applied physics – Plovdiv - BAS), South-Western region (Blagoevgrad), and Southeastern region (University "Prof. A. Zlatarov" - Burgas) of the country. Thus, they cover the whole territory of the country, except North-western region where there is no research infrastructure identified. Overall, 66 % of the research infrastructure is located in the capital of Bulgaria, while 34 % are in the rest of the country (e.g. Technical University – Varna, Technical University Gabrovo, South-west University Neofit Rilski, among others).

Figure 16: Level of significance of the PME infrastructures

Source: MES, Jan. 2017.

There are 2 infrastructures that have European significance, while 36 infrastructures have national and 19 infrastructures have regional significance (See, Appendix 2).

In terms of exploitation of the research infrastructures and research equipment, modern facilities are available in 42 % of the infrastructures (up to 5 years of exploitation), whereas only 16 % of overall infrastructures are fairly new (up to 3 years of exploitation) in the PME research area.

Figure 17: Exploitation of PME research infrastructure

Source: MES, Jan. 2017.

As far as funding for PME infrastructures is concerned, over 1.5 m. EUR in competitive funding (European and national funding instruments, like the National Science Fund and the National Innovation Fund) over the past five years has been attracted by only 22% of all relevant PME infrastructures. About 60 % of all infrastructures attracted less than half million EUR in the past five years. In fact, 38% of all were funded by less than EUR 25,000 on an annual basis.

Figure 18: Attracted competitive funding in PME, 2012-2016