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WHY INTERNATIONAL INSTITUTE FOR SUSTAINABLE TECHNOLOGY IN SOUTH-EAST EUROPE IS URGENTLY NEEDED

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Abstract
Though the major conflict within the SEE was 20 to 30 years ago, the SEE is still a major vulnerable area that can erupt and dangerously reverberate globally. The SEE is the most important unfinished job of the European unification. Seven countries in the SEE are still not members of the EU, and each enlargement creates at least mild frictions. The SEE has among the lowest employment rates in the world. All socio-economic and political indicators place the SEE countries at the bottom of Europe. The SEE is the major migratory route and within next decades about hundred million people will cross this area. The demographic and economic structures of the SEE aggravate the already vulnerable socio-political conditions. During the last 50 years the scientific activities in SEE countries have appreciably decreased creating a current intellectual vacuum in the most sensitive area – Mediterranean encounter of Africa, Asia and Europe. Therefore, it is necessary to establish a center of scientific excellence in SEE.

Keywords
South-East Europe, sustainable technology, scientific excellence

1. Why Urgently?

We live in the best world ever /**1**/,/**2**/, /**3**/. Yet, our world is not sustainable, it is economically, socially and politically extremely vulnerable and it is self-destructive. The Bulletin of the Atomic Scientists decided on January 25, 2018 to put the Doomsday Clock at 2 minutes to Midnight – the worst ever /**4**/ – as bad as in 1953 when testing of hydrogen bombs both by the USA and by the USSR implied that the world can be destructed by war, terror or error /**5**/. The dangers and threats are multiple now: in addition to military conflicts, we are threatening our only home – Earth: not only by climate change but also through the sixth biological extinction and enormous pollution where we use almost two Earth capacities and the wealthiest countries produce 200 times larger ecological footprint then the poorest ones /**6**/.

The humankind is aware of the dangers, threats and the need to act. On September 25, 2015 the UN General Assembly unanimously approved the UN Agenda 2030 – the Sustainable Development Goals, properly called 'Transform Our World!'/**7**/ Nobel laureates meeting in 2000 stated: "It is time to turn our backs on the unilateral search for security, in which we seek to shelter behind walls. Instead, we must persist in the quest for united action to counter both global warming and a weaponized world. ..... **To survive in the world we have transformed *(and are transforming)*, we must learn to think in a new way *(out-of-the-box thinking and acting)*. As never before, the future of each depends on the good of all.“ /8/**

Various activities evolve at the different time scale. For instance synthetic biology /**9**/ and the information-communication technology (ICT) evolve currently much faster than shipbuilding. In addition, different countries evolve at the different speed. These time scales - the speed of change - constantly change. In a global, interdependent and fast changing world the shortest time scale is the most critical one and it is about 10 years. **Therefore, our actions have to be urgent!**

2. Why in the South-East Europe?

Politics is very difficult and naturally one pays attention on problems that seem to be imminent. DPRK-North Korea and the Middle East appear now as the most demanding tasks. Even we tend to associate terrorism just with the Middle East ignoring extremism in our midst.

The South-East Europe (SEE) has been the center (ancient Greece is the source of our science, of democracy, of logic and philosophy), the crossroad of cultures and civilizations (Franks and Byzantine Empire, Ottoman Empire and Europe, crusades, Habsburgs and Romanovs) and a periphery. Throughout all its history it produced remarkable cultures, e.g. Vučedol and Vinča, geniuses and emperors, it initiated major socio-political actions, sometimes just because it was a periphery /**10**/.

Though the major conflict within the SEE was 20 to 30 years ago, the SEE is still a major vulnerable area that can erupt and dangerously reverberate globally. The SEE is the most important unfinished job of the European unification. Seven countries in the SEE are still not members of the EU, and each enlargement creates at least mild frictions. The SEE has among the lowest employment rates in the world. All socio-economic and political indicators place the SEE countries at the bottom of Europe.

Europe is characterized by a low fertility rate. Within several decades the indigenous population of SEE countries will decrease by about 10-20%. In addition to low fertility rate the SEE has appreciable difference in fertility rates among different ethnic groups thereby changing ethic compositions. The SEE is the major migratory route and within next decades about hundred million people will cross this area. The demographic and economic structures of the SEE aggravate the already vulnerable socio-political conditions.

The European Bank for Reconstruction and Development (EBRD) report 'Sustaining Growth' /**11**/ lists socio-economic indicators (Table 1).

Table 1

EBRD report 'Sustaining Growth' 2017

Country	Competitiveness	Good governance	Ecological approach	Resilience	Total
Germany	8.43	8.66	7.39	8.41	**8.06**
Slovenia	6.93	5.74	6.67	7.44	**6.90**
Poland	6.38	6.15	6.27	6.65	**6.64**
Hungary	6.42	5.31	6.37	6.65	**6.49**
Croatia	5.75	5.14	6.03	6.61	**6.07**
Bulgaria	5.96	4.69	5.82	6.54	**5.87**
Montenegro	4.89	5.12	5.15	5.93	**5.38**
Serbia	4.94	4.39	5.77	5.55	**5.37**

One of the current most serious threats stems from inequality. The ratio of wealthiest 20% population to poorest 20% is 3.6 in Slovenia, 5.0 in Croatia, 8.0 in Bulgaria and 10.0 in Serbia.

Indicators assessing political (DEM), structural (RoL – Rule of Law) and economic progress (ECON) for 27 countries in transition in Central and South-East Europe and in the Commonwealth of Independent States in 2001are summarized in Table 2 /**12**/ (the smaller value signifies better result).

Table 2

Country	DEM	RoL	ECON
Poland	1.44	1.88	1.67
Hungary	1.94	2.5	1.92
Slovenia	1.94	1.75	2.08
Croatia	3.25	4.13	3.58
Serbia+MN	4.63	5.88	5.33
Macedonia	3.75	4.63	4.58

The area that generated academies, schools and universities has not a single one within Emerging Europe and Central Asia top /**13**/ 30 universities. During the last 50 years the scientific activities in SEE countries have appreciably decreased creating a current intellectual vacuum in the most sensitive area – Mediterranean encounter of Africa, Asia and Europe. The beauty of the SEE has emphasized tourism and resulted in significant decrease of skill notably of technological skills. **Therefore, it is necessary to establish a center of scientific excellence in SEE.**

Our contemporary world is interdependent and any adverse fluctuation within SEE will influence the entire global world. Similarly, lack of action has grave consequences. An example is provided by an unsuccessful proposal /**14**/ to locate ITER in former Yugoslavia. Yugoslavia was an excellent country - neutral, nonaligned and positioned close to the heart of Europe and close to Asia and Africa - to host a major international endeavor crucial for developing fusion energy. Though the proposal went to the level of the prime minister and Presidency of Yugoslavia, and most of them supported it, it was drowned by meaningless political activities. More than 20 years was lost in fusion research and country suffered war and aggression. This was the failure of domestic and also international politics proving the warning by Axel Oxenstierna "Behold, my son, with how much stupidity is world politics done."

Socio-economic and political indicators of most of the countries in transition change appreciably and erratically (Table 1 and 2). **It follows that any meaningful action to influence SEE countries has to be accomplished within 5-10 years.**

3. Why Science?

Salient features of our contemporary world: fast changing, interdependent and global are all science generated. Succesfully facing most current challenges requires science, creativity and out-of-the-box thinking and action. Existential risks facing humankind are mainly caused by our ignorance /**15**/. The realization of the UN Agenda 2030 demands all scientific disciplines, multi-, inter- and trans-disciplinary research /**16**/.

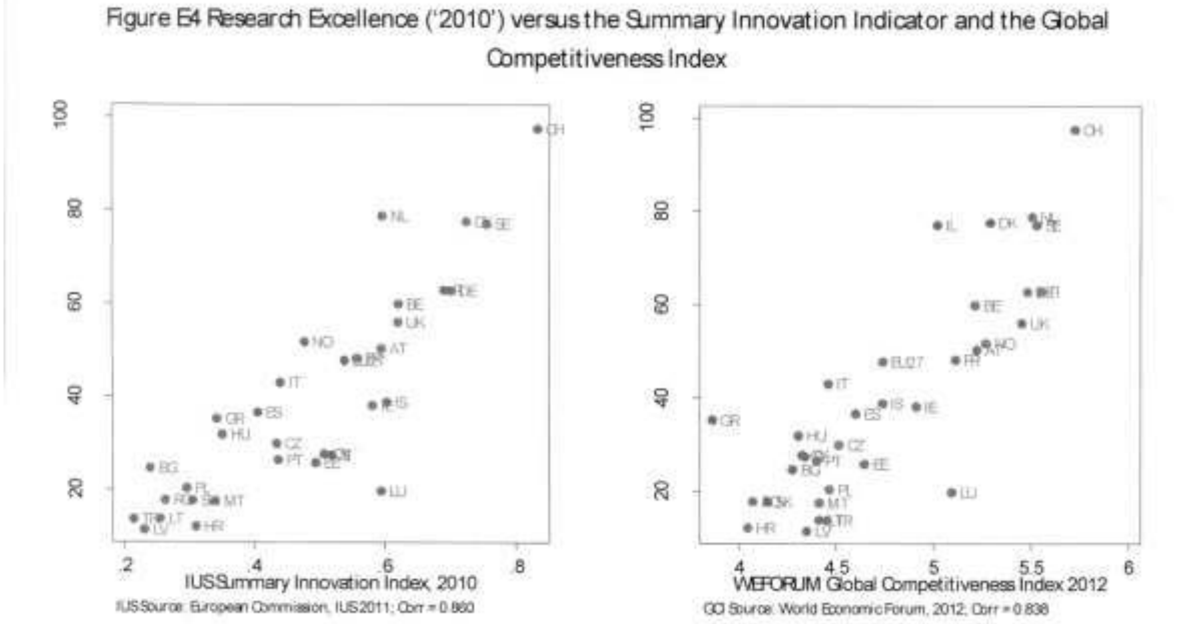
All major cultures developed science /**17**/ and scientific research is deeply rooted in each particular culture. Scientific research enriches each culture. Science is the best way to develop our own culture and in addition – since science is univeral, international, cumulative and objective, it links it with all other cultures and nations. „Science is a self-correcting system. Science is cooperative and at the same time encourages originality, independence and dissent. It stresses the need for an open mind; time and again the scientists must reverse direction, and they normally does. Proven scientific positions proved wrong no matter how great. Interpretations of experimental data and observations, explanations of events, and paradigms have had alternative rationalizations and have always been limited, never complete. This helps the scientists tolerate ambiguity, strive for improvement, and allow for self correction. Science teaches the value of relatedness. A necessary condition of all life is interdependence; everything relates to everything else; nothing exists in isolation. Hence everything assumes essence via its interactions with the something else. Science, therefore, seeks not only truth, but also relatedness and it is embedded within various domains. One branch of science relates to and in varied degrees is embedded in another. Out of this implicit coupling of the parts of science emerges the underlined unity among its seemingly chaotic functions. The mutual embeddedness of the parts of science allows for their integration, feedback, and accommodation. Science is changing, it is becoming more complex. Large international projects like the Intergovernmental Panel on Climate Change, the human genome, the International Thermonuclear Experimental Reactor, the European Organization for Nuclear Research, the large "user" facilities (e.g., particle accelerators), the big data facilities for medicine, and the knowledge being generated in cyber space, are but examples of this trend. Even the character and culture of today's large-scale research at major research facilities has been changing." /**18**/

Presently knowledge is the dominant political power /19/. Knowledge is inexhaustible. Knowledge is the most democratic source of power. ST breakthroughs act as equalizers creating a chance for resetting to zero economical and political advantages accumulated in some centers.[10)] "However significant science and technology are, it is of little use without concomitant socioeconomic inputs and appropriate political drive." /**20**/

4. Development and Research Excellence

Global competitiveness and Summary Innovation Indicators are strongly correlated with Research Excellence Score - RES - defined by OECD Oslo Manual /**21**/ (see Fig 1 taken from ref 22). This suggests that RES, which measures the top quality of the R&D potential could be a reliable indicator for assessing the effectiveness of the R&D potential in achieving social and economic goals.

Fig. 1



Research Excellence Score – RES is defined by four indicators: HICIT - top10% most highly cited publications/total number of publications, PACPAT - high quality patent/million inhabitants, TOPINST - number of world class universities and institutes/GNERD, and ERC - number of high prestige grants/public GNERD.

Table 3 summarizes Research Excellence Score for several countries:

Table 3 /22/

Composite score of research excellence

Country	Overall score	HICIT	TOPIN	PCTPAT	ERC
Germany	62.8	69	44	69	73
Hungary	31.9	39	20	17	82
Slovenia	27.5	48	10	25	48
Croatia	12.2	17	10	13	10
Latvia	11.5	14	10	12	10
Turkey	13.8	32	10	11	10
Greece	35.3	57	27	13	79

Fig. 2 /**22**/ shows the Composite Research Excellence Score for 2005 and for 2010. SEE countries are at the very bottom. In addition, they almost did not progress in those five years, opposite from the Netherlands, Denmark, Sweden, Germany and Norway which demonstrate a significant progress. Countries with highest Research Excellence Score are Switzerland, the Netherlands, Denmark, Sweden, and Israel, while Latvia, Croatia, Turkey, Lithuania, Slovakia, Romania and Malta have the lowest.

Publications that by citations rank in top 1%: 'Highly Cited Papers' for the period from 2014 to 2017 for several countries are listed below:

Table 4 /**23**/

USA	2644	Slovenia	4	Hungary	3	Germany	297
UK	542	Serbia	4	Croatia	1	Greece	15
China	249 ('17)	Slovakia	1	Romania	2	Bulgaria	1

(Symbols: AT Austria, BE Belgium, BG Bulgaria, CY Cyprus, CZ Czech Republic, DE Germany, DK Denmark, EE Estonia, GR Greece, ES Spain, FI Finland, FR France, HU Hungary, IE Ireland, IT Italy, LT Lithuania, LU Luxemburg, LV Latvia, MT Malta, NL Netherlands, PL Poland, PT Portugal, RO Romania, SE Sweden, SI Slovenia, SK Slovakia, UK United Kingdom, HR Croatia, TR Turkey, CH Switzerland, IS Iceland, NO Norway, IL Israel, , BR Brazil, RU Russia, IN India, CN China, KR Republic of Korea, JP Japan, US United States)

Figure 6.1 Composite Indicator scores for '2005' and '2010'

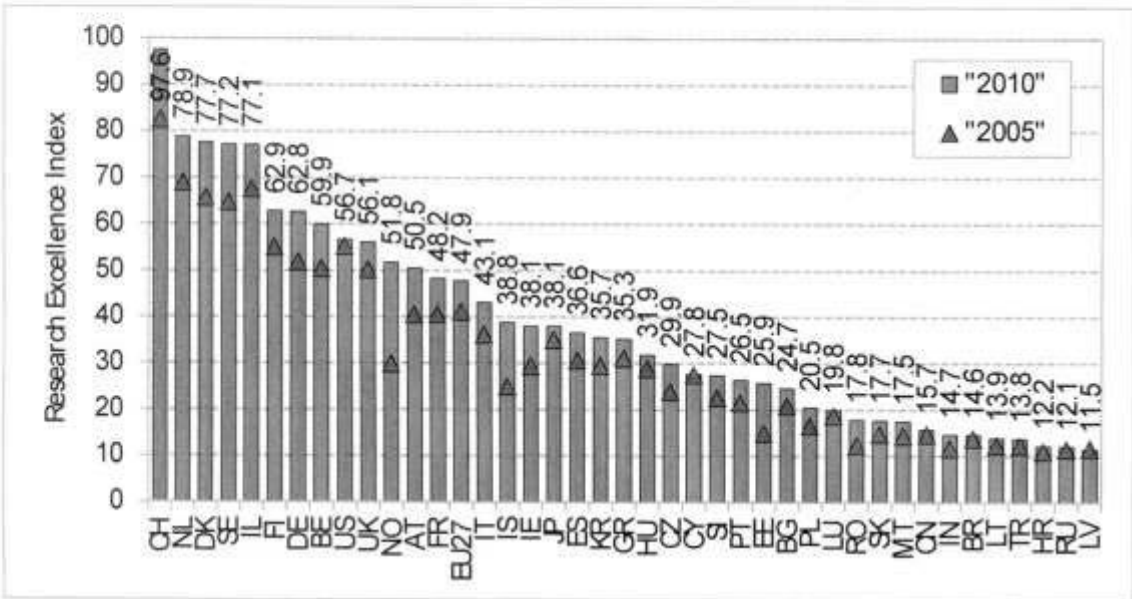


Fig. 2

Figure E3 Research excellence versus R & D Intensity by type ('2008')

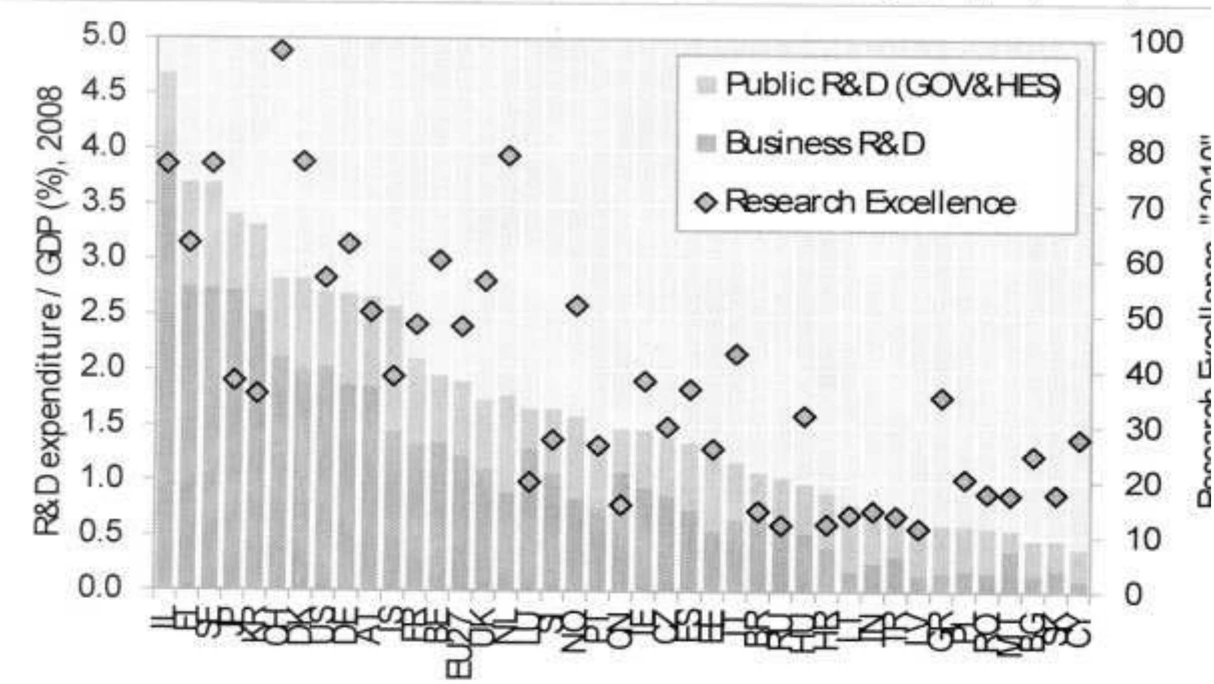
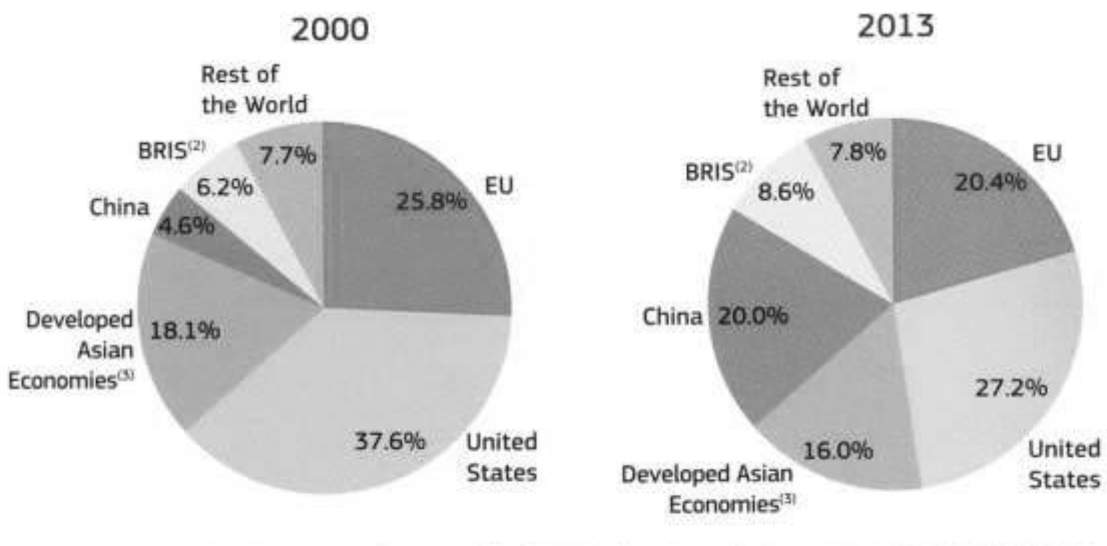


Fig. 3

Fig. 3 /**22**/ shows RES compared to the ration of the public and business R&D Expenditure to GDP. Even EU27 is just at the 2% level, and all SEE countries are quite low. The scatter among RES and public and business R&D expenditure indicates that Gross national expenditure for R&D (GNERD) is not necessarily a good indicator for the R&D activity.

The R&D potential consists of human power, science-technology infrastructure, organization of R&D, creative capacity, efficiency (measuring R&D activity vs. Science and technology: number of publications, impact factors, highly cited papers, number of patents) and effectiveness (accomplishing pursued socio-economic objectives) /**23**/, /**24**/. One can distinguish among input (number of scientists, number of engineers, number of technicians, GNERD) and output indicators (number of authors publishing in the Web of Science journals $\varrho(W)$ and four Research Excellence Scores: HICIT, TOPIN, PCTPAT and ERC. Any indicator is subject to uncertainties. The largest uncertainties are in the number of scientists and engineers (± 20%) and in the GNERD/GDP: (about 15% of governmental budget is 'lost' so this indicator carries also a large uncertainty ±20%). Output indicators are much more accurate: number of authors publishing in WoS journals has uncertainties of ±10% and highly cited papers, top institutes/universities of ±5%. Different accuracies of indicators stem from the fact that input indicators are compiled from various nation-state sources plagued often by somewhat different definitions. On the contrary output indicators are based on several international assessments thereby considerably reducing uncertainties. The basic question is: 'can measurement of top performance give a meaningful assessment of the entire R&D system'. The answer is in the fact that the relationship between indicators is described by the Matthew's effect 'to those that have, will be given more', or equivalently by the cumulative advantage distribution, the Lotka's law $P(n) \sim 1/n^2$, where $P(n)$ is the number of authors that published n publications /**26**/. **Therefore, identifying research excellence provides a good assessment of the entire R&D system.**



Source: Science, research and innovation performance of the EU 2016 - A contribution to the open innovation, open science, open

Fig. 4

The relationship between input and output R%D indicators measures the efficiency of the R&D potential. Fig. 4 and Fig. 5 /**27**/ represents world distribution of GNERD in 2000 and in 2013. represents the world share of highly cited publications in 2000 and in 2010. An impressive increase in the GNERD is achieved in China from 4.6% to 20% and it is significant that it is followed by a similar increase in the highly cited papers from 2.6% to 1.9%. The importance of these R&D indicators is best summarized by Maria Zuber, NSB Chair and Vice President for Research at the Massachusetts Institute of Technology. "This year's report shows a trend that the U.S. still leads by many S&T measures, but that our lead is decreasing in certain areas that are important to our country....That trend raises concerns about impacts on our economy and workforce, and has implications for our national security. From gene editing to artificial intelligence, scientific advancements come with inherent risks. And it's critical that we stay at the forefront of science to mitigate those risks." The US is still the undisputed leader in GNERD, but not for long. Last year, the US spent $496 billion on research and development, while also attracting $70 billion in private investment. China spent $408 billion and attracted $34 billion worth of venture capital in 2016. However, since the year 2000, China has been increasing its R&D expenditure by a staggering 18% a year while the US committed just a 4% annual increase. At this rate, it won't take long for China to invest more than any other country in R&D. In addition, between 2000 and 2014, the number of people graduating with a science bachelor's degree in China has risen from 359,000 to 1.65 million, compared to 483,000 to 742,000 in the US. In other words, China is on the cusp of becoming the undisputed king of science and technology /**28**/. China is the role model in R&D activity and productivity to be followed!

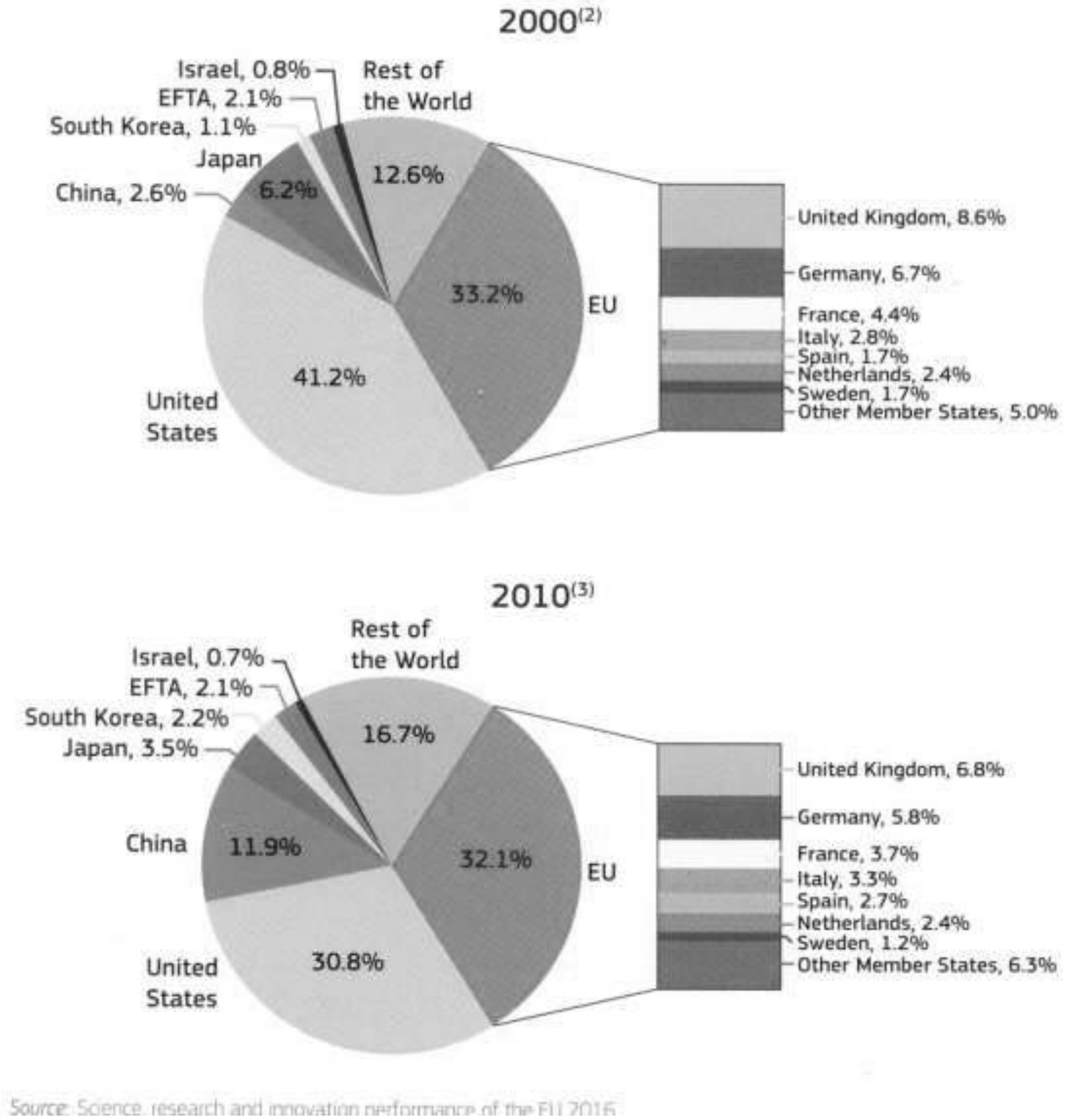


Fig 5

Measuring effectiveness is much more complex. General relationship between R&D input indicators and specific socio-economic results is described by an S-type curve. The features of this relationship are: a) there is a threshold. The R&D potential below the threshold cannot accomplish given socio-economic tasks. M.M. Quarashi defined the Development capability index /**29**/ - DCI.

$DCI = (GDP/c)^{0.45} \times (GDP)^{0.55} = (R\&D\ potential)^{0.45} \times (GDP)^{0.55} = (\varrho(W))^{0.45} \times (GDP)^{0.55}$

The essential step is linking GDP/c with the R&D potential and consequently with the number of authors publishing in WoS journals. b) The thershold is given by the following: ϱ(W) = 100 - 200/million inhabitants, GNERD/GDP = 0.8 -1.0% and number of scientists and engineers, technicians = 300-500 /million inhabitants.

From the analysis of Chapter 4 it follows that the R&D potential of the SEE countries is around the threshold and therefore, the essential political goal of these countries, but also of the EU is to strengthen the R&D potential of each SEE country so that specific given socio-economic objectives can be achieved. Plan how to achieve this goal will be outlined in the last chapter. Before approaching the Plan of Action three issues have to be clarified.

First, is the above expression which links DCI and the number of authors publishing in WoS journals reliable? The analysis of the Lamy's High Level Group /**30**/ comparing the EU and the USA is given in Fig. 6. It shows that the growth in the EU is larger in all scientific activities, but that the EU lags behind the USA in the number of patents and in the growth value added of business economy in the high-tech sectors. This seems to contradict the results shown in Fig. 1 that Research Excellence leads to prosperity. Interaction between science, technology, market and prosperity is complex. V. Bush in his famous report advocated the science-push model /**31**/. Few decades later, partly stimulated by the phenomenon described above which is particularly notable in the UK the market-pull model was proposed /**32**/. Actually, interaction evolves in bundles of streams synergistically synthetizing basic research and innovations /**33**/

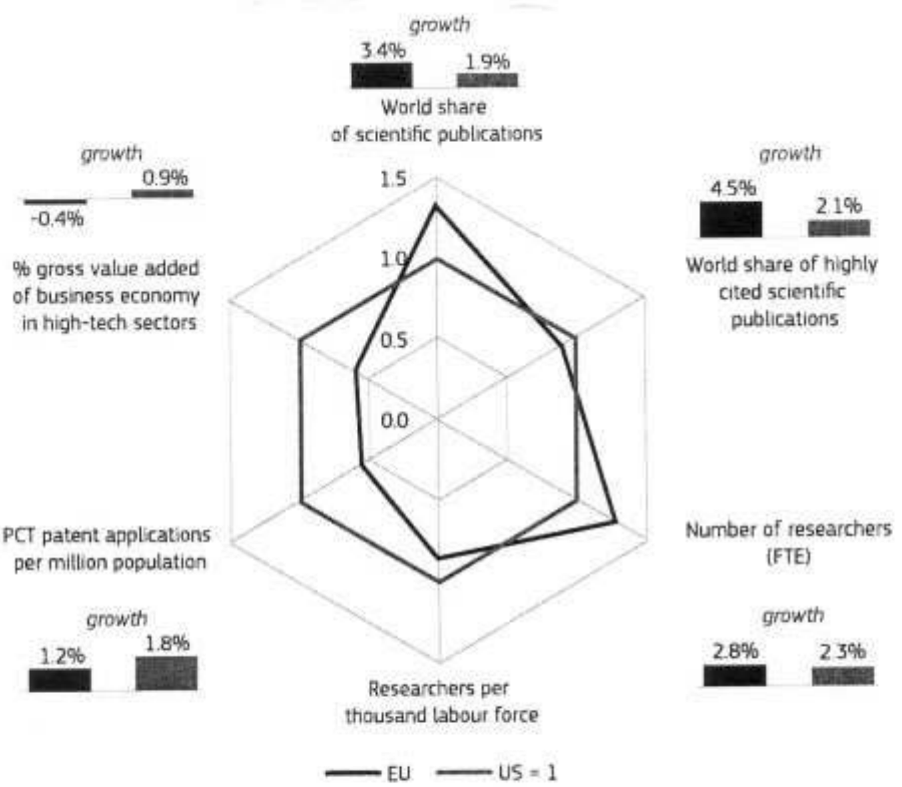


Fig. 6

Second, high cost of more and more basic research leads decision makers to suggest selecting priorities in country's research. While certainly one has to judiciously select among various major experimental facilities, it is necessary to appreciate that even the largest international facilities such as ITER cost less than 0.01% of the world GDP, and - as properly said by Erich Vogt, director of TRIUMF „Major experimental facilities today are expression of our worldview and of our culture as pyramids and cathedrals were centuries ago, and how much of then GDP was devoted to them." Though it is frequently said that the beginning of the 20th century was determined by breakthroughs in physics and the mid 20th by breakthroughs in biology, and most likely we are approaching the time when major breakthrough will develop in economics and political sciences, there is a unity of scientific endeavor – consilience /**34**/. New technologies always end as social activity and therefore social science, and all our concept are expressed in language. All scientific disciplines have to be developed and this underlines the essential role of universities and academies intertwined with the role of research centers.

Third, the dilemma: science-push vs. market-pull is sometime erroneously translated in curiosity-driven vs. applied research. This dilemma is easiest resolved by realizing that the most curiosity-driven research: x-rays is now the most applied one, and that an attempt to improve the antenna and cleaning birds' dirt gave finally the signal of the birth of our universe. Developments of instruments are milestone in the history of science.

5. Why international, why global?

Throughout our history centers of excellence were always international attractors and consequently many, often most researchers, professors and students working at these centers were foreigners. This was during the Tang dynasty in China, at University of Paris in Middle Ages and so it is today and it is increasing as Fig. 7 shows /**35**/. A question is: is it beneficial and in what way?

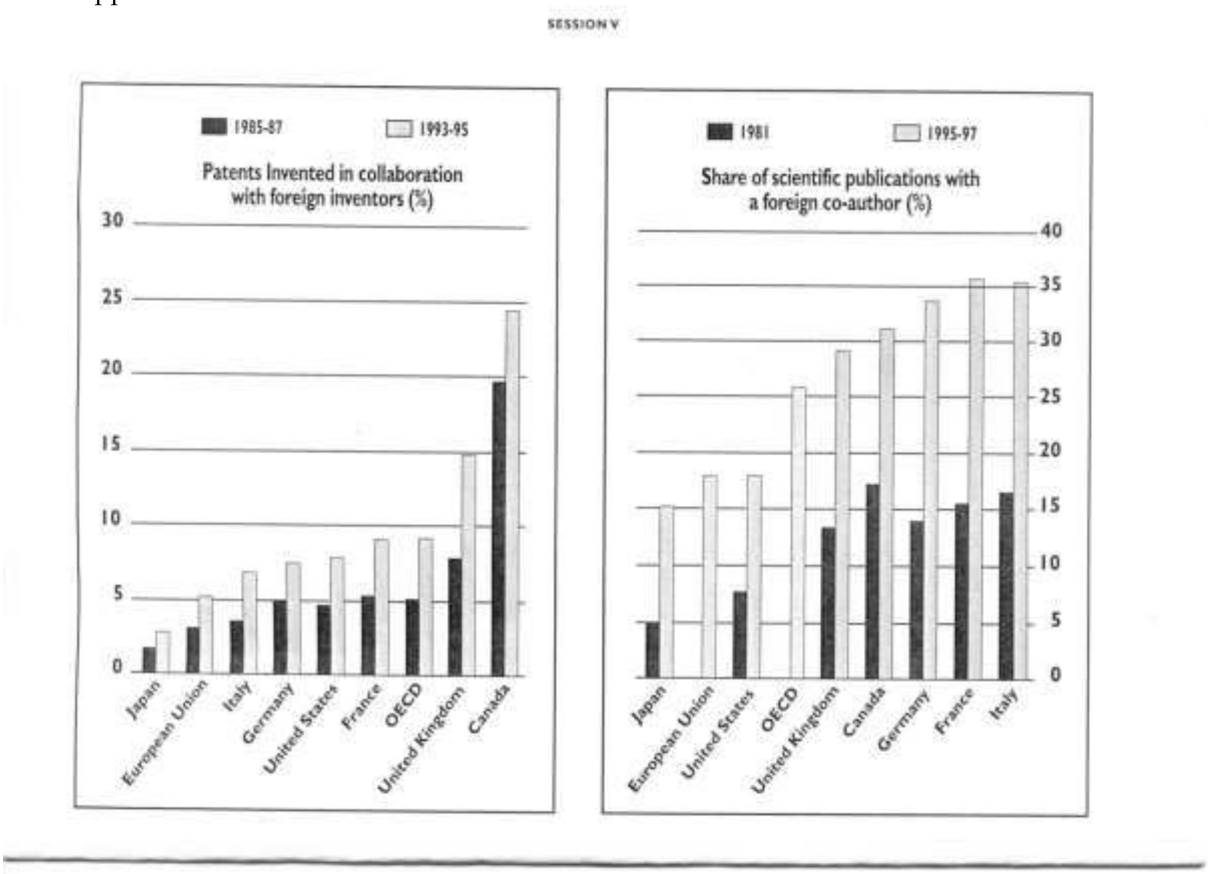


Fig. 7

Fig. 8 compares average relative citations of single-author publications with those of multi-authors publications but within one country and with publications involving several authors from many countries. Only international co-publications have average relative citations higher than 1, i.e. they are more cited than the world average /**27**/. Clearly, international co-publications provide greater scientific impact. They have multipled other benefits: facilitate technology transfer, improve all forms of communications and establish cultural understanding. There is no doubt that international scientific cooperation was at the core of second-track diplomacy as is the Pugwash Movement, and it was the basis of very successful international endeavors such as Intergovernmental Panel on Climate Change.

Therefore scientific centers of excellence have to be an international center.

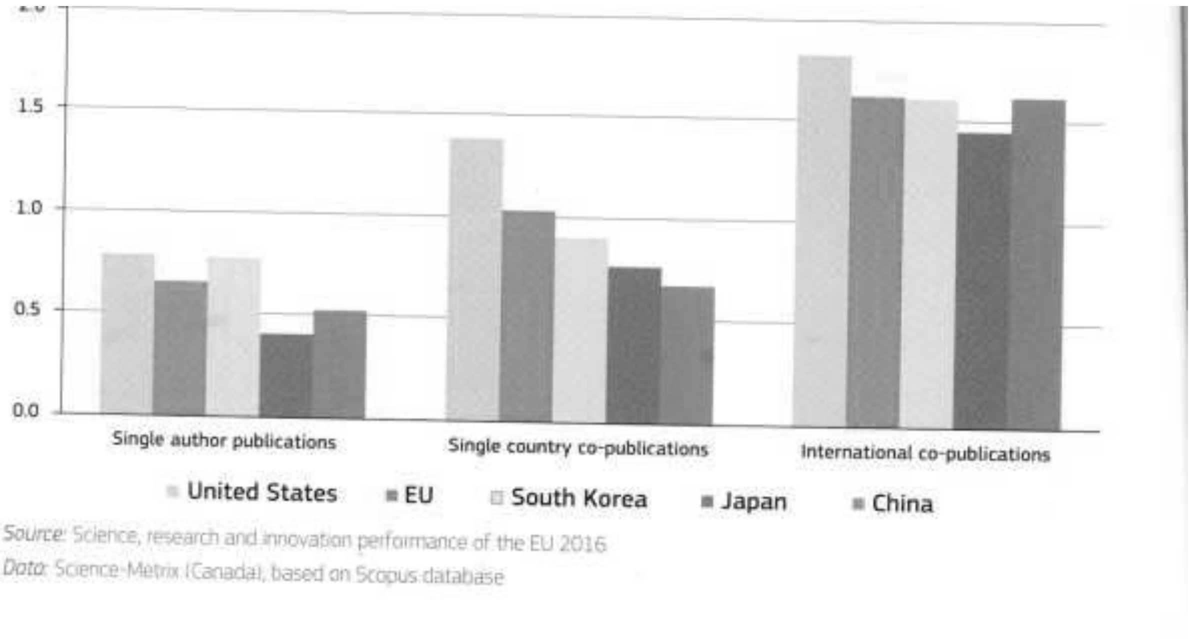


Fig. 8

6. Case Study 'The Rudjer Bošković' Institute

Contemplating establishment of an international center of excellence in SEE it is instructive to analyze the foundation and development of an institute that was established almost 70 years ago in Zagreb. Immediately after the end of the World War II Tito's Yugoslavia established three nuclear institutes: Vinča near Belgrade in 1948, 'Jožef Stefan' Institute in Ljubljana in 1949 and 'Rudjer Bošković' Institute in Zagreb in 1950). Persons leading these institutes were internationally well-known: Pavle Savić was collaborator of Irene Curie and F. Joliot Curie, Anton Peterlin later worked at TUMünchen and at Research Triangle Park, N.C. and Ivan Supek collaborated with Heisenberg and later was the founder of the Yugoslav Pugwash Movement and of the InterUniversity Center - Dubrovnik. Excellence and international dimension continued to be the essential feature of all three institutes and they are all internationally well-known and several of their professors taught and were researchers at best world universities. Nuclear Energy Institute in Bulgaria was founded in Sofia in 1972. The RBI was conceived as a nuclear institute with emphasis on nuclear sciences, but it quickly included most of theoretical physics, solid state physics, physical chemistry, organic chemistry, biology and electronics. During late 1960ties marine research developed and RBI included an old research institute founded by the Berlin Academy at the end of the 19th century in Rovinj.

Scientometric studies demonstrate that in the period 1960-1975 scientific productivity of scientists of Tito's Yugoslavia were comparable to that of scientists from Austria, Finland, Czechoslovakia, Hungary and Poland. During 1975-1990 it was behind all the above countries and comparable to Bulgaria, Greece, Ireland, Portugal and Romania. Foundation of three nuclear institutes in Yugoslavia has to be certainly credited for this success. Table 5. compares numbers of WoS publications during three periods: 1976-1990, 1991-2004 and 2005-2016 published by scientists from 'Rudjer Bošković' Institute with the number of papers published by all scientists of Croatia and with the number of papers published by scientists working in natural and life sciences and in engineering.

Table 5
Number of WoS publications

Period	IRB	Croatia(nat+engi)		Croatia(all)	
1976-1990	2.671	6.214	**43%**	7.487	**28%**
1991-2004	3.947	11.822	**33%**	16.309	**24%**
2005-2016	5.845	20.210	**29%**	40.749	**14%**

It is clear that the establishment of 'Rudjer Bošković' Institute (RBI) gave an impulse to scientific activity and scientific productivity of Croatia. Later many scientists from the Institute went to universities in Croatia, and some continued their career abroad. (Percentages of papers by scientists from RBI with respect to the corresponding total number are in bold.)

Basic features of the three nuclear institutes in Tito's Yugoslavia were international cooperation, inter-, multi- and trans-disciplinary and a large degree of flexibility. Naturally, these features varied among the three institutes. We will now focus on the RBI and mainly on physics since the discussion concerning establishing SEE international institute for sustainable development is now concentrated on two proposals dealing with synchrotron and hadron radiotherapy. Two additional features characterize the development of the RBI. One, from the very beginning promotion of physicists was based on international evaluations. Gradually this extended to all disciplines in the RBI. Two, besides full-time employees RBI open its facility to scientists from other institution who worked part-time.

Development of a center of excellence requires concentration on frontline research in certain niches where relative advantage could be found. Physicists from the RBI concentrated on five niches:

1. few particle studies. The first international conference was held in London in 1959, but already the next one was held on the Adriatic coast in Brela in 1967 /**37**/, and then a series of international conferences was established, each two-three years and physicists from RBI were most of the time among organizers, or speakers, e.g. in Los Angeles in 1972, in Santos in 2006, and the next conference will be in Caen in 2018. In addition physicists from RBI were among the initiators of the European Few Particle Community and European conferences were regularly held and in late 1980ties among the first EC project involved RBI, Tübingen and Bochum physicists. First successful study of the neutron-neutron force was done in Zagreb in 1961, and it led to addition information wherefrom it is possible to determine the difference between the masses of the down and up quarks, thereby providing information on charge symmetry breaking /**38**/. Few particle studies involved extensive international collaborations with UCLA, Rice University, Los Alamos National Laboratory, Naval Research Laboratory, Georgetown University, Duke University, Kyoto University, IKO Amsterdam, Louvain-la-neuve, Hokkaido University, North Carolina Central University and Vinča Institute._The few nucleon studies were based on the use of the 0.2 MeV Cockcroft-Walton accelerator used as a source of 14 MeV neutrons, on a counter, a 3-dimensional analyzer and on international collaboration with theoretical physicists from the USA, Germany, India, Japan, USSR and later with experimentalists from the USA, the Netherlands, Germany and Belgium. **Within about 6-7 years: 1956-1962/3 the group of physicists from the RBI became international well-known.** In addition to few particle research several other studies, e.g. fast neutron physics and nuclear reaction mechanism studies achieved international recognition in about the same time period.

2. radio-pharmaceuticals. It early 1950ties it was decided that local industry is capable to build a 15 MeV cyclotron. Construction started in 1953, and Tito opened the cyclotron in 1962. Unfortunately, it was impossible to extract the beam and only later on accelerating negative ions that deuteron beams were extracted in 1972. However, the internal beam was quite adequate to produce radiopharmaceuticals and to initiate studies of neutron radiotherapy /**39**/. During 1975-1983 ^{67}Ga and ^{81m}Kr were regularly produced and delivered to hospitals throughout Yugoslavia and Austria. In addition mathematical model for lung ventilation was developed. During this time RBI was together the largest producer of these two radiopharmaceuticals together with Hammersmith Hospital in the UK. The paper on the use of cyclotron in neutron radiotherapy is still one of the most read papers /**40**/. **It took about 25 years from 1955 to 1980 to achieve international recognition.**

Scientific productivity in physics and in medical science is shown in Table 6 /**41**/

Table 6.

	Articles in physics		**in medical science** (NSF-Science Indicators)	
	1997	2011	1997	2011
World	84,021	108,551	144,819	182,772
Austria	483	598	1,437	1,515
BG	226	127	67	58
Slovenia	116	216	91	176
UK	4,661	4.321	13,410	12,282
HR	77	104.5	115	192
Serbia		175		194
Montenegro		3.5		
Macedonia	7.7	14.9	5.7	9.5

(fractional credit for authorship)

3. computer-constructive visual art was developed during 1968 and 1974 by several electronic engineers led by Vladimir Bonačić working in nuclear physics lab. 'New Tendencies' are part of a broader European post-informel art movement which included famous Croatian artists, e.g. Ivan Picelj and sculptor Vojin Bakić. Group led by Bonačić extended their activities in Israel and in Germany and some of their work are in museums in Zagreb and in Karlsruhe.

4. Group of physicists from RBI founded 'Interdisciplinary frontline research center' in 1985 involving scientists from the Academy and the University of Zagreb. Among its most notable activities are: 4.1. endeavor to locate ITER in Yugoslavia (current project DONES - part of ITER - will most likely be located in Spain, but Croatia will be the prime collaborator); 4.2. including ex-patriots in the Yugoslav R&D program. It was estimated that Diaspora represents about 30% of the national R&D potential; 4.3. establishing Yugoslav Association for the Advancement of Science; 4.4 actively participated in the UNESCO 'Reconstruction of Scientific Cooperation in SEE' (1999-2001); 4.5. proposal to establish SEE Institute for Technology (2003) and 4.6. supported establishing South-East European Division (SEED) of the World Academy of Art and Science (WAAS fellowship increased from about 15 to over 100).

5. The 'R. Bošković' Institute was founded by group of professor from the University of Zagreb and the close relationship between the RBI and higher education is one of the essential features. Throughout the history of the Institute it secured best human resources. Several young researchers from RBI got their PhD with co-mentors from outstanding universities: University of Rochester, MIT and UCLA. The RBI was part of the University of Zagreb for about 10 years in 1980ties and during that time several M.Sc. and PhD degrees were bestowed.

The essential feature of all these niches was the development of human-resources. It started in 1946 through the seminar in theoretical physics and always was essential!

7. Conclusion - Plan of Action

Three centers of excellence - The Extreme Light Infrastructure - ELI were recently established in Bucharest, Szeged and Prague. The southern SEE - countries from Slovenia and Croatia to Bulgaria and Turkey - has no comparable major center of excellence. Our analysis, particularly that in Chapter 2, clearly demonstrates the imperative to establish a center of excellence, actually at least two centers in southern SEE, one in the West and one in the East part of the southern SEE.

Following the proposal by Herwig Schopper accepted by the Board of Trustees of the World Academy of Art and Science in 2016/7 such center should be focused on sustainable technology to contribute toward the realization of the Sustainable Development Goals – the UN Agenda 2030. From our analysis, particularly the case study of the RBI it seems that essential features of these centers of excellence should be multi-, inter- and trans-disciplinarity, strong connection with higher education and education in general, and since the salient characteristics of the contemporary world are fast changes, it is desirable that the center is flexible. **As we argued in Chapter 1 the establishment of such a center is urgent. It implies that within at most 10 years the center has to be internationally recognized as a center of global excellence.**

Each time has its own feature and presently I argue that it is necessary that the majority of scientists and technician working in the Institute are local, and by local I mean citizens from SEE countries. Majority means about 60-65% for the first 10 years and it would gradually become more international, but always keeping at least 30-40% local scientists and technicians. Administrative staff has to be kept to a minimum and it does not have to be local. The emphasis on inter- and trans-disciplinarity as well as experiences at RBI and elsewhere suggest that it would be advantageous if a fair number of researchers would be physicists: about 35-40%. All studies on the future of work stress that employment everywhere and in research as well should be flexible, but always assuring maximum human capital maintenance and development. One aspect of human resources flexibility could be realized as it was at the RBI when researchers from other institutions worked at the RBI. The essential feature is high quality of research.

Essential and necessary steps are:

1) Identify pillars,
2) Develop human resources and
3) Assure appropriate political drive: both national and EU to include also international action, and secure adequate financial support.

The pillars could be existing nuclear institutes in Slovenia, Croatia, Serbia and Bulgaria, parts of the universities, academies, but also two noticeable activities: IUC and SDEWES.

The InterUniversity Center IUC-Dubrovnik was established more than 40 years ago at the initiative of Ivan Supek, then rector University of Zagreb, who proposed it at the conference of the International Association of Universities in Montreal in 1970. It includes over 100 universities throughout the world. Courses, seminars and conferences are regularly organized and the IUC is one of the WAAS centers. The IUC is led by an international board and chairs of the Council and the Executive Board are always scientists from abroad. There were 598 courses and 266 international conferences with 38,881 participants during 1971-1991, and e.g. in 2011 there were 45 courses and 11 international conferences with 1,416 participants.

Sustainable development, energy, water and environmental systems (SDEWES) is a series of international conferences initiated by fellows of the WAAS N. Afgan and N. Duić. SDEWES is also a WAAS center. The first conference was organized in 2002, and so far 12 conferences in Dubrovnik, Piran, Ohrid and Rio de Janeiro and on a cruiser were organized with about 200-500 participants/conference, with 450 papers/conference and about 100 posters/conference, many published in scientific journals and also in their own journal JSDEWES.

Development of human resources should proceed in a three-prong way. First, establish joint degrees (essentially Ph.D.) and joint permanent education systems in collaboration with outstanding universities throughout the world. Good practices in the RBI are described in Chapter 6. It is interesting that a mono-disciplinary private university Zagreb School of Economy has founded a joint PhD program with the Sheffield Hallam University, UK. During Tito's Yugoslavia University of Zagreb attracted thousands of foreign students. Unfortunately, this number is now much smaller. Second, emphasize frontline research and concentrate on certain niches based on above outlined pillars. Strong support should be given to CERIC-ERIC (Central European Research Infrastructure Consortium) which includes centers in Trieste, Ljubljana, Krakow, Prague, Budapest, Zagreb, Belgrade and Bucharest. Due to the fast changes with characteristic time of about or less than 10 years, there should be some diversity among these niches. An example of an outstanding project is DONES and all support should be given to assure its full development. Third, develop human resources in as many scientific disciplines as meaningful, stimulate inventive education at all levels and establisg systems to develop instruments.

The Lisbon Strategy for growth and competitiveness agreed on March 23/24, 2000 defined a strategic goal that the EU should become in the next decade the most competitive and dynamic knowledge-based economy in the world. Obviously, more time is needed and certainly the 'vacuum' in the southern SEE countries has to be quickly corrected. How much financial investment is required and who and how should provide it? A major EU endeavor is needed! A well-defined political decision and directive is necessary including proper financial support. Financial support can come from the EU, from international sources (e.g. IAEA), from national sources and from private sources. Experience with private and even private-public funding has not been very good so far. For instance, a private medical center 'Medicol' in Zagreb is using the building where the RBI cyclotron was and located there a small cyclotron which is being used to produce ^{18}F – FDG, but there is absolutely no research. It is an entirely commercial activity with focused medical application. International sources can currently provide only a small fraction, so financial support has be assured from the EU and national sources, and possibly some support from interested major economies of the world. Starting with the investment in ELI (each about 400 million euros, to be followed e.g. in Romania by the center on Danube with about 200 million euros and an ICT center requiring 100 million euros) one can conclude that a 200-400 million investment should be made for southern South-East Europe International Institute for Sustainable Technology. **All of this should come from the EU while the continuous maintenance of the institute should be provided by the host country thereby approaching the necessary 3% level of the GNERD/GDP.** For instance, the GDP of Croatia is about 40G€ and assuming 3% of GDP allocated to GNERD it amounts to1.2G€. A reasonable fraction of about 25% would suffice for maintenance of the SEEIIST.

At the recent conference in Trieste two alternative types of facilities for the SEEIIST were outlined: synchrotron and hadron radiotherapy. Bulgaria declared its interest in the hadron radiotherapy. Since for western southern SEE countries facilities in Trieste as well as in other cities in Austria and Italy as well as CERN are much more convenient, it can hardly be justified that they would be focused on using facilities in eastern SEE and/or build a facility similar to those that already exist in Italy and Austria. It seems that it would be strategically appropriate to contemplate a center in the western southern SEE /**42**/ focused on sustainable technologies (and there SDEWES is ideal), linked with education (and IUC is appropriate), sea, marine and habitat research (there are centers along the Adriatic). **Clearly such a center could be established and it could reach international recognition within 6-10 years.**

In summary:
Step 1: clear political decision to establish two centers in southern SEE: one focused on SDEWES, sea, marine, habitat research and on IUC in the western southern SEE, and another on hadron radiotherapy in Bulgaria. Decisions about appropriate funding from individual countries and from the EU should be made.
Step 2: human resources development emphasizing joint degrees and simultaneously, support CERIC-ERIC and DONES endeavors.

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ZAŠTO JE HITNO POTREBAN MEĐUNARODNI INSTITUT ZA ODRŽIVU TEHNOLOGIJU U JUGOISTOČNOJ EUROPI

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Sažetak

Iako je glavni sukob u Jugoistočnoj Europi bio prije 20 do 30 godina, Jugoistočna Europa je i dalje glavno ranjivo područje gdje sukobi opet mogu početi, sa globalnim odjekom. Jugoistočna Europa je najvažniji nedovršeni posao europskog ujedinjenja. Sedam zemalja Jugoistočne Europe još uvijek nisu članice EU, a svako proširenje stvara barem blage razmirice. Jugoistočna Europa ima među najnižim stopama zaposlenosti u svijetu. Svi socio-ekonomski i politički pokazatelji stavljaju zemlje Jugoistočne Europe na europsko dno. Jugoistočna Europa je glavni put migracije, a u sljedećim desetljećima oko stotinu milijuna ljudi prijeći će ovo područje. Demografske i gospodarske strukture Jugoistočne Europe pogoršavaju već ranjive društveno-političke uvjete. Tijekom posljednjih 50 godina znanstvene aktivnosti u zemljama Jugoistočne Europe znatno su smanjene, stvarajući trenutni intelektualni vakuum na najosjetljivijem području - mediteranski susret Afrike, Azije i Europe. Stoga je neophodno uspostaviti centar znanstvene izvrsnosti u Jugoistočnoj Europi.

Ključne riječi

Jugoistočna Europa, održiva tehnologija, znanstvena izvrsnost