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SME/HPC

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Enabling SMEs to gain competitive advantage from the use of HPC

D6/4 – Final Region-Specific Action Guidelines

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0.1	31 January 2020	Template	UEFISCDI	Based on the results of the strategic workshops, there was a first iteration in developing the document. The final format was set up.
0.2	31 March 2020	Draft	UEFISCDI, FIS and WIT	The preliminary draft of the document was developed.
0.3	23 April 2020	Draft	UEFISCDI	The complete draft of the document was sent to all partners.
0.4	23-28 April 2020	Draft	All partners	Review and quality assurance reading
0.5.	30 April 2020	Final	UEFISCDI	Final version

Contents

Abbreviations

GDP – Gross Domestic Product

HEI – Higher Education Institution

HPC – High Performance Computing

ICT – Information and Communications Technology

NUTS - Nomenclature of Territorial Units for Statistics

R&D – Research and Development

Introduction

When launching the process of developing region-specific action guidelines, SME/HPC consortium committed not only to identify and propose place-based recommendations to support the development of HPC ecosystem in the three pilot regions, but also to explore and to promote synergies among the EU regions. The aim was to investigate options able to underpin innovation actions based on HPC.

The European Commission (EC) is working to support „an ambitious research and innovation agenda to develop and maintain in the EU a world-class High-Performance Computing ecosystem, exascale and beyond" (EuroHPC website). In this context, the EC proposed to support EuroHPC Joint Undertaking initiative in the next financial programme with EUR 2.7 billion from the Digital Europe Programme (DEP) and with additional funds from Horizon Europe. This is a clear message on the need to capitalise on the potential of HPC for supporting innovation in all European countries.

The SME/HPC team envisioned that the involvement and cooperation of both higher education institutions (HEIs) and industry representatives are the essential factor in fostering HPCA development. Therefore, it follows that in the three pilot regions set by the project it was possible to design concrete recommendations able to inform policies and to inspire concrete actions from the side of HEIs and companies.

The approach used in the final version is two folded: firstly, there is the place-based recommendations perspective; secondly, there is the cross-border perspective, enabling a set of transnational general guidelines aimed at fostering HPC development in different European regions.

The ultimate goal of Deliverable 6/4 is to provide a set of concrete recommendations on how to implement measures to stimulate the use of HPC and to create an environment conducive for HPC based innovation.

Previous deliverables played a key role in the elaboration of the final specific action guidelines. The final content is based on the results of WP2 „Institutional absorptive capacity" and WP3 „Regional HPC Benchmark Audit", which examined the existing and possible synergies between the actors involved in HPC ecosystem, including HEIs and businesses and which contributed to the development of D6/2 „Preliminary Region-Specific Action Guidelines". The work conducted for D6/3 „Strategic workshops with key stakeholders" brought added value to the process of developing the final recommendations, allowing SME/HPC partners to benefit from the expertise and experience of regional stakeholders in updating and validating the guidelines proposed.

How to read this document

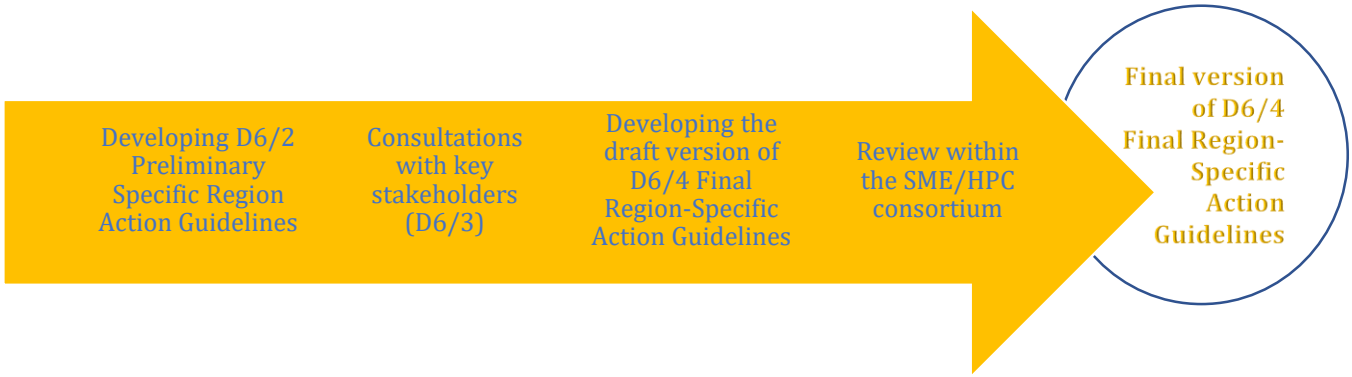
This document consists in four main sections: three of them presents the final guidelines for the pilot regions of the SME/HPC project, South East Ireland, Bucharest Ilfov, Romania and South East Slovenia and the fourth includes general transnational recommendation for the development of the HPC ecosystem. Each of the regional sections starts with an analysis of the context relevant to the development of HPC in the respective pilot region, including a presentation of the main socio-cultural, policy, infrastructural, and educational aspects that exert an impact on HPC. The guidelines further offer recommendations for enhancing public-private collaboration and using HPC to increase competitiveness and value-add in innovation.

Overall, for each category of the aspects analysed in the context section, one or several objectives are established. Starting from these objectives, recommended actions are set out for each of the pilot regions in relation to the results of the analysis.

Methodology

This section summarises the conceptual approach and methodology for developing the Final Region Specific Action Guidelines. The process was broken down in the following key steps, shown in Figure 1.

Figure 1: Methodology for developing D6/4



The approach used in the final version is two folded: firstly, there is the place-based recommendations perspective; secondly, there is the cross-border perspective, enabling a set of transnational general guidelines aimed at fostering HPC development in different European regions.

Thus, the development of the document proceeded in five steps.

Firstly, the D6/2 was developed including input from WP2 and WP3. The document was based on the template included in D6.1 and presented information on relevant aspects such as: socio-cultural, policy, infrastructural, educational etc.

Secondly, based on the content of D6/2, regional partners conducted strategic workshops (D6/3) in form of moderated discussion on Preliminary Region-Specific Action Guidelines, with the purpose to test their validity and to improve them.

Thirdly, regional partners from the pilot regions, UEFISCDI, FIS and WIT developed the draft version of D6/4 Final Region-Specific Action Guidelines.

This were debated at the consortium level in the fourth step.

Based on the feedback, the lead of WP6, UEFISCDI, developed the final version which was checked by the quality assurance readers. In this way the final version of the D6/4 Final Region-Specific Action Guidelines was completed.

I. Final Region-Specific Action Guidelines for Bucharest-Ilfov (Romania)

1. Regional context

High performance computing is characterised by a moderate development in the Bucharest-Ilfov Region. However, the region concentrates the majority of national total spending on research, technological development and innovation and also a large share of the HPC infrastructure. Also, the region accommodates the Politehnica University in Bucharest, which is the largest HEI in Romania and an important provider of HPC infrastructure and services. Still, the collaboration between public providers of HPC services and infrastructure and the business sector is limited since research institutes are the main users/beneficiaries of HPC resources in the region.

1.1. General appraisal of the regional context regarding HPC development in the pilot region

In Romania, high performance computing is characterised by a moderate development both at the national as well as at the regional level. The Bucharest-Ilfov region makes no exception, although it concentrates the largest share of national spending on research, technological development and innovation [1], as well as an important share of the HPC infrastructure. Thus, according to the mapping performed by Engage in the Romanian Research Infrastructures System (ERRIS), the region accommodates over 400 pieces of equipment matching HPC and 7 major HPC centres [2]. The policy framework is still developing, but HPC has been recognized as having a major role in “solving the big societal problems”, as pointed out in the National Strategy for RDI 2014-2020 [3].

The main HEI that provides HPC services in the Bucharest-Ilfov region is the Politehnica University in Bucharest, which houses a High Performance Computing Centre as part of the Computer Science Department from the Faculty for Automatic Control and Computers. The centre, which includes the NCIT High Performance Computing Cluster, provides entities from academia and the business sector with the computing resources necessary to solve scientific and engineering problems [4]. The centre has a variety of architectures, some of them developed with the support of large IT companies, such as Intel, IBM, HP or Lenovo, allowing researchers and students to test different configurations.

The use of HPC in the private sector is modest (although increasing), as the existing infrastructure is mainly used by universities and research institutions. Although several universities and research institutions own and manage HPC resources, researchers are the main beneficiaries of these resources. Only a limited number of companies are aware of the benefits of HPC and have access to HPC resources. Moreover, the collaboration between public providers of HPC services and infrastructure (such as Politehnica University) and the business sector is limited since research institutes remain the main users/beneficiaries of HPC resources in the region. However, there are several private companies offering HPC facilities, including SMEs (e.g. Spearhead Systems, Wing Computer Group etc.).

1.2. Appraisal of socio-cultural aspects relevant to HPC development in the pilot region

The Bucharest-Ilfov region is home to Romania's capital city. Bucharest is the country's largest city, with a population of over 2 million people, and is home to the majority of research institutes and R&D infrastructures. The city witnessed a rapid development in the past two decades, as it attracted a high number of talented people, particularly millennials, from other regions in the country. One of the reasons behind the city's attractiveness is the availability of numerous bachelors' and masters' programmes in Bucharest's many universities (Bucharest hosts 16 state universities – both civil and military - and 15 private universities).

Moreover, at the time being, Bucharest-Ilfov is the only region in Romania (NUTS II level) regarded as developed (as opposed to the other NUTS II regions, which are regarded as "developing"), which implies that average income per capita and average GDP is also higher. With a GDP per capita of over 40.000 Euros (139% of the average GDP per capita in EU28), the region surpasses other EU capitals such as Athens (92% of the EU28 average), Madrid (125%) or Budapest (102%) [5]. Moreover, despite being the smallest region in terms of surface (albeit the most populous), Bucharest-Ilfov generates 25% of the national GDP and over 21% of the country's exports, and is also home to the majority of Romania's largest companies [5].

Bucharest-Ilfov is also the region with the highest number of entrepreneurs. There are almost 120.000 SMEs in the region, which means there is one SME per 5.25 inhabitants [6]. Many people, especially millennials, work in creative and technology-related industries. Hence, the attitude towards technology is quite positive. Still, although people and organisations are open to new technologies, there is a delay (as opposed to other EU countries) regarding the usage and implementation of the latest technologies.

As regards the attractiveness of HPC, although Romania has been struggling with brain drain for almost thirty years, there are some incentives for talented people. There is a diversity of projects that are both interesting and relevant, with a high degree of applicability. In fact, the region offers projects that are highly interesting (e.g. using HPC for the study of deep-focus earthquakes) and talented people are thus offered the opportunity to make a positive contribution to society.

Actors in HPC now have access to opportunities and knowhow, and there are several ways to receive the information (i.e. thematic events) on HPC projects and opportunities. Cooperation between regional business actors and entities outside the region is in its early stages, but the majority of HPC projects are implemented in partnerships comprising entities from the same region. Moreover, civil society plays an increasing role in the promotion of new technologies and processes, including HPC. According to the interviews carried out with stakeholders in the region (as part of WP3), one actor with an important role in the support of HPC is ARCAS (Romanian Association for the Promotion of Advanced Computing Methods in Scientific Research), an association based in Bucharest which brings together people interested in HPC (simulation, application development, education). Its members come from various research institutions, including institutes of the Romanian Academy, the Institute of Spatial Sciences, the Romanian Space Agency etc. The majority of the members are people with technical competencies, which are able to disseminate information on HPC both within the association, as well as in their own organizations.

Overall, the development is still slow, this also being due to the weak connections between research institutions and the business sector [7]. However, the use and application of HPC is on an upward

trend, and several cooperation projects have been implemented so far or are under way. For example, the Politehnica University in Bucharest, the main HEI that provides HPC services in the Bucharest-Ilfov region, developed several HPC architectures with the help of Intel, IBM, HP and Lenovo, which allowed the university to test different configurations and enhance the practical skills of our students. The university also collaborates with other HEIs, one relevant example being the CoLaborator Project, whose aim is to bring the Romanian academic community together around the HPC infrastructure. The project will facilitate the "development of a new collaboration paradigm between computer specialists, scientific computing and other fields of research" [8].

Another good practice example is the project implemented by Spearhead Systems together with the National Institute for Aerospace Research (INCAS), the University of Bucharest, the Romanian Institute of Astronomy and the Horia Hulubei National Institute of Physics and Nuclear Engineering for the development of new HPC infrastructure to be used in R&D. The SGI UV HPC System installed at the Romanian Aerospace Agency by Spearhead Systems allows INCAS researchers to "obtain results for complex aerodynamic problems using complicated geometries for different aircraft and spacecraft vehicles" [9].

1.3. Appraisal of policy aspects relevant to HPC development in the pilot region

Romania is still underdeveloped in the field of high performance computing, but the importance of HPC was recognised in the National Strategy for RDI 2014-2020. Thus, the strategy mentions that "developing software, technologies for the internet of the future and high performance computing play a central role in solving the big societal problems" [3].

In Romania, at policy level, the initiatives concerning HPC are part of the policies of Ministry of National Education, Ministry of Economy, Energy and Business Environment, Ministry of Transport, Infrastructure and Communication. However, the stakeholders interviewed in the current project consider that, at the time being, public policies do not have a powerful role in advancing the development of HPC as authorities do not manage to intermediate between actors using HPC. Although several HEIs and public research institutions own and manage HPC facilities which are not yet used at full capacity, these facilities are rarely available to private actors. One of the reasons behind this situation is the fact that public entities are not allowed to generate revenues from the exploitation of public infrastructure. Thus, companies are rarely able to use public HPC infrastructure, even if they have the resources to pay for it.

Local actors feel that public support for the development and use of HPC is limited, especially in the case of private companies. Some companies have benefitted from financial support as a result of implementing EU-funded innovation projects in partnership with HEIs or research institutions. Moreover, since public authorities do not play an active role in supporting this sector, there is also a lack of vision and strategy as regards the development of HPC.

At the time being, fiscal facilities are available both for companies engaged in R&D, as well as for their employees. Thus, companies are exempted from corporate income taxes, while employees working in R&D (software development included) are also exempted from personal income taxes [10].

Overall, the stakeholders engaged in the SME/HPC project underlined the necessity of implementing the actions allowing the development of a functional HPC framework that would bring benefits to the business actors and the academic environment alike. They stressed the importance of measures

that would increase the awareness of the subject among general public and political decision-makers, they strengthen the need for education and request support measures for SME's that were trying to gain access to the EUROHPC supercomputing.

1.4. Appraisal of HPC infrastructure in the pilot region

There are several organisations in the Bucharest-Ilfov development region that own or have access to HPC facilities. As also presented above, Politehnica University is the main HEI that provides HPC services in the Bucharest-Ilfov region. The University currently houses a High Performance Computing Center as part of the Computer Science Department from the Faculty for Automatic Control and Computers, which provides entities from the academia and the business sector with the computing resources necessary to solve scientific and engineering problems [4]. The centre has a variety of architectures, some of them developed with the support of large IT companies, such as Intel, IBM, HP or Lenovo, allowing researchers and students to test different configurations.

The NCIT Cluster at University Politehnica of Bucharest was created in order to enhance the communication between Universities, at a national level, using the national network infrastructure for education and research. The structure of the computing centre is heterogeneous in terms of hardware platforms and programming environments and there are 6 different computing architectures available [11]: Intel Xeon Quad 64b, Intel Xeon Nehalem 64b, AMD Opteron 64b, IBM Cell BE EDp 32/64b, IBM Power7 64b, NVidia Tesla M2070 32/64b. The laboratories of NCIT provide support in programming parallel computing systems using the latest technologies, such as programming in MPI, OpenMP and hybrid mode, CUDA, OpenCL, Cell Computing or batch-queue system for task submission [4].

The Politehnica University also has a uniquely designed centre for advanced research and development called CAMPUS (Center for Advanced Research on New Materials, Products and Innovative Processes). HPC equipment is used in four laboratories within CAMPUS:

- CAMPUS - Centre for Advanced Research on New Materials, Products and Innovative Processes - Robots – Autonomous and Adaptive Systems Lab, University Politehnica of Bucharest: 3 x Ultra High Definition Display, 12 x High Performance Computing Systems, 12 x High Performance Portable Computing Systems;
- CAMPUS - Center for Advanced Research on New Materials, Products and Innovative Processes - Multimedia Content Processing and Analysis Lab: 3 x Ultra High Definition Display, High definition video projection system, 7 x High Performance Computing System, 3 x High Performance Portable Computing Systems;
- CAMPUS - Center for Advanced Research on New Materials, Products and Innovative Processes - Human-Computer Dialogue Systems and Speech and Audio Forensics Lab: 2 x Ultra High Definition Display, 6 x High Performance Computing Systems, 7 x High Performance Portable Computing Systems;
- CAMPUS - Center for Advanced Research on New Materials, Products and Innovative Processes - Metamaterial Structures and Dielectrics with Special Properties Laboratory: High Performance Computing System, High Definition Video Projection System, Ultra High Definition Display.

Apart from the Politehnica University in Bucharest, various public research institutions own and manage HPC facilities, mainly for research activities:

- Institute of Geodynamics of the Romanian Academy: HPCC - High Performance Computing Cluster and HPVC - High Performance Visualization Cluster;
- The National Institute for Research and Development in Microtechnologies - IMT Bucharest: Server for High Performance Computing (HPC) / SuperMicro and Intel Corporation integrator PRO SYS SRL;
- The "Horia Hulubei" National Institute of Physics and Nuclear Engineering (IFIN-HH);
- The National Research and Development Institute for Earth Physics: High Performance Computing System;
- The Centre for Advanced Laser Technologies;
- The Institute of Atomic Physics (IFA);
- "Ilie Murgulescu" Institute of Physical Chemistry;
- The National Meteorology Administration;
- The Institute of Space Science;
- The Institute of Mathematics of the Romanian Academy;
- The National Institute of Aerospace Research "ELIE CARAFOLI" – INCAS – it manages a SGI HPC system, which includes [9]:
  - SGI UV Server – designed for high performance, in-memory computing. The SGI UV is the organization's key computational and analytical system used by INCAS' scientists and engineers
  - SGI InfiniteStorage 5000 – a field-proven storage platform offering a highly modular, flexible and cost-effective path to consolidated storage
  - SGI InfiniteStorage NVRAM card – the industry's fastest storage technology, used to support demanding applications and run real-time computations.
  - SGI NAS InfiniteStorage Server – provides customers with high levels of configuration flexibility. INCAS installed this server in 2012 as a central storage point for all scientific data generated for all of INCAS' research teams.

According to the interview results, stakeholders estimate that the capacity use of public infrastructure is about 65-70%.

There are several private enterprises that own HPC facilities and offer HPC services, including subsidiaries of multinational firms (Siemens, IBM), companies with production facilities within or in the vicinity of research institutes (e.g. Optoelectronica 2001), as well as locally-based SMEs (e.g. Spearhead Systems, Pro Sys, Maguay). Some of these companies are aware of the funding opportunities available to them and have improved their infrastructure following the implementation of EU-funded projects together with universities or research institutions and all

them provides services locally (both to public institutions, multinationals as well as to Romanian-based firms), but also on external markets (e.g. on Middle-East countries, Georgia, Turkey, UK and the USA).

1.5. Appraisal of educational aspects relevant to HPC development in the pilot region

The main provider of education programmes in the field of HPC is the Politehnica University of Bucharest. The University has two computing centres and both have their own staff, with employees working both in education as well as in system maintenance. Some of the staff has benefited from training programmes on HPC, with the support of the University and of commercial partners: Intel, IBM, HPE, Oracle, Microsoft, BitDefender etc. Moreover, lecturers have been attending events (conferences) in the USA and the EU. These are generally events that offer networking opportunities with people employed in the management of computing systems, and not only in the scientific and technical administration components.

Lectures on HPC and related subjects (parallel programming, cluster and grid computing, data centre management, cloud computing etc.) are delivered as part of the University's bachelor and master programmes. Moreover, there is a course dedicated to HPC which is delivered as part of a master's programme (in advanced computing architectures). However, there is no master programme focusing exclusively on HPC.

Furthermore, although there are several professors delivering courses on HPC and on HPC-related subjects, the University does not have a professorship with a main focus on HPC. Most of the staff delivering courses on HPC work in the Department of Computer Science and Engineering, which employs more than 75 people, but which is not dedicated exclusively to HPC.

1.6. Summary

Overall, in the Bucharest-Ilfov region and broadly in Romania, HPC is still developing. The interviews carried out with stakeholders in the field of HPC show that there is a growing interest in the field, as people and organisations are open to HPC. Thus, the attitude and culture of the population are quite positive. In fact, Bucharest-Ilfov is the region with the highest number of entrepreneurs per capita and many people (especially millennials) work in creative industries. The fact that entrepreneurship is quite developed in the region and people are open to new technologies has a positive impact on the development of HPC. However, access to information is generally low, and few people are aware of funding opportunities, projects, partnerships, etc. The business environment is currently little aware of HPC and the opportunities it poses, but the situation is gradually changing.

The use and application of HPC in the business sector is still in its early stages. Although several universities and research institutions own and manage HPC resources, researchers are the main beneficiaries of these resources. Thus, HPC application in the region is not oriented towards in-company R&D, but rather towards advancing and developing public research projects (e.g. in life/earth sciences, modelling/simulation and big data/analytics). In some cases, private companies act as partners in these projects, but the focus in not on developing their R&D capacity. Moreover, the use of HPC in the business sector is limited by the fact that SMEs still lack technical skills, and

some companies ask for the help of specialised providers only after they realise that either they cannot manage these systems or that they do not have the skills to ensure the scaling up of codes.

While most businesses have limited access to HPC, there are several private enterprises that own HPC facilities and offer HPC services, including subsidiaries of multinational firms (Siemens, IBM, Lenovo, Intel), companies with production facilities within or in the vicinity of research institutes (e.g. Optoelectronica 2001), as well as locally-based SMEs (e.g. Spearhead Systems, Pro Sys, etc.). Some of these companies are aware of the funding opportunities available to them (e.g. Spearhead Systems) and have implemented EU-funded projects together with universities or research institutions. An essential challenge is the lack of use of HPC among start-up and SMEs, as they do not have the knowledge and the technical and financial capacity to integrate HPC in their work. At regional level, multinationals are the industry actors which have the know-how on HPC and also use HPC in their operations.

As regards the policy framework, there seems to be no coherent vision regarding the development of HPC. Moreover, the stakeholders interviewed as part of the project mentioned the lack of a competence centre (i.e. to act as a partner to similar institutions in the EU) as one of the factors hampering the development of HPC. At the time being, public authorities do not play an active role in the support of HPC at the regional level, and the development of the sector in the region can be attributed almost entirely to the efforts of individual stakeholders.

However, the availability of EU-funding for partnership projects is regarded as an incentive for both public as well as private actors. In fact, involvement in transnational projects in particular has played an important role in raising awareness regarding new technologies. Romania is one of the founding members of the European High-Performance Computing Joint Undertaking (EuroHPC-JU), but the country does not host any of the eight supercomputers which will be hosted within this project with the support of the pan European programme Digital Europe.

There are some incentives aimed to attract talented people in the national calls for innovation. Thus, there is a diversity of projects that are both interesting and relevant, with a high degree of applicability. However, HPC is still underdeveloped as opposed to other regions in Western Europe, which might attract young and talented people out of the country in search of better opportunities.

2. Final recommendations for the development of HPC in the pilot region

Given the socio-cultural, policy, infrastructural and educational aspects analysed above, we identified the following recommendations and objectives for the development of HPC at regional level:

1. Recommendations related to socio-cultural aspects

Recommendation 1: Create mechanisms for improving science-industry collaboration

Recommendation 2: Stimulate the culture on HPC-based innovation

2. Recommendations related to policy aspects

Recommendation 3: Integrate HPC within the strategic policies for innovation

Recommendation 4: Correlate with European developments on HPC

3. Recommendations related to HPC infrastructure

Recommendation 5: Support the exploitation of the existing infrastructure

4. Recommendations related to educational aspects

Recommendation 6: Improve higher education programmes with focus on HPC

Recommendation 7: Provide access to learning opportunities with regard to HPC

3. Final actions for the development of HPC in the pilot region

Recommendations are drawn based both on the results of the analysis, as well as on the results of the interviews and consultations with actors active in HPC performed as part of the SME HPC project.

1. Recommendations related to socio-cultural aspects

Recommendation 1: Create mechanisms for improving science-industry collaboration

Action 1: Develop joint internship programmes and provide support for the elaboration of academic thesis in joint coordination university-industry

Recommended driver(s): academia in partnership with industry

Action 2: Develop partnerships with international initiatives in the field (e.g. InnoHPC Lab)

Recommended driver(s): both research and industry

Action 3: Create a community-platform of experts working and interest on HPC

Recommended driver(s): policy makers

Recommendation 2: Stimulate the culture on HPC-based innovation

Action 1: Organise periodically innovation festivals focused on the digital transformation technologies and initiatives: HPC, artificial intelligence, block chain etc.

Recommended driver(s): policy makers in partnership with research and industry

Action 2: Increase the visibility in public sphere of HPC benefits and existing infrastructure and presenting success stories of cooperation and good practices in the field

Recommended driver(s): policy makers in partnership with research and industry

2. Recommendations related to policy aspects

Recommendation 3: Integrate HPC within the strategic policies for innovation

Action 1: Set a working group for consultations on how to integrate HPC in the next strategic framework for innovation at national level (2021-2027) and to further regularly update the HPC related policies and measures

Recommended driver(s): policy makers

Action 2: Create the policy framework for the establishment thematic department/national network – *institutional driver* to act as a partner to similar institutions in the EU and to act as a unique voice at international level

Recommended driver(s): policy makers

Recommendation 4: Correlate with European developments on HPC

Action 1: Collecting the necessary data requested in the European statistics

Recommended driver(s): policy makers

Action 2: Include HPC as a key domain in the next strategic framework for innovation at national level (2021-2027) capitalising on the opportunity offered by the Horizon Europe programme for HPC (2.7 bn financing under Digital Europe)

Recommended driver(s): policy makers

3. Recommendations related to HPC infrastructure

Recommendation 5: Support the exploitation of the existing infrastructure

Action 1: Building capacity of human resources to use HPC infrastructure

Recommended driver(s): policy makers

Action 2: Provide support for projects initiated by economic operators by funding RDI projects conducted by enterprises, individually or in partnership with research institutes and universities for process and product innovation (goods and services) in economic sectors with high growth potential (ICT including HPC is a national smart specialization)

Recommended driver(s): policy makers

Action 3: Provide support for projects in industry verticals / smart specialization areas where digitization can have significant impact (e.g. smart/autonomous cars, smart cities, agritech, energy 4.0, e-health, fintech)

Recommended driver(s): policy makers

Action 4: Support companies interested in benefitting from the expertise of HPC specialists working in universities or public research centres to host their clusters in the HPC centres (e.g. tax incentives, grants etc.)

Recommended driver(s): policy makers

Action 5: Create a unique point to provide increased access to infrastructure for both public and private entities

Recommended driver(s): policy makers

4. Recommendations related to educational aspects

Recommendation 6: Improve higher education programmes with focus on HPC

Action 1: Develop curricula of bachelor and master's programmes to include HPC-related subjects

Recommended driver(s): academia

Action 2: Correlate existing programmes with the labour market (e.g. educational offer based on ICT to be at least 30% of compulsory educational programmes)

Recommended driver(s): academia in partnership with industry

Recommendation 7: Provide access to learning opportunities with regard to HPC

Action 1: Develop courses on HPC addressed to companies (online – e.g. MOOC; thematic training courses)

Recommended driver(s): academia

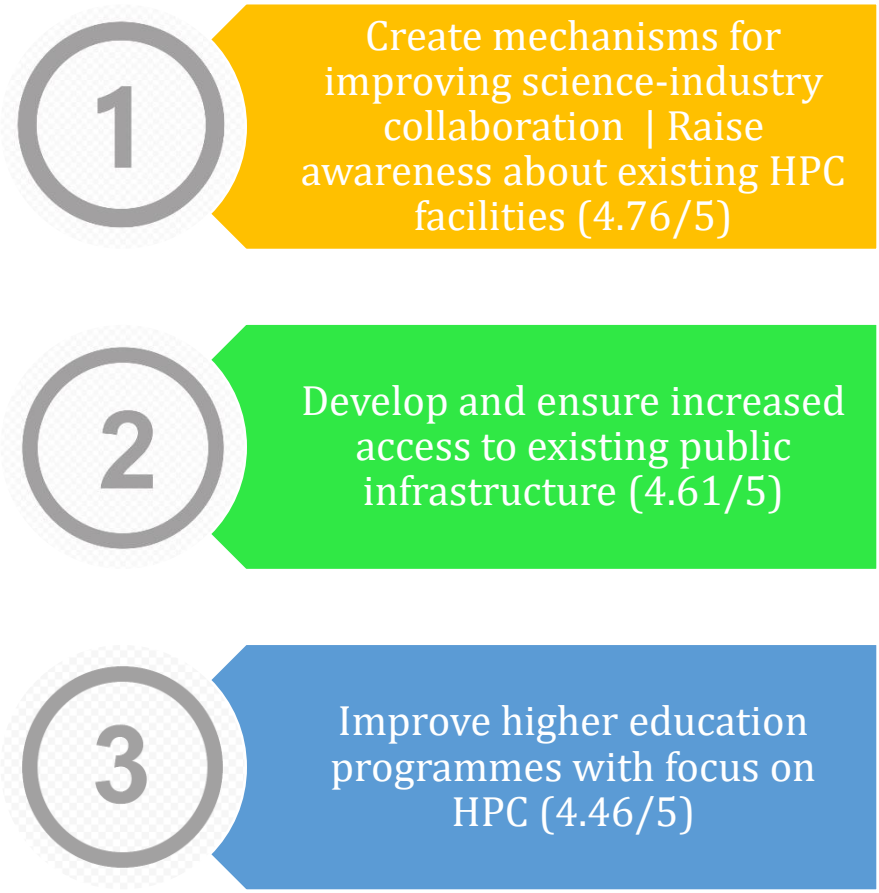
Action 2: Develop an open source virtual library with main resources relevant for learning on HPC

Recommended driver(s): policy makers in partnership with research

Action 3: Develop partnerships with educational initiatives on HPC

Recommended driver(s): industry

Figure 2: The most feasible recommendations for Bucharest-Ilfov resulted from the strategic workshops (on a scale from 1 to 5)



II. Final Region-Specific Action Guidelines for South-East Ireland

1. Regional context

1.1. General appraisal of the regional context regarding HPC development in the pilot region

The economy of South-East Ireland, based primarily on services and industry sectors, congregates a number of strategic industry and service sectors, such as Life Sciences, Medical Devices, Finance and Internationally Traded Services and Engineering. However, the economy of the region only plays a minor role in the Irish economy (over 6%). Waterford Institute of Technology (WIT) hosts the primary supercomputer of the main organisation (the Irish Centre for High End Computing (ICHEC)) in the country focusing on promoting HPC skills for researchers based on Irish Higher-Education Institutes (HEI). However, even though the South-East has an HPC facility as well as a young and well-educated workforce, the region does not seem to be benefiting from it. The aspects that lead to this understanding are detailed in the following sections of this document: socio-cultural, policy, infrastructure and education. A summary of each section is as follows:

1. Socio-cultural aspects relevant to HPC development: The region comprises of 12% of the Irish population, which is the third largest in the country. The majority of the population are between the ages between 25 and 64 years, which represents the most economically active people. However, the tertiary education level age group (between 17 and 24 years), represents the lowest proportion of population in the region. There are 26,625 active enterprises in the South-East region, which is about 11% of the total number of active businesses in the country. Moreover, 99.8% of these enterprises are micro-enterprises and SMEs (CSO, 2016). Research, development and innovation in the region is supported by two Institutes of Technology and a number of research centres based on pharmaceutical, microbiology, advanced engineering, telecommunications and design and new products development.

2. Policy aspects relevant to HPC development: The development and articulation of enterprise and innovation policy in Ireland is centralised. The Irish government Department of Business, Enterprise and Innovation (DBEI) implements the innovation, research and development policy agenda by working with and funding a number of strategic agencies and programmes, such as Enterprise Ireland, Science Foundation Ireland, IDA Ireland, InterTrade Ireland, and the Programme for Research in Third Level Institutions.

3. HPC infrastructure: The South-East region hosts the primary HPC facility for ICHEC, the main organisation promoting HPC services and knowledge in Ireland. However, the knowledge on HPC that is required for enterprises in the region to benefit from it, especially those of smaller size, is still incipient. The South-East also hosts a number of multinational enterprises (MNEs), which may have their own HPC facilities. However, this information is not publicly disclosed.

4. Educational aspects relevant to HPC development: Both Institutes of Technology (Waterford Institute of Technology (WIT) and Institute of Technology Carlow (ITC)) in the region do not have departments, working groups or academic courses dedicated to HPC. However, they use supercomputing power to run tests and analyses for academic research. This is done by ICHEC,

which uses Kay[1] as a primary source to perform the task. Therefore, HEIs in South-East Ireland do not provide adequate HPC education and their involvement with HPC is greatly limited to research. Education related to HPC knowledge in Ireland is mostly provided by ICHEC through training and education programmes for researchers and the Irish workforce.

1.2. Appraisal of socio-cultural aspects relevant to HPC development in the pilot region

The land area of the South-East comprises of 7,198 km², which corresponds to 10.2% of the total territory of Ireland. The socio-cultural aspects that are considered to influence the development of HPC in the region are divided according to (1) Population; (2) Economy; and (3) Research, development and innovation.

Population

The different elements that are considered in relation to the population of the South-East are the number of inhabitants, language and age. According to the latest census figures (CSO, 2016), 581,615 people live in the region, of which 292,576 (50.3%) are female, and 289,039 (49.7%) are male. The majority of the population of the South-East resides in County Tipperary (159,553 people), followed by Counties Wexford (149,722 people), Waterford (116,176 people), Kilkenny (99,232 people) and lastly, Carlow (56,932 people). The population represents just over twelve per cent of Ireland's approximately 4.76 million people. The South-East is the third most populated of the eight regional authorities in the country, just after Dublin, and the South West regions. Even though Irish is spoken in the region, it is restricted to Gaeltacht na nDéise, a small locality with less than 3,000 inhabitants. Therefore, English is vastly the main spoken language in the South-East.

The latest census figures also reveal that the majority (52.1%) of the population of the South-East region are between the ages of 25-64 years, which is a favourable result for the region ragarding the fact that this group accounts for most of the economically active people in most given populations. On the other hand, the tertiary education level age bracket (17-24 years) accounts for the lowest proportion in the region with just a 11.6 percent share. The youngest (0-14 years) and the oldest (over 65s) age groups make up 21.7 per cent and 14.6 per cent share of the region's population respectively.

In 2018, there were approximately 205,000 people aged 15 years and above in the South-East region's labour force, representing an increase of around 4.3 per cent in relation to 2017. However, between 2008 and 2018, the total number of individuals in the region's labour force decreased by 15%, whereas a marginal increase of 5.3 % in the size of the country's labour force was recorded during the same period (CSO, 2018), which may have been due to the economic recession which weakened the region's economic condition during this period.

Economy

The South-East region, based primarily on the services and industry sectors, plays a minor role in the Irish economy accounting for 6.83% of the country's GDP. However, the region is performing well in areas such as Life Sciences, Medical Devices, Finance & Internationally Traded Services and

[1] Kay is the name of the supercomputer that is hosted by WIT in the South East, but is owned by ICHEC.

Engineering (Joint Committee on Jobs, Enterprise and Innovation, 2013). The region has good quality transport and other economic infrastructure consisting of two Higher Education Institutes, a young and highly educated labour force, and a network of region-wide Industry and Technology Parks (Irish Regions European Office, 2019).

In 2016, there were approximately 26,625 active enterprises in the South-East region, about 11% of the total number of active businesses in the country. Based on Gross Value Added (GVA), the tertiary sector generated the most economic contribution in the South-East region (65%), followed by the Manufacturing, Building and Construction sector (32%). Size-wise, 99.8 per cent of all the active enterprises in the South-East region are SMEs (employing up to 250 workers), while the remaining 0.2 per cent share are large businesses employing over 250 workers. The vast majority (92.5%) of these SMEs are micro businesses (employing under 10 staffs); small enterprises (employing between ten to 49 staffs) make up 6.6 per cent share and then 0.8 per cent of the SMEs are medium sized enterprises, employing between fifty and two hundred and forty-nine personnel (CSO, 2016).

Research, development and innovation

None of Ireland's seven universities is based in the South-East region. However, the region has two of the country's fourteen Institute of Technology (IoTs). The research centres within these IoTs engage with and render services to industry. For instance, the Telecommunications, Software and Systems Group (TSSG) in Waterford Institute of Technology (WIT) is an internationally recognised centre of excellence for ICT research and innovation which engages with over 340 organisations globally. Pharmaceutical and Molecular Biotechnology Research Centre (PMBRC) which is also at WIT is an applied research centre which aims to support the growth of the pharmaceutical and healthcare industry sectors in the region. It has a state-of-the-art facility which allows companies to embed R&D into their activities and has links with national and international partners in industry, academia and medical care. Another research centre at WIT is the South-East Applied Materials (SEAM) Research Centre. It is an industry focused applied research centre recognised worldwide providing innovative materials engineering solutions for companies from a wide range of sectors, including bio-medical devices, pharmaceuticals, micro-electronics, precision engineering and industrial technologies.

One of the research centres in the Institute of Technology Carlow (ITC), Designcore, is an established centre for innovation and commercialisation in design and new product development. The team of dedicated researchers and designers has the expertise and skills to understand consumer motivations, culture and human behaviours to provide real market gain for their clients and establish collaborative relationships with industry.

There are also other public body research centres, for example, Teagasc, which is an agriculture and food development authority and research centre which provides integrated research, advisory and training services to the agriculture and food industry and rural communities. It is the leading organisation in the fields of agriculture and food research in Ireland, undertaking innovative research in: animal and grassland research and innovation crops, environment and fand use as well as food and rural economy and development. Teagasc collaborates extensively with Irish universities and Institutes of Technologies (IoTs) through their post-graduate fellowship programme, which supports more than 100 MSc and PhD students annually in their research centres.

1.3. Appraisal of policy aspects relevant to HPC development in the pilot region

The Irish Department of Business, Enterprise and Innovation (DBEI) implements the innovation, research and development policy agenda by working with and funding a number of agencies and programmes (Department of Business, Enterprise and Innovation, 2019), as follows.

Enterprise Ireland

Through Enterprise Ireland, the Government provides support to expand research capacity in Irish companies, to increase the collaboration between enterprises and the research sector and to maximise the commercialisation of the country's research investment. Enterprise Ireland provides hands-on support to indigenous companies, promotes awareness of the benefits of innovation and provides important funding support in the form of both grants and equity and promotes awareness of incentives such as the R&D tax credits and other incentives available to all industry sectors in Ireland.

Science Foundation Ireland

Science Foundation Ireland (SFI) invests in academic researchers and research teams who have the potential to generate new knowledge, leading edge technologies and competitive enterprises. SFI programmes form a key element of the drive to boost Ireland's international competitiveness and attract Foreign Direct Investment (FDI), which is a key stimulator of the Irish economy through job creation. The expansion of SFI's new remit under the Industrial Development (Science Foundation Ireland) Act 2013 has allowed SFI to fund activities in the applied research arena, as well as continuing to provide key supports for oriented basic research, representing an important step in the development of the relationship between industry and academia in Ireland.

IDA Ireland

IDA Ireland's main objective is to encourage investment into Ireland by foreign-owned companies. It works as a strategic partner and provides consultancy and support services free of charge to help organisations set-up and grow. IDA Ireland partners with potential and existing investors to help them establish or expand their operations in Ireland.

InterTrade Ireland

InterTradeIreland is an organisation that helps small businesses explore new cross-border markets, develop new products, processes and services and become investor ready. It offers practical cross-border business funding, information, advice and support to SMEs across the island, North and South, looking to grow their businesses.

Programme for Research in Third Level Institutions (PRTLI)

DBEI funding for the Programme for Research in Third Level Institutions enhances Ireland's competitive offering in terms of research capability, through funding of PhD programmes and delivery of key physical research infrastructure such as buildings and equipment).

Disruptive Technologies Innovation Fund

Since 2019, DBEI also has funding available through the Disruptive Technologies Innovation Fund (DTIF), which is providing €500 million over the period 2018-2027 for collaborative enterprise-driven

projects with SMEs that will research, develop, deploy and commercialise disruptive technologies to transform business. The DTIF prioritises six generic themes. Under the theme on ICT, three priority areas are aligned with HPC applications: (1) Future Networks, Communications and Internet of things; (2) Data Analytics Management, Security, Privacy, Robotics, Artificial Intelligence, Augmented Reality, and Virtual Reality; and (3) Digital Platforms, Content and Applications.

Moreover, policy actions specific for the South-East region can be implemented by business development organisations that are established in the region such as Enterprise Ireland and IDA. The former focuses on growing Irish enterprises in world markets and the latter focuses on investment into the country through FDI. Thus, Enterprise Ireland can provide hands-on support to companies willing to get involved with HPC and also provide important funding support in the form of grants and equity as well as promoting awareness of HPC-related incentives, such as tax credits, R&D and business innovation projects (Enterprise Ireland, 2018). IDA, on the other hand, can provide financial incentives for multinational companies located in the South-East to carry out in-house R&D projects, collaborative projects with third-level institutes and industrial partners and a 25% tax credit available for companies engaging in R&D. Since multinational companies are more likely to be using HPC, IDA can facilitate this knowledge to 'spill over' to indigenous firms in the region (IDA, 2019).

1.4. Appraisal of HPC infrastructure in the pilot region

The public-owned HPC infrastructure in Ireland is run by the Irish Centre for High-End Computing (ICHEC), a national body under the aegis of the National University of Ireland, Galway with offices in both Galway and Dublin. Among ICHEC's core objectives are:

- provision and support of the National HPC Service to academia;
- provision of commercial services related to HPC and technical computing to industry, semi-state and the public sector;
- participation in joint R&D activities with FDI companies;
- provision of training and education initiatives in support of the third level sector, the National HPC Service (the primary mechanism through which Irish researchers gain access to a supercomputer) as well as business and industry (ICHEC, 2017).

Thus, ICHEC is involved with providing HPC service, support and education to both academia and industry. However, according to Simon Wong (ICHEC's Education, Training and Outreach Lead and Computational Scientist) in a presentation about ICHEC for the partners of the SME/HPC Project, around 80% of HPC services are destined to academia. ICHEC is a member of the Partnership for Advanced Computing in Europe (PRACE), which comprises of HPC organisations from over twenty countries that work to create a pan-European supercomputing infrastructure and ecosystem. Through PRACE, ICHEC provides access to high-performance computing and data management resources and services for large-scale scientific and engineering applications. Since its creation, in 2005, ICHEC has supported over 1,400 academic researchers (undergraduate, PhD and post-doctoral) and interacted with more than 150 companies through face-to-face meetings (ICHEC, 2016). Before ICHEC was created, HPC facilities in Ireland were very limited (Coghlan, Walsh and O'Callaghan, 2005).

The first known public-owned supercomputer in South-East Ireland was Fionn (Linpack Performance of 140.4 TFlop/s), delivered by ICHEC and hosted by Waterford Institute of Technology (WIT) from September 2013 to August 2018 (ICHEC, 2018). Fionn, whose name was chosen from a competition run for first level and second level students in Ireland and originated from the Irish word Fionnachtana (translated: as action of discovery), was ICHEC's primary supercomputer and Ireland's national supercomputer for academic researchers. Before being replaced by a higher grade HPC, Fionn enabled a vast range of research and development (R&D), including resolution in weather and climate forecasting, larger and longer simulations for research in areas such as medical device development, nanotechnology, genomics, drug design, etc.

Fionn was replaced in WIT's premises by Kay (Linpack Performance of 665 TFlop/s), which is currently ICHEC's primary supercomputer and Ireland's national supercomputer for academic research. Similarly to Fionn, the kind of R&D enabled by Kay ranges from weather and climate forecasting to larger and longer simulations for research in areas such as medical device development, nanotechnology, genomics, drug design, etc. Kay can also run heterogeneous workflows that require large computer processes and large amounts of memory either during the pre- or post-processing phases of researchers work (ICHEC, 2019).

Even though Kay is located in Waterford, according to Simon Wong, its use is not restricted to the South-East region. It is also be used by organisations and individuals located throughout Ireland and abroad. Moreover, companies in the South-East are not especially benefitted with HPC access just because Kay is based there. According to interviews with WIT key personnel in maintaining Kay, companies located in the region are not interested in using supercomputing just because they are close to the HPC facility in Waterford; nor does WIT have specific actions targeting companies in the region to use Kay. The promotion of HPC in Ireland is done by ICHEC, which regularly organises roadshows and informative sessions across all the third-level institutions (HEIs) in Ireland, including the South-East, giving informative sessions about the services available, facilities, resources and scientific support.

The name Kay, in memory of Kay Antonelli, an Irish-American computer programmer, was decided through a supercomputer naming competition among six other names. Kay is the only public-owned supercomputer in the South-East which is known by the general public. There are many more supercomputers in Ireland, and possibly in the South-East. However, their location and ownership are not disclosed because they are the property of private companies. Kay, according to the November 2018 Irish Supercomputer List, and based on the number of Tflops/s, is ranked nationally as 16th. The top 15 ranked supercomputers in the list are all privately owned and belong to a software company in Ireland (this company is referred to as Company M) whose name and location are not disclosed (ICHEC, 2019).

Kay's features are as follows:

1-Cluster of 336 nodes where each node has 2X 20-core 2.4 GHz Intel Xeon Gold 6148 (Skylake) processors. 192GB of RAM, a 400 GiB local SSD for scratch space and a 100Gbit OmniPath network adaptor. This partition has a total of 13,440 cores and 63 TiB of distributed memory.

2-GPU with a partition of 16 nodes with the same specification as above plus 2x NVIDIA Tesla V100 16GB PCIe (Volta architecture) GPUs on each node. Each GPU has 5,120 CUDA cores and 640 Tensor Cores.

3-Phi consists of a partition of 16 nodes, each containing 1x self-hosted Intel Xeon Phi Processor 7210 (Knights Landing or KNL architecture) with 64 cores @ 13 GHz 192 GiB RAM and a 400 GiB local SSD for scratch space.

4-High memory with a set of 6 nodes each containing 1.5 TiB of RAM, 2x 20-core 2.4 GHz Intel Xeon Gold 6148 (Skylake) processors and 1 TiB of dedicated local SSD for scratch storage.

5-Service and storage with a set of service and administrative nodes to provide user login, batch scheduling, management, networking, etc. Storage is provided via Lustre filesystems on a high-performance DDN SFA14K system with 1 PiB of capacity.

Regarding software applications that are available on Kay, they are as follows: ABAQUS, AMBER, ANSYS CFX & Fluent, CMAKE3: Cross-platform make, DL_POLY, GAMESS-US, Gaussian, GNU Parallel, GROMACS, GSL, NAMD, OpenFOAM, Python, Quantum Espresso, R, Siesta, VASP, and VORO++

ICHEC has launched a European network called SESAME (Supercomputing Expertise for Small and Medium Enterprises), which aims to give Irish SMEs affordable access to high-performance computing (HPC) technology. However, the number of SMEs involved in this network from the South-East region has not been specified by ICHEC. Furthermore, based on the interview given by the engineers who are part of the team who maintains Kay at WIT, there is no knowledge of SMEs involved with HPC processes in South-East Ireland.

1.5. Appraisal of educational aspects relevant to HPC development in the pilot region

Based on the interviews with staff from the two Higher-Education Institutes (HEI) in South-East Ireland, WIT and ITC, there are no departments, working groups or academic courses dedicated to HPC. Both of these institutions use supercomputing power to run tests and analyses for academic research. However, this is done by ICHEC, which uses Kay (see above for details) as a primary source to perform the tasks. Therefore, HEIs in South-East Ireland do not provide adequate HPC education and their involvement with HPC is greatly limited to research.

Education related to HPC knowledge in Ireland is mostly provided by ICHEC, which conducts extensive training and education programmes for researchers across third level educations and more generally the Irish workforce by providing training courses, graduate modules as well as mentorships and internships that cover basic to advanced HPC skills. In order to engage the scientific community and users to create a vivid ecosystem between HPC and science in Ireland, ICHEC regularly organises roadshows and informative sessions across all third-level institutions in the country providing information about the services available, facilities, resources and scientific support.

1.6. Summary

An analysis on the main aspects concerning the regional context regarding HPC development in South-East Ireland leads to the conclusion that knowledge on HPC is still scarce in the region. This is aggravated by the fact that, currently, there are no HPC education programmes at Higher Education Institution level in the region and also due to the fact that the number of students prepared to do engineering under-graduate courses is low relative to the region's total population. Moreover, the fact that the great majority of enterprises established in the region are SMEs limits the propensity of individuals working in these firms to start implementing HPC solutions because generally SMEs

do not have the financial resources that are required to learn and use supercomputers. Also, most of these SMEs would state that they do not have the time to be involved with new technologies, even though these technologies may be of huge benefit to them. Academic research tends to benefit the most from HPC in the region as there are a number of research centres in the region that are likely to continue using HPC or even increase HPC usage over time.

There seems to be no specific efforts for the industry sector to use HPC because, even though the Irish Department of Business, Enterprise and Innovation (DBEI) produces considerable efforts to promote innovation in the country, including the South-East region, none of the actions are focused on diffusing HPC knowledge and usage. For example, whereas the National Planning Framework: Ireland 2040 focuses on innovation, technology disruption, sustainable economic development and job retention and creation, it does not contain any policy pertaining to the use of HPC to improve the competitiveness of Irish industry.

Moreover, there are no structured actions from the two Institutes of Technology in the region to start disseminating HPC knowledge and skills to their students, since no departments, working groups or academic courses dedicated to HPC exist. Education related to HPC knowledge in Ireland is mostly provided by ICHEC through training and education programmes for researchers and the Irish workforce. However, ICHEC is a small organisation located in both Galway and Dublin. Therefore, it lacks resources to be continuously present in regions such as the South-East, which are far away from these urban centres.

2. Final Recommendations for the development of HPC in the pilot region

Based on an analysis of the main aspects that can support the development of HPC in the South-East, the following directions can be anticipated and objectives drawn.

1. Recommendations related to socio-cultural aspects

Recommendation 1: Create interest and conditions for SMEs to engage with HPC skills and knowledge

Recommendation 2: Increase the number of specialised professionals on HPC in the region

2. Recommendations related to policy aspects

The innovation policy agenda in Ireland does not focus on diffusing HPC knowledge to the industry.

Recommendation 3: Implement a strategy of HPC knowledge diffusion in the innovation agenda in South-East Ireland

3. Recommendations related to HPC infrastructure

The South-East has HPC infrastructure, which is hosted by WIT. However, apart from media interest that promoted the news about HPC throughout Ireland, the benefits for the region are yet to be seen. There is little awareness of the benefits that supercomputing can bring to companies in the region. Also the staff who maintain the supercomputer in WIT is not trained to facilitate industry, including SMEs, to learn about HPC.

Recommendation 4: Promote awareness and benefits of the HPC infrastructure in South-East Ireland

4. Recommendations related to educational aspects

There is no promotion of HPC knowledge and skills derived from the existing HEI infrastructure in the South-East. The two Institutes of Technology that are based in the region do not have departments, working groups or academic courses dedicated to HPC Education. HPC knowledge in Ireland is mostly provided by ICHEC, which conducts extensive training and education programmes for researchers across HEIs in the country.

Recommendation 5: Foster HEIs to become more involved with HPC education

Recommendation 6: Have an ICHEC office in the South-East

3. Final actions for the development of HPC in the pilot region

Based on the directions and objectives indicated in the previous section, recommendations of actions and guidelines for the development of HPC in the South-East are made as follows.

1. Recommendations related to socio-cultural aspects

Recommendation 1: Create interest and conditions for SMEs to engage with HPC skills and knowledge

Action 1: Promote networking events whereby companies based in the South-East have the opportunity to interact and learn from experienced HPC users and developers.

Recommended driver(s): policy makers in partnership with research

Action 2: Establish incentives and subsidies for multinational companies that cooperate with SMEs in HPC-related projects

Recommended driver(s): policy makers

Recommendation 2: Increase the number of collaborations between specialised professionals on HPC in the region

Action 1: Create opportunities for research collaboration between researchers based in the South-East and researchers with expertise on HPC from elsewhere

Recommended driver(s): policy makers

Action 2: Create a department dedicated to HPC in WIT as well as working groups and academic courses

Recommended driver(s): academia

Action 3: Establish innovation cooperation projects between SMEs and multinational companies that have HPC capability and capacity

Recommended driver(s): policy makers

2. Recommendations related to policy aspects

Recommendation 4: Implement a strategy of HPC knowledge diffusion in the innovation agenda in South-East Ireland

Action 1: Ensure that a section on HPC is embedded into the South-East section of the National Planning Framework: Ireland 2040. This will be achieved by submitting relevant information about HPC implementation, usage and benefits into this policy document.

Recommended driver(s): policy makers

Action 2: Achieve critical mass in terms of understating the link between HPC & innovation by the cooperation of key stakeholders (e.g. WIT and private companies).

Recommended driver(s): policy makers

3. Recommendations related to HPC infrastructure

Recommendation 5: Promote awareness on the HPC infrastructure in South-East Ireland

Action 1: Hold a series of HEI-Industry workshops in the region focused on HPC infrastructure in the region

Recommended driver(s): academia in partnership with industry

Action 2: Promote HEI-Industry networking events to analyse and debate SME HPC use-case studies

Recommended driver(s): policy makers in partnership with academia and industry

Action 3: Engage ICHEC in these workshops and network events to provide HPC knowledge and expertise to potential HPC users.

Recommended driver(s): research

4. Recommendations related to educational aspects

Recommendation 6: Foster HEIs to become more involved with HPC education

Action 1: Create a department dedicated to HPC in WIT as well as working groups and academic courses (same as Action 1 for Objective 2)

Recommended driver(s): academia

Action 2: Provide specialised training to companies on HPC topic

Recommended driver(s): academia

Recommendation 7: Have an ICHEC representation in the South-East

Action 1: Establish an ICHEC office in the South-East dedicated to supporting industry in HPC solutions and applications

Recommended driver(s): policy makers

Figure 3: The most feasible recommendations for South East Ireland resulted from the strategic workshops (on a scale from 1 to 5)

III. Final region-specific action guidelines for South-East Slovenia

1. Regional context

1.1. General appraisal of the regional context regarding HPC development in the pilot region

In Slovenia, the computer clusters can be divided into those owned by public entities and those owned by private companies. Additionally, the HPC clusters owned by research organizations, are mainly used by the research groups within the hosting institution which provided funds for this equipment (Bahor and Povh 2019). In the South-East region Higher Education Institutions that have an HPC are: University of Maribor and Faculty of Information Studies. Additionally, these two HEIs alongside the Institute of Information Sciences, launched the project Upgrading National Research Infrastructures – HPC RIVR. The aim of the project is to establish a national supercomputing centre with the principal objective of strengthening national high-performance computing capacities for the needs of Slovenian research and innovation as well as in the economic area. RIVR will be one of the eight supercomputer centres in the European Union that were selected to host the EuroHPC supercomputer infrastructure. Thus, it will support both the European research and industrial spheres in the development of new knowledge and applications in all areas, from medicine and advanced materials to the fight against climate change (Government of Slovenia 2019).

With the HPC RIVR project, Slovenia is setting up its own state-of-the-art supercomputer centre for processing big data, which will include researchers and development centres. With its clear orientation towards the information and technology society, it has set Slovenia at the nexus of regional and European cooperation and has given us the tools we need in the era of ubiquitous data processing and machine decision-making and will provide digital security. Slovenia is thus cooperating in an ambitious initiative to establish a modern, competitive European EuroHPC supercomputer infrastructure with an exceptionally advanced solution in the hands of local experts.

At the same time, the region lacks programmes and institutions that would be dedicated/oriented toward HPC, because mainly the main concentration on knowledge is in the capital.

Novo Mesto, situated in South-East Slovenia, is the regional and national centre of economic development. Thus, the region has market-leading companies as Krka, Revoz, Adria Mobil, TPV, which are the engine of the economy and economic development in general. In addition to the leading chemical industries and the automotive industry, a great potential in Novo Mesto is also seen in strengthening the IT industry, production industry and design (Municipality Novo Mesto 2019).

The region of South-East Slovenia is highly export-oriented, as the share of net sales revenues achieved on foreign markets is considerably higher than the share of the country. As a result, from the point of view of the structure of activity, the processing activity plays a dominant role. Economic companies also play an important role in the field of trade, maintenance and repair of motor vehicles and construction.

The region boasts a rich industrial tradition, which has a great contribution to the development of the region as such. Let's just mention a few main companies in the region: Krka, Revoz, Akrapovič, Adria Mobil, Terme Krka, Trimo, Dana, Kolpa, HYB, Riko, Mikrografija, Yaskawa etc. (Development Centre 2019).

1.2. Appraisal of socio-cultural aspects relevant to HPC development in the pilot region

According to the Digital Slovenia 2020 – Development Strategy for the Information Society until 2020 (Ministry of Public Administration 2016), the provision of long-term preservation of digital cultural content in Slovenia is not systemically regulated. Until now, strategic documents for long-term preservation have not been adopted at the national level. At the moment they exist only for the Slovenian public archive service and the National and University Library. Both have adopted the strategy of the long-term preservation of e-materials; the strategy for the Archives has been confirmed by the Government of the Republic of Slovenia and is now implemented. In order to develop this sector, it is considered that cultural institutions need a long-term common strategy of keeping digital cultural heritage, better interaction (coordination), exchange of experience and, if possible, a common information infrastructure.

E-services in culture are underdeveloped. As Digital Slovenia 2020 states, there are several aspects that favour the presence of an underdeveloped e-service in culture:

- Administrative and professional processes of cultural heritage protection, of archives and library material and processes in the area of creativity and media lack information support.
- Processing of archives and library material does have full support, whereas in the area of non-movable cultural property only non-movable cultural property register is being held and partially a register on guidelines and spatial acts, systems for museum documentation are likewise incomplete.
- The existing systems do not meet the digitisation challenges and are in great need of updating. The optimization of business processes and the use of modern ICT tools can provide more efficient public services and the functioning of cultural public services, while ensuring other stakeholders the availability and connectivity of data and facilitating the development of related e-services.

At the same time, a number of studies have reported a low level of computer use in the population over 50, a low level of activities and policies for the introduction of e-skills, while the starting points in education are the lack of ICT skills among teachers and professors, insufficient public sector funds for adequate training, a general lack and obsolescence of ICT equipment and the education system that gives students too much theory and not enough practice. As a result, the lack of digital skills in persons entering the labour market, including employees, is a major obstacle for the further technological modernization of enterprises and the economic development of the country. Digital illiteracy hampers economic growth and employment as well as personal development. Additionally, it can be stated that it affects the HPC sector, even if not directly.

Accordingly, it is important that the already established mechanisms for increasing the access to ICT are joined by further measures for their increased use and development of new services that will

better suit the requirements of the digital age, which will also boost the competition in developing new employment opportunities in the labour market. In March 2013, the EC launched the Grand Coalition for Digital Jobs, whose aim is to not only slow down the decrease in the number of ICT experts by 2015 but also increase the number of experts to fulfil the needs for such labour by 2020. The Grand Coalition helps promote and boost the efforts for European development policies such as DAE, Employment Package, Opening up Education Initiative, Rethinking Education Strategy, Youth Opportunities Initiative and EU Skills Panorama. As a part of further endeavours in the framework of the Grand Coalition, the EC encourages the Member States to establish local or national coalitions for digital jobs, i.e. strategic national partnerships for digital jobs in the EU Member States. The principal objective of these coalitions is to work with interested parties registered in the Member States in order to provide special digital skills to the young, stimulate them to choose ICT careers and connect them with the trainings of the private sector for new jobs. With the aim of drafting measures for providing web-accessibility, the EC ordered an analysis in 2014; the aim of the analysis was to provide an up-to-date description of the situation of web-accessibility monitoring in the countries covered, validate the monitoring methodologies for verifying compliance with national provisions on web-accessibility and present a recommended monitoring methodology for the proposal for a Directive on the accessibility of public sector bodies websites. The analysis also included Slovenia. Apart from this, no comprehensive analysis of the situation in the field of web accessibility has been made. The area is relatively poorly developed, with only some websites of public sector bodies being adapted for certain vulnerable groups. Also problematic is the fact that there is no established standard methodology of adaptation of web accessibility; this has led to a variety of practical solutions, most of which do not follow a comprehensive and inclusive adaptation of websites for all representatives of persons with disabilities.

Slovenian authorities have the aim to support and promote the development and use of high-quality digital content and e-services in Slovenia, the digitisation of cultural heritage, long-term preservation of digital materials as well as the general development of digital language technologies and resources, which will allow the population to use them and encourage it to use the internet.

Cultural institutions need a long-term common strategy for preserving digital cultural heritage, better interaction (coordination), exchange of experience and, if possible, a common information infrastructure.

1.3. Appraisal of policy aspects relevant to HPC development in the pilot region

The Government of the Republic of Slovenia has adopted several strategic documents relating to the development of information society to 2020 (Ministry of Public Administration 2015):

Public Administration Development Strategy 2015 -2020 (SJU 2020)

Strategy's objectives:

- rational organisation of public administration,
- programme-oriented budget and reinforcement of internal control mechanisms for public finances,
- effective management of human resources,

- professional qualification of civil servants,
- transparent and efficient public procurement,
- regulated physical assets of the State,
- better regulations and effective administrative procedures,
- reinforcement of transparency and integrity,
- establishing a quality system in public administration,
- reformed inspections,
- digitalisation of public administration.

Information Society Development Strategy to 2020 – DIGITAL SLOVENIA 2020

The detailed objectives of the strategy are:

- raising general awareness of the importance of information and communications technologies (ICT) and the Internet for the development of society,
- sustainable, systematic and targeted investment in the development of a digital society,
- general digitalisation according to the "Digital by Default" principle,
- competitive digital entrepreneurship and digital industry for digital growth,
- intensive and innovative use of ICT and the Internet in all segments of society,
- high speed access to open internet for all,
- inclusive digital society,
- secure cyberspace,
- trust and confidence in cyberspace and the protection of human rights,
- Slovenia – reference environment for the deployment of innovative approaches in the use of digital technologies.

Thus, the vision of the strategy is for Slovenia to, by accelerated progress of the digital society, take advantage of the development opportunities of ICT and the Internet. It will allow becoming an advanced digital society and reference environment for the deployment of innovative approaches in the use of digital technologies on a systemic level. Additionally, high-performance computing is one of the strategic objectives of the Slovenian Digital Strategy 2020

Next-Generation Broadband Network Development Plan to 2020

In a modern digital society, economic, as well as overall development is directly linked to the high-quality broadband infrastructure, which serves as the basis for the development and use of the Internet.

As a result, the plan aims to co-finance and provide inhabitants of rural areas with access to modern communication infrastructure and very fast internet access. This will also create conditions for the preservation of the countryside and for continuous balanced development of this kind of infrastructure in all regions of Slovenia.

In light of less developed broadband infrastructure in Slovenian countryside, the Government of the Republic of Slovenia adopted the "Next-Generation Broadband Network Development Plan to 2020". The objective of the Plan is to ensure equal standing of rural, urban and suburban population in Slovenia in this area.

The Plan establishes strategic guidelines for co-financing the construction of broadband infrastructure through public resources, especially in rural areas. The objective of the guidelines is, by 2020, to provide most households with broadband internet access with at least 100Mb/s.

Cyber Security Strategy

It is expected that by 2020 Slovenia will have set up an effective system for ensuring cyber security in preventing and addressing the consequences of security incidents. To achieve this objective a set of measures will have been taken in the following areas:

- reinforcement and organisation of the regulatory framework of the national cyber security system,
- citizen security in cyberspace,
- cyber security in the economy,
- ensuring the functioning of critical infrastructure in the sector for information and communication support,
- ensuring cyber security in the field of public security and combating cybercrime,
- ensuring safe functioning and availability of key information and communication systems in the event of major natural and other disasters.

An essential objective of the strategy is the regulatory framework organisation at strategic level for ensuring cyber security. Therefore, the Government of the Republic of Slovenia assigned the role of the national authority for cyber security to the Government Office for the Protection of Classified Information. The authority will, at strategic level, coordinate activities and resources for ensuring development of cyber defence capabilities and reinforcement of national cyber security through international co-operation in the Republic of Slovenia.

According to the European Commission, besides these strategic documents, Slovenia is the ninth Member State to sign the European declaration on high-performance computing and will participate in the joint efforts to build the next generation of computing and data infrastructures. It is expected that these documents will prepare an implementation roadmap to deploy the European exascale supercomputing infrastructure. The EuroHPC goal is to develop a high-performance computing ecosystem based on European technology, including low power chips and to have exascale supercomputers based on European technology in the global top 3 by 2022. This should make available top class HPC infrastructure and services to a wide range of users: large industry and SMEs, as well as the public sector. Additionally, this will also support the European Open Science Cloud

and will allow millions of our researchers to share and analyse data in a trusted environment across technologies, disciplines and borders.

1.4. Appraisal of HPC infrastructure in the pilot region

Slovenian researchers participate in several EU projects that are directly linked to the e-infrastructure and high-performance computing (HPC), but so far they do not have the sufficiently powerful equipment to establish the critical mass of the HPC knowledge by which they would be able to obtain computer time in major centres on the basis of the already tested code.

The ARNES network as the central national infrastructure for powerful distributed computing is also established. SLING (Slovenian initiative for national grid) also operates within this and is open for use by all research and educational institutes in Slovenia and is the basis for the effective use of computer facilities in Slovenia.

Computer clusters in Slovenia can be divided into national research centres and independent HPC providers.

National research centres:

- Jožef Stefan Institute (IJS) with its first HPC being built in 1990's. At the moment they possess several clusters being located in different laboratories.
- Faculty of Mechanical engineering at University of Ljubljana manages its HPC cluster HPCFS being used for solving problems for industry and academia.
- National Institute of Chemistry manages two HPC clusters named HPC and Vrana.
- Slovenian Environment Agency ARSO uses its clusters SGI ICE-X for weather simulations.

In South-East Slovenia, we can mention two institutions that have HPC facilities:

- Faculty of Information Studies in Novo Mesto manages its HPC cluster Rudy for numerical simulations on different projects and tasks.
- University of Maribor manages its HPC CORE@UM the Faculty of Mechanical Engineering.

Additionally, it is important to mention that the largest HPC Centre in Slovenia is HPC RIVR whose partners are the University of Maribor, the Institute of Information Sciences (IZUM) and the Faculty of Information Studies in Novo mesto (FIŠ).

In the HPC RIVR project, there will be set up a supercomputer capacity of at least 1.5 petaFLOP/s of data capacity of at least 22 PB, which would make it the 23rd most powerful in Europe and the 90th in the world. The new supercomputer system will operate on the principle of open access, and it can be primarily used by researchers at public research institutions, and, to a lesser extent, by external users, for example companies. Nevertheless, it is expected to be launched in 2020.

In case of independent HPC providers a few companies can be mentioned.

- Arctur with its two HPC clusters Arctur1 and Arctur2 is offering HPC services to SME's in Slovenia and across the border in Italy.
- Kolektor Turboinsitute manages HPC with name BladeCenter HS21.

However, none of them are located in South-East Slovenia, but in the Western region.

1.5. Appraisal of educational aspects relevant to HPC development in the pilot region

Slovenia is a small country with only 2 million inhabitants that are somewhat well educated. As mentioned earlier, South-East Slovenia has two major HEIs: University of Maribor and Faculty of Information Studies.

University of Maribor

At the University of Maribor, the Faculty of Electrical Engineering and Computer Science has programmes dedicated/ targeting HPC.

The programme consists of three levels:

(1) First Cycle Bologna Study Programmes

- The academic-degree study programmes: Electrical Engineering/ Computer Science and Information Technologies / Informatics and Technologies of Communication/ Telecommunications/ Media communications/ Mechatronics
- The professional higher education programmes: Electrical Engineering/ Computer Science and Information Technologies/ Informatics and Technologies of Communication/ Mechatronics

(2) Second Cycle Bologna Study Programmes

- Electrical Engineering/ Computer Science and Information Technologies/ Informatics and Technologies of Communication/ Telecommunication/ Media Communications/ Mechatronics

(3) Doctoral study programmes

- Electrical Engineering/ Computer Science and Informatics/ Media Communications

Faculty of Information Studies

During WP2, it was pointed out that regarding educational possibilities, FIS offers a Big Data course with reference to HPC and working with distributed computer systems. Furthermore, the faculty developed an online course. FIS is also about to offer a new master programme with the option to focus on HPC. Nevertheless, one module about Big Data, which also deals with HPC, is not enough to bring up highly educated graduates, which then might fill the personnel requirements of the FIS and the regional industry with respect to HPC.

At the same time the FIS' programme, which can relate to HPC is BA level: Professional study programme Computer science and web technologies. The programme Computer science and web

technologies comprises the following subject areas of acquiring knowledge and skills: information science/ programming/ computer engineering/ mathematics/ statistics/ communication/ economics and business sciences/ management.

During their 2nd and 3rd years of study, the students are able to select several elective courses such as: Network Analysis Methods/ Open-Source Solutions/ Applied Cryptography/ Geographic Information Systems/ Process Modelling within Organisation using UML/ The Influence of Information Technology on eBusiness/ Dealing with Information and Knowledge in Organization/ Management of Projects/ Development of Solutions for Small Companies/ Fundamentals of Document Systems/ Database Administration/ Information Society/ Business Ethics/ Organisational Communication/ Communication Skills Training/ Web Communications and Public Relations/ Web and Mobile Solution Development Project/ Job Seeking/ High Performance Computing Systems/ Introduction to Modelling and Simulation of Discrete and Continuous Systems/ Algorithms in Computer Science.

At MA level, the Faculty offers the following courses: Contemporary Social Theories/ Qualitative Research in the Social Sciences/ Quantitative Analysis/ Management Information Systems/ Social Aspects of Information Technologies/ Information Technology Projects/ Security of Electronic Commerce/ Informatization of Organization/ Management of Information and Communication Systems/ Testing, Evaluation and Auditing of Information Systems.

Moreover, a number of elective courses are available: Quality of Information/ Multimedia Systems/ Internet Research/ Survey Research/ Intercultural Education and Competences/ Intercultural Communication/ Strategies of European Integration Process/ Management of Intercultural Differences/ Data Mining/ eBusiness Systems B2C and B2B/ Decision Support Systems/ Knowledge Management/ Processes and Document Systems/ Computer Forensics/ Biometrics/ Lobbying and Negotiations in EU/ Big Data Analysis/ Basics of Information Security/ User Experience/ User Centered Design and Development/ Introduction to Modelling and Simulation of Discrete and Continuous Systems/ Agent Based Modelling/ Advanced Statistical Methods/ Constraint Management in Organizations.

Meanwhile, at the Doctoral level, students have the possibility to choose from the following elective courses: Centrality Measures and Network Models/ New Approaches to the Use of ICT in the Political Administrative Systems/ Interorganisational Business/ The new Paradigm of the Information Society/ Information Systems/ Modelling and Simulation of Logistics Systems/ Data Mining/ Network Theory/ Contemporary Theories in Economic Sociology.

Additionally, it can be pointed out that the Western part of Slovenia is better developed from this perspective. Thus, it offers more programmes that are dedicated at or targeting HPC. Creative thinking, pedagogic diversity, intellectual challenge and interdisciplinarity have always been fundamental to education in Slovenia. The goal to deliver teaching and learning programmes that deliver skills for life are attractive to students from all backgrounds and satisfy the need for a pool of talented young people in informatics and related subjects. Secondary education programmes for computer science, electrical engineering and telecommunications attract nearly 5,900 students and some 4,000 students enroll in the University of Ljubljana or Maribor in ICT programme of studies.

Other faculties, research institutions and associations that are situated outside the South-East region:

- Universitiy of Ljubljana, Faculty of Computer and Information Science,
- University of Ljubljana, Faculty of Electrical Engineering,
- University of Ljubljana, Faculty of Electrical Engineering, Laboratory for Telecommunications,
- Chamber of Commerce and Industry of Slovenia, Group of Slovenian export-oriented IT companies – ZITex,
- ICT Technology Network,
- Institute for Project.

1.6. Summary

Based on the WP2 results and the conducted analysis, it can be stated that a drawback to technology of high-performance computing is the licensing policy of SW providers and also highly educated workforce needed to use HPC. At the moment, engineers coming from Universities are mostly not familiar with HPC technology which has a negative impact on HPC implementation in industry. Slovenian students are acquainted with knowledge on HPC only in case of post graduate studies on a few programmes. Presumably, with a higher demand from industry for educated workforce on the field of HPC, Universities with their education programme will also follow.

The region lacks programmes and institutions that would be dedicated to/ oriented toward HPC, because mainly the main concentration on knowledge is in the capital.

The adaptation to the requirements of the new reality of a digital society demand adequate ICT skills. That is why Slovenia encourages and pursues the objective of enhancing e-skills and knowledge in order to empower its citizens, so they can fully integrate in the digital environment and be innovative and creative in the use of ICT, and will participate in the process of changing and creating new knowledge, ideas, solutions and ways to use technology.

The establishment of an inclusive digital society will facilitate and expedite the adjustment to the digitization of existing jobs and contribute to the development of new business models, work processes and jobs and thereby accelerate the integration of the so-called fourth industrial revolution.

2. Final recommendations for the development of HPC in the pilot region

Considering the above mentioned, these are the main potential directions for the development of HPC in South-East Slovenia:

1. Recommendations related to socio-cultural aspects

Recommendation 1: Improve communication and assure harmonisation with public administration with the help of digital channels

Recommendation 2: Improve the digital literacy of population; improve e-competencies and e-skills of the population

2. Recommendations related to policy aspects

Recommendation 3: Extend the working partnership with big companies

Recommendation 4: Increase the access of EU funds for R&D

Recommendation 5: Provide stable and predictable legislation - regulatory framework for the work of electronic communications operators

3. Recommendations related to HPC infrastructure

There is currently no shortage of HPC hardware resources in Slovenia; demand and supply are in balance. This clearly leads to the conclusion that demand needs to be stimulated.

Recommendation 6: Raise awareness and inform the industry about the potential of Realtime Industrial Data analytics

Recommendation 7: Establish a national HPC competence centre; this action can be aligned with the forthcoming action of EuroHPC which is aimed at establishing a network of national HPC competence centres

4. Recommendations related to educational aspects

Recommendation 8: Improve education on fields of HPC and simulation on the national level

Recommendation 9: Create favourable conditions by HEI for the development of the HPC experts

3. Final recommended actions for the development of HPC in the South East Slovenia

Based on the directions and objectives indicated in the previous section, recommendations of actions and guidelines for the development of HPC in the South-East and recommendations from Bahor and Povh (2019, 241) and InnoHPC (2018), the following objectives and actions are proposed:

1. Recommendations related to socio-cultural aspects

Recommendation 1: Improve communication and assure harmonisation with public administration with the help of digital channels

Action 1: Provide a suitable network and service digital infrastructure for the needs of education, research and culture

Recommended driver(s): policy makers

Action 2: Provide the long-term preservation of digital content

Recommended driver(s): policy makers

Action 3: Increase digital content and better digital literacy at all levels of the education system

Recommended driver(s): policy makers in partnership with education institutions

Recommendation 2: Improve the digital literacy of population; improve e-competencies and e-skills of the population

Action 1: Better e-inclusion and enabling the access to e-services to all groups of population, especially less educated, elderly, disabled and inactive

Recommended driver(s): policy makers in partnership with research

Action 2: Promote HPC among both researchers and private actors through communication campaigns, thematic events, success stories, common projects etc.

Recommended driver(s): policy makers in partnership with research

2. Recommendations related to policy aspects

Recommendation 3: Extend the working partnership with big companies

Action 1: Promote and stimulate the usage of simulation chains in companies

Recommended driver(s): industry in cooperation with research

Action 2: Support and promote new value chains with high-tech products requiring simulations in R&D phase based on HPC technology

Recommended driver(s): industry in cooperation with research

Action 3: Support, on both national and EU level, of collaboration between research institutes and industrial companies should also be offered to large companies not only to SMEs

Recommended driver(s): policy makers

Action 4: Better collaboration between industrial sectors to increase uptake of HPC technologies

Recommended driver(s): industry in cooperation with policy makers

Recommendation 4: Increase the access of EU funds for R&D

Action 1: Increase public and private sector investment in ICT R&D

Recommended driver(s): policy makers

Action 2: Stimulate demand of HPC services through innovation cooperation funding calls and projects

Recommended driver(s): policy makers

Recommendation 5: Provide stable and predictable legislation - regulatory framework for the work of electronic communications operators

Action 1: Incorporate measures to follow the strategic scientific directions, published in The Scientific Case for Computing in Europe 2018-2026

Recommended driver(s): policy makers

Action 2: Define the open data of the public sector as a national treasure and strategic resource of the digital society

Recommended driver(s): policy makers

3. Recommendations related to HPC infrastructure

Recommendation 6: Raise awareness and inform the industry about the potential of Realtime Industrial Data analytics

Action 1: Connect with national and international research centres

Recommended driver(s): research in partnership with policy makers

Action 2: Exploit existing infrastructure at its maximum potential

Recommended driver(s): research and policy makers

Action 3: Virtualization of operations – virtual factory

Recommended driver(s): industry

Action 4: Establish value added chains via a digital platform

Recommended driver(s): industry

Action 5: Stimulate the usage of simulations in innovations of current products and processes in industry, e.g. by introducing dedicated vouchers for HPC training and for pilot development project based on HPC

Recommended driver(s): policy makers

Recommendation 7: Establish a national HPC competence centre; this action can be aligned with the actions of EuroHPC, establishing a network of national HPC competence centres in Europe

Action 1: Accomplish the establishment of national supercomputing centre

Recommended driver(s): policy makers

4. Recommendations related to educational aspects

Recommendation 8: Improve education on fields of HPC and simulation on the national level

Action 1: Develop a list of mandatory and elective courses which will be part of the curricula of study programmes in several domains, ranging from mathematics and physics via engineering do social science and medicine

Recommended driver(s): policy makers in cooperation with academia and industry

Action 2: Recommend a designated study programme on postgraduate level devoted to high performance computing; we suggest an inter-university programme, also with foreign universities

Recommended driver(s): academia

Action 3: Establish new scientific research programmes strongly related to HPC

Recommended driver(s): academia

Action 4: Improve quality of the education system with open learning environments, rational use of ICT in learning processes and efficient digital learning content

Recommended driver(s): policy makers and academia

Action 5: Provide suitable network and service digital infrastructure for the needs of education, research and culture

Recommended driver(s): policy makers

Action 6: Open and adapt the education system to new generations and needs of the digital society

Recommended driver(s): policy makers in partnership with academia

Action 7: Increase the collaboration with companies with HEIs

Recommended driver(s): industry in partnership with academia

Action 8: Increase the digital training in industry

Recommended driver(s): industry and academia

Action 9: Optimise the steering and management of educational institutions by digitisation of operation

Recommended driver(s): academia

Recommendation 9: Create favourable conditions by HEI for the development of the HPC experts

Action 1: Increase the percentage of ICT professionals in the Slovenian economy

Recommended driver(s): policy makers in partnership with academia

Action 2: Attract foreign experts to Slovenia

Recommended driver(s): policy makers in partnership with academia

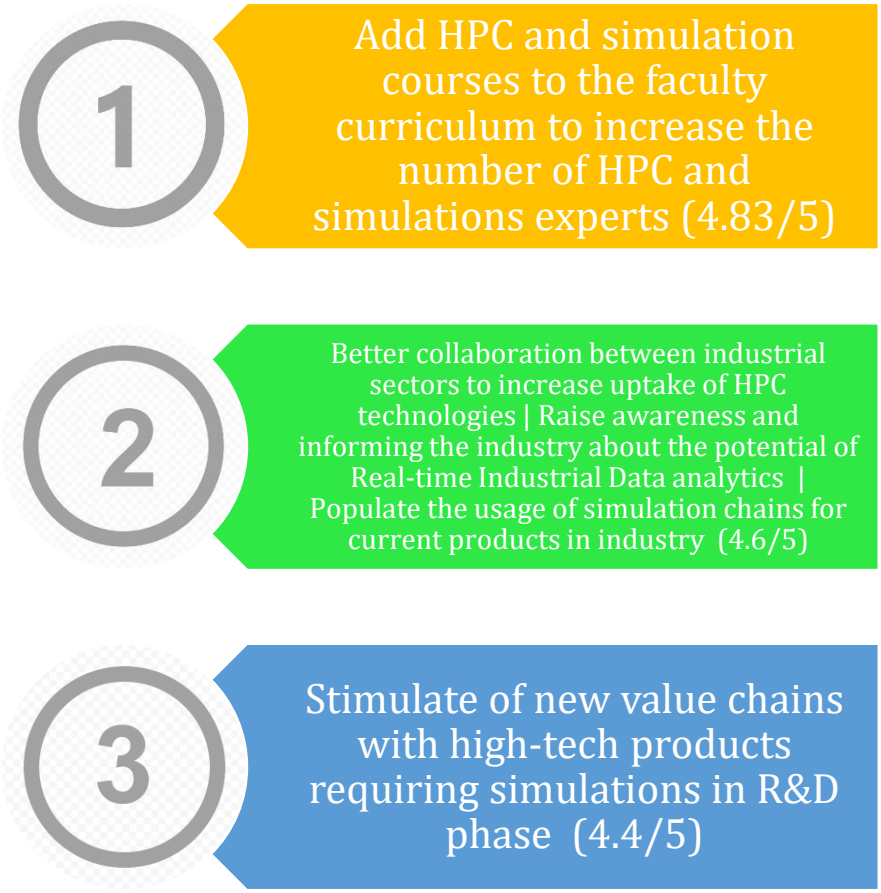
Action 3: Support "institutional" HPC systems (small systems owned by scientific or university departments), since this will increase the knowledge related to HPC and will also generate new users and new applications

Recommended driver(s): academia

Action 4: Establish strong links with future pre-exascale and exascale systems that are planned to be available in the period from 2021 on; this will give the opportunity to Slovenian researchers and students to work on these systems and therefore keep contact with the best

Recommended driver(s): policy makers in partnership with academia

Figure 4: The most feasible recommendations for South East Slovenia resulted from the strategic workshops (on a scale from 1 to 5)



IV. General transnational recommendation for developing the HPC ecosystem

The exploitation of commonalities is a necessary requirement prior to the definition of synergic measures supporting HPC development within the EU.

SME/HPC consortium partners identified some key areas which are core actions to support HPC development in any European region. They started from the prerequisite that HPC development is about capitalising on its potential to become an accelerator of the digital transformation in Europe. The success of each initiative depends on the capacity of the territorial systems to orchestrate initiatives advancing the know-how and increasing the capacity of using HPC.

The identified transnational recommendations viable for various EU regions are:

- In terms of **Human Capital**: there is a recommendation to **build capacity and to form a community of HPC public experts** able to facilitate the connection between researchers, HPC infrastructures and companies.
- In terms of **Education**: there is a recommendation to develop **thematic HPC educational programmes** to be accessed by companies (for technical personnel & for managers).
- In terms of **Culture**: there is a recommendation to **raise awareness of HPC potential, benefits and opportunities** which may be reached through periodically events and media campaigns.
- In terms of **Policies**: there is a recommendation to **developing regional/national HPC supporting policies aligned with the European evolutions**, allowing the region/country to be an active player in the HPC "game" at European level.
- In terms of **Funding**: there is a need to design **thematic funding instruments** supporting both infrastructure development and exploitation as well as collaborative projects between research and industry.

In the opinion of the SME/HPC consortium, this represents an appropriate combination of actions which contributes to the goal of developing the HPC ecosystem in the European regions.

Final remarks

This deliverable represents the critical steps designed by the SME/HPC consortium to achieve the goal of contributing to improve European regions' innovation capability and capacity through fostering innovation in HEIs and enterprises. The approach used goes beyond short-term actions stimulating the cooperation between HEIs and enterprises, and it was focused on the ecosystem scale, proposing recommendations able to produce systemic changes.

The elaboration of this deliverable was the results of an intense period of work where all consortium partners collaborated and cooperated to establish concrete regional actions able to improve the HPC situation locally and also to exploit current and future synergies with the HPC initiatives deployed at European level.

Two main lines of actions are: (a) development of guidelines which can improve the dynamic of HPC exploitation in the three pilot regions – Bucharest-Ilfov Romania, South East Ireland, South East Slovenia; (b) discovery of common priority recommendations which are valid beyond these three regions and may help other EU regions to design and implement specific measures to tackle HPC challenges.

Thus, the recommendations designed are aimed to develop an environment conducive to innovation which valorises the HPC potential and opportunities and to support the perception of enterprises on HPC as a pole for development in the middle of the quotidian challenges and needs.

The use of this document go beyond the SME/HPC borders and represents a practical tool informing the design and implementation of HPC related policies and actions supporting the cooperation between research, academia and industry.

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