2018 Progress Monitoring Report

H2020
Contractual Public-Private Partnership on High-Performance Computing

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ETP4HPC Association – www.etp4hpc.eu

Contents

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EXECUTIVE SUMMARY

The objective of the European HPC strategy is to develop a competitive, complete European ecosystem, encompassing exascale HPC and the corresponding data infrastructure that will serve a large spectrum of users from scientists to industry (including SMEs) and the public sector. The ambition is also to strengthen the European HPC supply chain and to close the gap from research and development to the delivery and operation of exascale HPC systems co-designed between users and suppliers.

An HPC contractual Public Private Partnership (cPPP) between the European Commission and the European Technology Platform for High Performance Computing (ETP4HPC) was put in place in 2014 for this purpose, with EUR 700 million from the Horizon 2020 research and innovation programme, supporting HPC technologies and application R&D. In addition to the cPPP, the European Commission also invested in the PRACE HPC infrastructure (Partnership for Advanced Computing in Europe).

ETP4HPC Strategic Research Agendas (2013, 2015 and 2017 editions) were a main source for the definition of the cPPP research priorities, and the official technical reference for these calls. Strategic Research Agendas are elaborated by ETP4HPC members, but also with other stakeholders and European or international associations or initiatives, such as BDVA, HiPEAC, BDEC, in particular. The 3rd edition (2017) has significantly broadened the scope of the SRA to include much more on Big Data - requirements and related technological needs - throughout the document and in its recommendations. ETP4HPC and BDVA collaborated via workshops and a dedicated joint task force for this purpose; a Memorandum of Understanding was set up between the two associations to strengthen and sustain this relationship, followed by another MoU signed between ETP4HPC and AIOTI, still widening and strengthening the links between HPC and the broader ICT ecosystem at large.

Subsequent to the mid-term review of all cPPPs in 2017, the cPPP has reached a first significant stage: most of the projects stemming from Work Programme 2014-2015 finished in 2018, while approximately EUR 400 million of the provisioned funding has now been granted (including projects selected and launched in 2016 and 2017, which are still running, and recent ones launched at the end of 2018). Although it is still early to assess the longer term effects of the cPPP, a first round of significant and more precisely measurable outcomes are now visible – both at the technology and application levels:

Mobilised private investments: in terms of specific leveraged investments, a close to five-fold effect in private effort per public euro in the PPP is estimated, i.e. five euros of private effort for each public euro funded, during and after the projects (mostly explained, approximately 90%, by the industry effort).

New skills/jobs: in the industrial sector, capturing in the order of 1/4 of the total funding of the cPPP, an estimated 100+ jobs were created from the programme projects, and an equivalent of at least 50 permanent FTEs is expected to remain after the end of the current projects. This is mostly in HPC technology – hardware, system, storage - and application software. More indirect and more important job creation effects in the various areas of HPC use are expected, but would require more time and efforts to be observed and measured.

Tremendous training efforts have been deployed by PRACE for many years and by the Centres of Excellence since 2015 (hundreds of training sessions, workshops, seasonal schools, webinars, coding sessions – for an estimated 20000+ person-days of training between 2014 and 2018).

Impact on SMEs: compared with the 7th Framework Programme (FP7), the share of SME participation in HPC EU funded project has seen a significant increase under Horizon 2020. The SMEs also consider today H2020 projects as a building block for their R&I strategy: As to today, four of the "TOP10" industrial beneficiaries in cPPP related calls are SME with a total funding of EUR 8,5 million. SMEs are an important contributor to job creation in HPC in Europe, and interviewed companies engaged in a project running for long enough report a positive impact of H2020 funding on their turnover and business increase.

Significant innovations: HPC technology projects (FETHPC) and Centres of Excellence (CoEs) have so far worked on the preparation and delivery of many innovative hardware and software

building blocks for HPC solutions, as well as the evolution and improvement of many HPC applications. In particular, several system prototypes with innovative architectures or features have stemmed from FETHPC projects, while Centres of Excellence have contributed to many significant evolutions of community codes (in terms of features and/or portability and/or performance improvement and scaling).

In 2017, the European Commission launched the preparation of the EuroHPC Joint Undertaking, starting with a declaration signed by seven countries in March 2017 in Rome. At the time of writing this report, twenty-nine Participating States (incl. 26 Members States) had joined EuroHPC ramping-up activities, since its official creation in October 2018. The EuroHPC Joint Undertaking is key to reach the overall objective of the European HPC strategy. It enables Member States to coordinate together with the Union their supercomputing strategies and investments. It pools Union and Member States resources to develop top-of-the-range exascale supercomputers based on competitive European technology, in order to address extreme computing and big data applications. Its objective is to acquire, build and deploy across Europe a world-class High-Performance Computing (HPC) infrastructure. It will also continue the research and innovation programme started under the HPC cPPP, to develop the technologies and machines (hardware) as well as the applications (software) that would run on these supercomputers.

The EU's contribution in EuroHPC will be up to EUR 486 million for the years 2019-2020, matched by a similar amount from Member States and associated countries. Overall, around EUR 1 billion of public funding would be invested by 2020, and private members of the initiative would also add in kind contributions. This will bring the overall financial effort from the European Union well above the initially agreed level of EUR 700 million.

In addition, the Commission also implemented in 2017-2018 an important new call to establish a Framework Partnership Agreement on European low-power microprocessor technologies, in order to establish a stable and structured partnership between the EC and committed institutions and organisations. The "European Processor Initiative" (EPI) consortium was selected to co-design, develop and bring to the market a European low-power microprocessor, one of the core elements needed for the development of the European supercomputers with exascale capacity. The first specific grant agreement for this FPA was signed in 2018 with a first EC contribution to the initiative of EUR 120 million. The R&D project started in December 2018 and is not included in the scope of this report.

The EuroHPC R&I Pillar will take over from the cPPP for application and technology R&D from 2019 onwards: the cPPP has indeed been formally terminated in April 2019, while the Work Programme 2019-2020 calls initially planned under Horizon 2020 in the cPPP scope were cancelled before the end of 2018. EuroHPC published new calls for proposals in its R&I Pillar in July 2019. EuroHPC will go on coordinating the different aspects of the strategy and preparing their further development in liaison with the Horizon Europe and Digital Europe programmes. EuroHPC would also take over from the cPPP for impact assessment of the HPC programme.

1. INTRODUCTION: THE HIGH-PERFORMANCE COMPUTING CPPP

High-Performance Computing (HPC) is a branch of computing dealing with technologies and methodologies for large-scale compute- and data-intensive applications - often simulation and modelling of science and engineering problems. It is a critical tool for understanding and responding to major scientific, industrial and societal challenges. As the problems modelled in computer simulations and decision support systems grow in size and complexity (to enable more detailed predictions and/or to cope with ever larger amounts of data or both), so do the demands on computational resources.

HPC mobilises densely integrated computing and storage hardware configurations, together with parallel programming. Deployed solutions may range from the massively parallel extreme scale, commissioned in very large infrastructures, to more compact and pervasive configurations. HPC is a generic enabler for more competitive research, industry, and the economy in general when it comes to producing goods and services more efficiently, and has become indispensable in tackling societal challenges requiring large scale numerical approaches.

In many areas spanning academia to industry and commerce -- from cosmology, material science, health, biology and climate change to automotive, aerospace, energy, and banking -- general-purpose computers can no longer provide a practical solution to address the necessary complexity and access to HPC becomes essential. HPC has also a pivotal role in supporting the digital industrial revolution, which is deeply transforming traditional industries by changing how engineers collaborate and explore new designs and technical solutions. For example, in the automotive and aerospace industries, Computer Aided Engineering and the design of new aircrafts and cars is carried out through large-scale simulation instead of or in addition to physical testing.

The contractual Public Private Partnership (cPPP) on high-performance computing[1] initially planned to invest EUR 700 million from the Horizon 2020 research and innovation programme with the objective to develop a competitive European ecosystem, and exascale HPC and data infrastructure, that would serve a large spectrum of users from scientists to industry (including SMEs) and the public sector. The ambition to strengthen the European HPC supply chain and to close the gap from research and development to the delivery and operation of exascale HPC systems, co-designed between users and suppliers, will now be continued through EuroHPC. EuroHPC[2] will bring further resources beyond Horizon 2020, in Horizon Europe[3] and more specifically Digital Europe[4], with the ambition to rank the EU among the world's top supercomputing powers by realising competitive exascale supercomputers around 2022/2023, based on EU technology, while promoting and stimulating the pervasive use of HPC at all scales and for a wide diversity of scientific and technical applications.

The present report does not take the European Processor Initiative (EPI) project into account (whose effective implementation and R&D activities only started in December 2018 with its first Special Grant Agreement – SGA1). Centres of Excellence granted in 2018 (ten 2018 CoEs + FocusCoE CSA) also started at the end of 2018, they are included in operational statistics but are considered to have no influence yet on socio-economic KPIs. The holds true for the ICT HPC and Big Data Applications 2018 call. These projects, starting in the last quarter of the year 2018, did not have a big impact on socio-economic indicators of that year. This means that in 2018 we mainly measured the impact of the projects starting in 2017 or before - amounting for a total of EUR 213 million out of the 400 granted.

[1] https://ec.europa.eu/digital-single-market/en/high-performance-computing-contractual-public-private-partnership-hpc-cppp
https://www.etp4hpc.eu/cppp.html

[2] https://ec.europa.eu/digital-single-market/en/eurohpc-joint-undertaking
https://eurohpc-ju.europa.eu/index.html

[3] https://ec.europa.eu/info/designing-next-research-and-innovation-framework-programme/what-shapes-next-framework-programme_en

[4] http://europa.eu/rapid/press-release_IP-18-4043_en.htm

2. MAIN ACTIVITIES AND ACHIEVEMENTS DURING 2018

2.1. Implementation of calls for proposals evaluated in 2018

In 2018 the European Commission continued with the implementation of four calls for proposals to support the European HPC strategy (see Annex 5.1).

- Centres of Excellence (INFRAEDI-02-2018)
- Support to the governance of High Performance Computing Infrastructures (INFRAEDI-03-2018)
- HPC and Big Data enabled Large-scale Test-beds and Applications (ICT-11-2018-2019)
- Specific Grant Agreement under the Framework Partnership Agreement "EPI FPA" (SGA-LPMT-01-2018)

The INFRAEDI-02-2018 call included two topics addressing research and innovation actions and coordination and support actions. The first topic targeted support to Centres of Excellence (CoE) that promote the use of upcoming exascale and extreme performance computing capabilities. 8 application areas were identified for proposal submission:

- Engineering: aeronautics, automotive and/or new combustion engines;
- Environmental sciences: climate and weather simulation, natural hazards forecast and prevention;
- Bio-molecular research: combined research in chemical, biological, physical and computational science;
- Health/medicine:, computational methods and simulation in the biomedical domain;
- Materials science and engineering: materials design, simulation and modelling;
- Energy: optimising energy consumption and supporting the transition to a reliable and low carbon and clean energy supply;
- Big Data and Global Challenges: Big Data analytics for strategic global issues;
- Performance optimisation: optimisation and productivity services for HPC academic and industrial code(s) (including support to selected Centres of Excellence)

One additional application area was left open and the successful proposal was selected in the area of solid earth simulation and natural hazards prediction.

A total of 274 participants (applicants) were involved in the 19 eligible proposals submitted for the call. 130 participants (i.e. 47.4 %) were involved in the 9 proposals retained for funding.

The second topic addressed the fragmentation of activities for excellence in HPC applications, and fostering the widening of the use of HPC codes in the EU, by establishing a focal point for the consulting skills and training available from the CoE, and from other HPC centres or organisations, including PRACE.

A total of 11 participants (applicants) were involved in the only eligible proposal submitted for the call and retained for funding.

The INFRAEDI-03-2018 call asked for a coordination and support action for the governance of the High Performance Computing Infrastructures and the coordination of the relevant public and private stakeholders.

A total of 9 participants (applicants) were involved in the 3 eligible proposals submitted for the call. 3 participants (i.e. 33.3 %) were involved in the proposal retained for funding.

The ICT-11-2018-2019 call[5] targeted the development of large-scale HPC-enabled industrial pilot test-beds supporting big data applications and services by combining and/or adapting existing relevant technologies (HPC / BD / cloud) in order to handle and optimize the specific features of

[5] This actually refers to the topic (a) of the call. The particularity of this call subtopic is to refer to the scope of both Big Data and HPC cPPPs, a logical match in the context of a vivid collaboration between ETP4HPC and BDVA on their respective visions and roadmaps. We have accounted for 50% of the EU funding for this call in HPC area (approximately EUR 24 million, included in the 400 granted under the cPPP.

processing very large data sets. The call asked for the industrial pilot test-beds to be designed to handle massive amounts of diverse types of big data coming from a multitude of players and sources and to clearly demonstrate how they would generate innovation and large value creation. Pilot test-beds should also aim to provide, via the cloud, simple secure access and secure service provisioning of highly demanding data use cases for companies and especially SMEs.

A total of 308 participants (applicants) were involved in the 14 eligible proposals submitted for the call. 88 participants (i.e. 28.6 %) were involved in the 4 proposals retained for funding.

Within the Framework Partnership Agreement on European low-power microprocessor technologies awarded in 2017, the EPI was invited to submit by April 2018 a Research and Innovation Action proposal for the design and development of European low-power processors and related technologies in accordance with the research roadmap defined in the FPA. The proposal was evaluated and retained for funding.

All the evaluations of proposals for the above calls were carried out with the assistance of external experts and were monitored by observers.

2.2. Mobilisation of stakeholders, outreach, success stories

2018 was a busy year for the European Commission in terms of mobilisation of stakeholders and outreach to European countries and organizations, following the publication in January 2018, of the European Commission proposal to invest EUR 1 billion jointly with the Member States in building a world-class European supercomputers infrastructure.

In the first two quarters of 2018, the Commission and Member States of the Union had regular and intensive exchanges at ministerial level while negotiating the objectives and the legal framework regulating the new Joint Undertaking The European Commission also reached out to the European Parliament and the European Economic and Social Committee explaining the initiative and securing a positive opinion from these bodies. In late September, the Council finally adopted the Regulation establishing the European High Performance Computing Joint Undertaking.

This legislative process was punctuated by press releases and other communication events, such as the Digital Day 2018, to a mark the progress and the final agreement on EuroHPC JU.

Digital Day 2018 took place in Brussels on 10th April 2018. This one-day event brought together high-level stakeholders in the fields of digital technology and telecommunication. The event was organised by the European Commission under the Bulgarian Presidency of the Council of the European Union. The first session of the event covered HPC, taking stock of developments since 2017. It highlighted again the need for EU investment in digital capacities in areas such as HPC, Artificial intelligence, Cybersecurity and advanced digital skills to ensure European socio-economic progress and leadership. It also emphasized the importance of innovation in industrial tissues, in particular SMEs.

The steady promotion of the European HPC strategy and EuroHPC initiative contributed to attract more committed countries and increase its number from the initial 7 signatories of the EuroHPC declaration in March 2017 to the 25 Participating States of the EuroHPC Joint Undertaking before the end of 2018 (and 28 as of July 2019[6]).

Following the publication of the regulation[7], the Joint Undertaking was legally established and started the implementation of the strategy. Its Governing Board has been meeting each month since November 2018 and an Interim Executive Director is in charge of its operations. In particular the calls for expression of interest for the selection of Hosting Entities have been issued in January and

[6] https://eurohpc-ju.europa.eu

[7] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2018:252:TOC

February 2019 – resp. for Precursors to Exascale Supercomputers[8] as well as for Petascale Supercomputers[9]. A EuroHPC Infoday took place in March 2019[10].

The EU's contribution in the joint undertaking will be around EUR 486 million under the current Multiannual Financial Framework, matched by a similar amount from Member States and Associated Countries. Overall, around EUR 1 billion of public funding would be invested by 2020. The EuroHPC Advisory Groups (INFRAG for Infrastructures, and RIAG for R&I) have been formed. Half of the RIAG's 12 members are named by the JU private members, ETP4HPC and BDVA (4 for ETP4HPC for the first two-year period). Ten more observers are also participating in the RIAG, again with half of them named by private members - 3 provided by ETP4HPC and 2 by BDVA. In 2018 ETP4HPC had already provided the JU with an updated SRIA digest, anticipating the RIAG role. ETP4HPC and BDVA RIAG experts, together with the respective association members, started working formally with the JU at the end of 2018, providing input for the R&I Work Programme 2019-2020 which should be approved before mid- 2019, and followed by the first EuroHPC R&I calls. These Work Programme calls will take over from the HPC cPPP and H2020 calls (Work Programme 2019-2020 H2020 HPC calls were cancelled mid-2018, with the intention that they be replaced by R&I EuroHPC calls).

On its side ETP4HPC[11] has been steadily growing: 12% more members in number, compared with December 2017, most coming from the private sector. As of December 2018, ETP4HPC had 96 members from 23 countries, of which 54 come from the private sector, including 36 SMEs. This shows that ETP4HPC is generating interest from a community that goes beyond the traditional HPC stakeholders. Efforts to engage more industrial partners and to attract a wider community are ongoing.

The ETP4HPC Strategic Research and Agenda has been updated every two years. As explained below, material from the 2017 SRA (third edition) has been exploited to feed the initialisation of EuroHPC R&I programme definition, eventually via its RIAG Advisory Group. This has provided an opportunity for further strengthening the multi-year collaboration with BDVA (Big Data Value Association), jointly exploring both use cases and computing technologies relevant to both HPC and Big Data.

2018 has also given the opportunity to start preparing a fourth edition of the SRA (planned for the end of 2019), and to develop more links with other stakeholders (AIOTI association for IoT: Alliance for Internet of Things Innovation; also foreseeing European IA ecosystem contacts, e.g. with the CLAIRE association). Memorandums of Understanding have been formally signed with both BDVA[12] and AIOTI. ETP4HPC "SRIA 4" will partly use previous SRAs processes (topical work groups) but will target more synthetic and cross-cutting visions (technology-wise as well as application-wise), and should also have inbuilt features for addressing dynamic EuroHPC requests. Of course Centres of Excellence (which now have a coordination and support action FocusCoE) and PRACE will remain privileged partners in the process of the SRIA elaboration.

Preliminary production for 2020 vision and beyond encompass a BDVA/EPT4HPC joint paper on the "Technology stacks of High Performance Computing and Big Data Computing" [13], as well as a vision paper – a blueprint for a new SRA for HPC[14].

The EXDCI-2 coordination and support action (PRACE and ETP4HPC) also started in 2018, seamlessly following-up on EXDCI efforts, with a deeper and wider ecosystem vision at the

[8] https://eurohpc-ju.europa.eu/documents/call-exascale/01_Call_Expression_Interest_EuroHPC_Hosting%20Entities_PreExa.pdf

[9] https://eurohpc-ju.europa.eu/documents/call-petascale/01_Call_Expression_Interest_EuroHPC_Hosting%20Entities_Peta.pdf

[10] https://eurohpc-ju.europa.eu/event-eurohpc-ju-info-day-2019.html

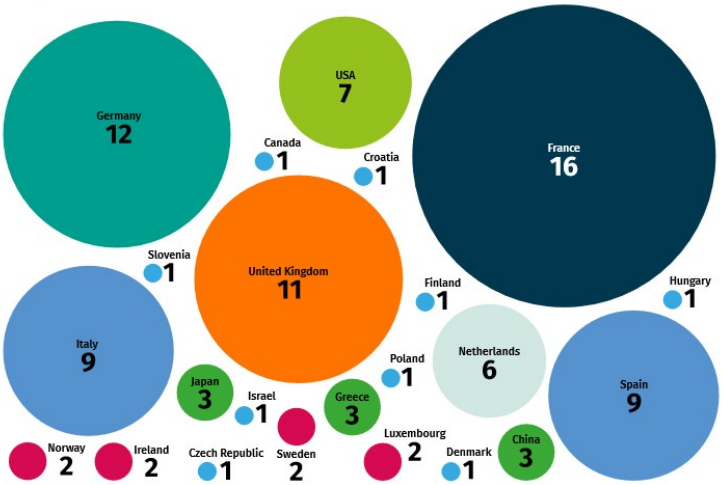
[11] https://www.etp4hpc.eu/pujades/files/ETP4HPC_Annueal-Report-2018_web.pdf

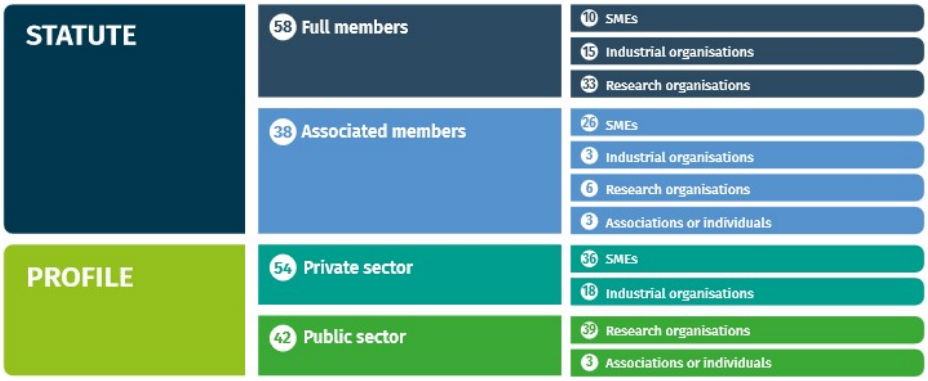
[12] http://www.bdva.eu/node/1162

[13] https://www.etp4hpc.eu/news/197-first-joint-white-paper-by-etp4hpc-and-bdva.html

[14] https://www.etp4hpc.eu/hpc-vision-018.html - April 2019

European and international levels (active participation in BDEC[15]). EXDCI-2 still supports the ETP4PHC SRIA elaboration and application road mapping, as well as more in-depth impact assessment of EU HPC programme (after 3-4 years of cPPP projects, FETHPC and CoEs in particular). In 2019 the recurring HPC event organised with EXDCI-2 support will be the "EuroHPC Summit Week", foreseeing a stronger coordination between all facets of EU HPC strategy, previously supported via different (although inter-connected) Work Programmes – FET, LEIT/ICT, EINFRA…).





Some statistics on ETP4HPC 96 members - as of December 2018
Breakdown by countries and by categories

2.3. Outreach highlight

DGCNECT had developed a single point of access for all information about the EC HPC strategy, work programmes and other HPC-related news including events, blog posts, reports, and policies[16]. In 2018 an official EuroHPC web page has been created[17].

ETP4HPC, the EXDCI- 2 support action, all FETHPC and CoE projects have strong focus on their dissemination activities which are complementary – ETP4HPC and EXDCI-2, together with PRACE, focus on ecosystem-level dissemination and networking support, whereas the projects promote their own specific scientific and technical activities and results.

[15] https://www.exascale.org/bdec/

[16] https://ec.europa.eu/digital-single-market/en/high-performance-computing

[17] https://eurohpc-ju.europa.eu/index.html

EXDCI-2 has had the opportunity to create a large annual pan-European HPC event, the "European HPC Summit Week", with a first edition in 2016 in Prague, a second in 2017 in Barcelona (Spain), and a third one Ljubljana (Slovenia) in May 2018. EHPCSW is gathering several hundred experts in HPC technology development, HPC infrastructures and HPC applications.[18] As mentioned in the previous section, the 2019 edition will take place in Poznan, Poland, in May, now as "EuroHPC Summit Week".

ETP4HPC published two technical and vision documents, prior to the full update of its SRA in 2019:

- *The Technology Stacks of High Performance Computing and Big Data Computing: What they can learn from each other* [19]
- *A blueprint for a new Strategic Research Agenda for High Performance Computing* [20]

2.4. Governance

Two new regular cPPP Partnership Board (PB) meetings took place in 2018, in May and October, co-chaired by the EC and ETP4HPC Chair, with the participation of the 'private side' and of EC/DGCNECT representatives. The HPC cPPP had reached a stable configuration in 2015 already, with the inclusion of the Centres of Excellence in Computing Applications (CoEs) in these bi-annual PB meetings - in addition to representatives from the ETP4HPC Steering Board; PRACE representatives are also invited to participate in the PB meetings.

ETP4HPC held one General Assembly in March 2018, to which all members of the association were invited, as well as PRACE, EC representatives and other guests.

The cPPP PB tenth meeting of October 2018 was actually the last one: it was the opportunity to discuss the emergence of EuroHPC and the termination of the cPPP. This termination was formalised through an exchange of letters: ETP4HPC requested the termination in a letter to Commissioner Mariya Gabriel in March 2019; the Commissioner acknowledged receipt and accepted the cPPP termination in a letter dated April 10, 2019.

[18] https://exdci.eu/events/european-hpc-summit-week-2017

[19] https://www.etp4hpc.eu/pujades/files/bigdata_and_hpc_FINAL_20Nov18.pdf

[20] https://www.etp4hpc.eu/hpc-vision-018.html - April 2019

3. MONITORING OF THE OVERALL PROGRESS SINCE THE LAUNCH OF THE CPPP

3.1. Achievement of the goals of the cPPP

The build-up and creation of the Partnership gave new momentum to European HPC. This is reflected in the growing number of organisations joining ETP4HPC, as well as through the response to the Calls for Proposals that were closed between 2014 and 2018, which allocated EUR 400 million in funding to 56 technical projects targeting technological blocks related to the Exascale goal - with the selected FETHPC projects mostly covering SRA topics and vision – plus 5 coordination and support actions, for a total EU funding of EUR 11 million– see Annex 5.1.

The initial momentum of the HPC cPPP has been maintained and even amplified: several FETHPC and two CoE calls led to many projects, between 2014 and 2018; the rest of the calls initially planned in 2018-2020 have been postponed to be re-organised under the umbrella of EuroHPC (continuation of FETHPC), but are following the envisioned trajectory; in the meantime the European Processor Initiative has been added to the programme, while an extra call at the midpoint between HPC and Big Data was launched in 2018.

This funding engaged in the updated cPPP scope is about 60% of the total amount initially planned for the HPC cPPP in the 2014-2020 period. Union budget not spent under H2020 and the cPPP, will be shifted to the EuroHPC R&I Pillar funding and complemented by national funding, reaching an estimated additional EUR 392 million for the years 2019 and 2020. It must be noted however that the initial scope of the cPPP did not encompass the more recent effort towards the European processor (3 ICT projects amounting to 90 M€, in particular the large EPI project – FPA/SGA1).

More generally, in Chapter 2 the most recent cPPP calls and related projects selected are described, but these projects are considered as not yet having influenced the socio-economic KPIs.

Let us note also that, although the funding now granted since 2014 is a significant fraction of the cPPP provisioned budget, and also recalling that a number of projects (FETHPC and CoEs) are now terminated, not all granted funding has been distributed yet. The most recently launched projects only received a first chunk of pre-financing, and still less has actually been used and spent. Only FETPHPC-1/2-2014 and E-INFRA-5-2015 (CoEs) are mostly, although not all, finished. The more recent projects related to FETHPC-01-2016 and FETPHC-2/3-2017 are still running (see Annex 5.1 and Annex 5.2).

The Innovation KPI only takes into account the projects started before 2018. For the other KPIs, we take a reference of EUR 213 million - amount granted to projects starting before Q4 of 2018. We also estimate approximately EUR 187 million of this amount has been used (some projects from 2015-2017 were still running as of the end of 2018 and will not end before 2019).

Annex 0 summarises the scope, methodology and data sources used for the KPIs estimated in the next section. In particular we give details on the samples used for data collection and their representativeness.

Annex 5.3 gives some extra highlights and quotes from H2020 HPC projects' industrial participants, interviewed as explained in Annex 0.

3.2. Progress achieved on KPIs.

3.2.1. Mobilised private investments

Regarding private-for-profit organisations investments directly related to the cPPP activities, we will follow the updated categorisation agreed upon for these KPIs:

- Direct leverage 1: financial and/or in-kind contributions by partners (as declared in project description and reporting)
- Direct leverage 2: other investments mobilised with the initial investment from the partnership's partners in the project
- Indirect leverage: public and private investment mobilised to exploit or scale-up the projects' results (beyond their lifetimes)

General considerations

In the 2019 study with industrial companies, more than half (55%) of the projects they were involved in had been completed, and the rest due to end within 24 months. As in the 2018 study, a large majority of industry participants (73%) rated the H2020 funding as "extremely important for our future," and this was uniformly true for the SMEs. The three other participants (27%) rating the funding as only "somewhat important" were large corporations who viewed the funding as indispensable but small compared with their employers' substantial R&D budgets. Without the H2020 funding, all the industry participants would either not have pursued this important research (14%) or would have been forced to pursue it on a more limited basis (86%). The participants agreed unanimously (100%) that it is "very important" for funding of this kind to remain available to European industry.

Direct leverage 1

From EU databases[21], in-kind (unfunded) contributions by partners declared in the projects amount to EURO 916 000 (less than a million, to be compared to the EUR 213 million of the four calls we are taking into account – this is less than 0,5%). In essence, all 2014-2018 cPPP-related projects started before end of Q42018 are RIA (Research and Innovation Actions), 100% funded for all partners.

Direct leverage 2

The industry participants interviewed (our 'industrial sample' here) together received a little more than EUR 26 million euros in funding under the H2020 HPC program (21 projects). This is approximately 55% of the funding going to private companies between 2014 and 2018. As a group, the 11 participating companies made substantial in-kind contributions that included, among other things, about EUR 11 million in supplemental funding during the project life times. Assuming a sample which is representative, this give a partial leverage factor of 0.4 for this tier.

Higher and Secondary Education (HSE) and research Organisation (RO) institutes, get ca. 76% of the cPPP-related funding, and thus form the majority of the so-called 'private' side of the cPPP, in terms of funding. Despite the 100% funding rate under H2020 rules (for RIA actions), surveys amongst ETP4HPC members revealed significant additional contributions during the project lifetime, which we estimate to be at least 25% of the funded total personnel cost (mostly related to higher indirect costs than the standard H2020 25% rate). Other extra contributions identified are related to additional personnel assigned to project-related effort (in-kind), use of equipment such as access to computing facilities, software licenses etc. However this latter category of contribution has not been precisely measured.

Mixing a 0.4 leverage factor (weight of industry = 30%) and 0.25 (weight of research = 70%), we end up with an estimated leverage factor of ~ 0,3 for this "Direct leverage 2" level (close to zero for Direct Leverage 1 level).

Indirect leverage

In the 2018 study, nearly the same participants as in the 2019 study said they plan to invest an aggregate EUR 120 million to turn the project innovations into commercial products. The 2019 study added another EUR 1 million to this total, which is not significantly different. The leverage factor here is in the order of 4.6 (120/26).

In total an extrapolated global leverage factor of all 3 levels combined would be close to 5 (4,6+0,3+epsilon). This is above the target factor of 4.

3.2.2. New skills and/or job profiles

Skill development and training

Supercomputing sites have always had an extensive, recurring, and evolving activity to teach the fundamentals of HPC to practitioners/users (parallel programming, use of systems and resources,

[21] https://cordis.europa.eu/fr

code optimisation and more); this is deployed at regional and national levels. Initial, vocational training is also covered in HPC via many undergraduate and graduate curricula – not to mention on the job training. This is often mixed with education in simulation, modelling, and more and more frequently big data and AI methods, and of course very important to develop skills and produce talents for academia and industry (both the technology supply industry, and industry as a user of HPC).
We will not report on these activities, to focus more on two main contributions at the European level:

- PRACE impact on growing HPC know-how in Europe [22,23];
- Centres of Excellence activities and impact in the same area.

These activities both benefit from EU funding - PRACE via H2020 EINFRA PRACE Implementation Phase projects (PRACE 5IP in 2018).

Since 2008, PRACE has been developing education and training for computational scientists in Europe through:

- the PRACE Advanced Training Centres (6 PATCs in Finland, France, Germany, Italy, Spain, UK) and PRACE Training Centres (from 2017 onward, 4 PTCs in Czech Republic, Greece, Ireland and Netherlands);
- the International HPC Summer School;
- PRACE Seasonal Schools
- 4 Massive Open Online Courses (MOOC)

PATC / PTC training events, Seasonal Schools and the International HPC Summer School are offered free of charge to eligible participants from academia and industry.

In between August 2008 and December 2017, PRACE provided 36 273 participant-days of training through attendance-based courses, with an upward attendance trend. PRACE courses were attended by over 11500 individuals.

In 2017 the number of participants attending PRACE courses was 1858 (1 487 from academia and 371 from non-academia affiliation). More than 80% of participants attending trainings days have an academic affiliation (1487).

Between 2015 and 2018, the H2020 Centres of Excellence for Computing Applications have organised and delivered:

- 33 training workshops
- 10 topical schools
- More than 50 webinars
- ca. 100 others training events
- More than 8 ‘coding sessions’

This represents more than 10 000 days of training delivered. The transversal CoE on code performance optimisation also evangelised 1300 users/’customers’ to performance analysis.

Jobs in industry

The PMRs produced 1 and 2 years ago used the same kind of methodology and confidential (company) interviews to detect trends in jobs creation stemming from, or related to H2020 funding. Although not strictly identical, the ‘samples’ of companies were similar in size and profiles over the years.

PMR 2016: projects were roughly in the middle of their lifetime, the interviews revealed 61 jobs created from the projects for 9 companies.

[22] http://www.training.prace-ri.eu/
[23] http://www.prace-ri.eu/prace-kpi/

PMR 2017: one year later, the interviews revealed 73 jobs creations from the projects for 11 companies (a reasonable extrapolation was ca. 115 jobs for all the private companies participating in cPPP projects at this time).

PMR 2018 (this current report): interviews confirm 60 jobs creation for 11 companies during the projects lifetime. It must be noted that 55% of projects in which these companies are involved are finished, while some new projects started over the 18 months predating the study. Regardless of the sampling effects, we can suspect some fluctuation due to the projects ending and starting. A conservative extrapolation from our sample (representing 55% of the funding received by private companies) gives an estimate of 100 jobs created.

Attesting to the strong impact of the H2020 HPC program, the 11 companies expect that after completion, the projects will produce 30 permanent FTEs, i.e. 50% of jobs active during the currently running projects. That total is likely to rise again as post-project plans firms up for the 45% of participants whose projects are scheduled to continue running for as much as 24 months. Analyst studies tend to confirm that most job creation related to advanced R&D happens after the R&D project is finished, especially when a commercial product is being prepared for and introduced into the market.

The profiles of the 60 jobs observed from the sample so far during the lifetimes of the projects were analysed. The largest reported category was developers of system software—a broad category that could refer to any part of the software stack between the operating system and the application kernel. Next in frequency were developers of hardware and applications. Many of the applications developers were engaged in scaling and optimizing existing application codes. Respondents were unable to categorize six (10%) of the jobs created to support the projects.

Job Category	Number
System software developer	17
Hardware developer	14
Application developer	14
Storage specialist	6
Project management role	3
Other	6
Total	60

Jobs in the public research sector

Impact on jobs in the public research and academic area is more difficult to measure. An ETP4HPC survey towards its members, early 2018, revealed of the order of 150 new jobs related to the cPPP activities, created in 2017 in the public research sector (this figure arising from 33 organisations of various sizes). However it was difficult to tell whether the related positions were permanent. Research organisation tend to hire a significant number of people under doctoral or post-doctoral positions, or temporary research positions, in the context of R&I projects. The corresponding job profiles are diverse, relating to R&D in hardware and software.

Early 2019, a sample of 9 large EU Research Organisation of Higher Level Education entities participating in a large subset of the cPPP projects, report 245 jobs created in 2018, out of which 97 are related to HPC funding. This sample of organisations gets 30% of funding going to the public research sector.

3.2.3. Impact on SMEs

Since the start of the FP7 Framework Programme and then continued in H2020, the share of SME participation in HPC EU funded project has been significantly improved. The SMEs have not only increased their participation in general, but also today consider H2020 projects as a building block of their R&I strategy: as of today, four of the "Top10" industrial beneficiaries in cPPP related calls are SMEs;. SMEs get a total funding of EUR 25 million in the FETHPC programme (out of the 213 M€ considered here). The strategic importance of H2020 for SMEs is also confirmed by interviews: all SMEs consider H2020 funding as "extremely important for our future". In particular working less in isolation and get into the habit of collaborating closely to advance technologies is considered of utmost importance.

In addition to the main confidential interviews focussing on business aspects, and carefully insulated from other more open data collection actions, we directly interviewed 10 SMEs from five different countries (DE, UK, FR, GR and SE). These companies participate in 16 different H2020 HPC cPPP projects (launched between 2015 and 2018) and receive 14.8 M€ of H2020 funding, which is 60% of the funding received by SMEs in this scope.

The average staff size of the sample is 49 employees (total staff summed is 486+, ranging from 4 to150, with a median of 40).

Clustering the activities of these companies into three categories, we have:

- 6 in hardware and IP blocks development, equipment manufacturing, or being system vendor
- 3 acting as software editor/vendor
- 5 in services/consulting/project management

NB: the total is more than 10 because some SMEs are active in more than one of these sectors.

NB: the interviewees reported more than 15 jobs directly created thanks to H2020 funding between 2014 and 2018. This is consistent with the findings of section 3.2.2, although this previous section on the jobs KPI relies on a different sample and interview approach, with no easy way to aggregate the separate results.

Turnover: for 6 companies, the H2020 funding had a positive contribution to the increased turnover/business (though exact quantification of the contribution is not possible). It is too early to tell about any influence or correlation for 3 others (too recent projects). One company spun-off a new HPC activity, still operational but no longer in the HPC sector.

For the 2 smallest/youngest companies (staff still under 10), H2020 funding was instrumental – weighting up to 25% of operational costs and 50% of staff increase over the last 3-4 years.

General benefits: for 3 companies, the main perceived and reported benefits are enhanced reputation, networking, increased collaborations, and better ecosystem role (fostering dissemination, gaining new projects or activities and partners, or potential future improved products and services)**.**

For 3 companies, new contracts or customers or business stemmed from H2020 funding (H2020 supported skills/staff increase and new activities, which in turn helped get new business).

For 2 companies, it is still too early to tell, but one of them already modified its roadmap in the light of new needs in the HPC area (not technical aspects but other IT/management aspects).

A start-up boosted its growth and is on its way to turn initially academic developments into implemented/productised solutions.

The company which created a spin-off which eventually stopped HPC activities - but still exists and continues in other areas with the spun-off know-how – considers it positively.

3.2.4. Significant innovations

This section comprises two parts fed by two different sets of projects – and systematic interviews or questionnaires achieved with all the FETPHC and CoE projects (from 2015, i.e. those of the projects that are finished or about to be finished, as of end of 2018). Of course many partners participate in more than a project, and often in the two categories.

In short, all together we observe a rich portfolio of innovations, not easily summarised nor quantified in a short list or mere figure, mainly in the following categories:

- Hardware and software building blocks for 'supercomputing' solutions
- Different prototypes of full systems with innovative architectures or features
- Important evolutions or optimisation of community application codes
- New models, or methodologies, or software components useful for application scale up and improved performance towards exascale
- New application features, and new or better modes of exploitation of applications

FET-HPC 2015 projects[24]

Most of the FET-HPC projects related to the September 2015 call are now finished. The end of 2018 was a good time to analyse the outcomes of these projects and what could be suggested for maximizing the impact of these projects.

First, let us go back to the topics addressed by the 19 projects. Even if this is schematic, they can be classified as follows:

HPC system focused projects	
From package to system	Exanode/ExaNest/EcoScale
ARM based HPC	Mont-Blanc
Reconfigurable systems	Mango, Extra
IO	Sage, NextGenIO
HPC stack and application-oriented projects	
Energy efficiency	Readex, Antarex
Programming model	InterTwine
Multiscale	AllScale, Compat
Generic applications: Hyperbolic PDE, Machine learning, Fluid dynamics, Numerical linear algebra, Weather models	ExaHype, Excape, Exaflow, NAFLET, Escape

The most relevant so-called IP (Intellectual Property) elements generated by the projects has been established. A first quantitative analysis shows that most of the results are in the field of software. Out of the 171 IP elements listed, two thirds are software and 20 are hardware related. The other types of results are APIs, applications optimizations, benchmark suites, trainings and demonstrators.

It is interesting to notice that most of the IP elements can already have some exploitation. They address the needs of different types of actors that can be represented in the following table.

[24] The following analysis was performed in Work Package 2 of EXDCI-2 CSA, thanks to the participation of all projects to a survey

Type of innovation vs. Needs of actors	API	Application optimisation	Benchmark suite	Demonstrator	H/W	Report	S/W	Training	Total
Application developer	**7**						**39**	**4**	**50**
Application developer / computing centre				**8**			**4**	**1**	**13**
Application developer / end user							**10**		**10**
Computing centre		**1**	**4**				**5**		**10**
End user		**6**				**2**	**34**	**2**	**44**
Large scale demonstrator					**4**		**5**		**9**
HPC system customer					**1**				**1**
HPC system provider					**13**		**9**		**22**
HPC system provider/ application developer					**1**		**3**		**4**
HPC system provider/ computing centre			**2**				**4**		**6**
HPC system provider/ Processor provider					**1**		**1**		**2**
Total	7	7	6	8	20	2	114	7	171

IP elements by category vs. actors' needs covered

This shows that the FET HPC 2015 projects have generated a lot of IPs that can be useful for end users and application developers. Some of them target HPC system providers, computing centres or could be good inputs for integration projects (advanced demonstrators).

At a qualitative level, starting with the hardware side, we see the development of several processor or FPGA boards, active interposer technology, interconnect technologies (one using photonics) and cooling technology.

The system-oriented projects have developed 8 demonstrators, most of them being open to experiment by external teams. The larger ones in terms of computing power come from ExaNest-EcoScale, Mont-Blanc and Mango. IO (Input/Output) related projects, Sage and NextGenIO, have also demonstrators that can be useful for testing new storage hierarchy or object file system.

Some APIs have been proposed by the projects in domains like FPGA management, object file system, energy efficiency and interaction between runtimes.

On the software side, besides the enhancement of several applications or application kernels, we see results in domains such as FPGA programming, file systems, runtime, energy efficiency, time constrained computing, tuning/debugging tools.

The complete set of results is very rich and for the exploitation of this basis, we have some new FET-HPC 2017 or other projects that will continue some of these efforts (EuroExa, Mont-Blanc 2020, Sage2, Escape-2 or Recipe).

In summary, the FET-HPC 2015 call has produced a rich set of IPs that could be reinforced by vertical or horizontal integration projects pushing these new technologies toward industrialization for the European ecosystem.

Technology Targeted user	Computing node/board	Interconnect Memory hierarchy	Storage/file system	Tools for FPGA	Software stack	Programming model/ tool	Optimization tools	Library	Application
Demonstrator	Ecoscale Exanode Mont-Blanc 3	NextGenIO ExaNest Ecoscale	SAGE	MANGO EXTRA	Greenflash EcoScale Antarex	Exanode InterTwine	Ecoscale		
HPC system provider	Greenflash ExaNest Ecoscale Mont-Blanc 3 Exanode	NextGenIO ExaNest	SAGE	MANGO Ecoscale	MANGO Greenflash Mont-Blanc 3 Readex	AllScale InterTwine			NextGenIO COMPAT Antarex
Computing centre			SAGE		MANGO NextGenIO Mont Blanc 3 COMPAT Readex Antarex	InterTwine			NextGenIO COMPAT Antarex
Application developer			ExaNest SAGE NextGenIO	MANGO Ecoscale EXTRA	Readex Antarex	MANGO AllScale Greenflash MontBlanc3 Exanode InterTwine Antarex	Greenflash Mont-Blanc 3 EXTRA Readex Antarex	ExaFlow ExCAPE NLAFET Readex Antarex	
End user						ExaFlow	NLAFET	NLAFET	ExaNext ExaFlow ESCAPE ExHype ExCAPE NLAFET Readex Antarex

Summary of projects innovations by type of technology and targeted users

A brochure listing all FETHPC (and CoE) projects can be found on the ETP4HPC website[25].

CoE 2015 projects

In addition to the very important contribution of CoE projects to skill development and training reported in section 3.2.2, the CoEs were questioned on their main self-assessed achievements/innovations. The following table does not pretend to map and classify all CoE activities, but to identify the self-perceived most salient and/or innovative ones. E.g. having only one CoE mentioning ISV interaction does not mean the others had none, but that they rather highlight other achievements first.

[25] http://www.etp4hpc.eu/european-hpc-handbook.html

Kind of self-assessed innovation or achievements by Centres of Execellence	# of CoEs mentioning this
Community code scaling, porting, or performance optimisation	6*
Other kinds of s/w environment improvement: cloud access mode, workflow management, data services	3
Various new pieces of software developed (components, DSL…)	3
New model or method	2
Patent	1
Start-up	1
Spun-out activity	1
New skills/competences and/or related material, dissemination	4
Community structuration	1
New collaborations, networking and ecosystem effects	2
ISV interaction	1

** We include here the transversal CoE on Performance Optimisation which oriented most of its effort towards performance analysis, related tools and methodology, and organised related services and training (in particular producing139 performance analysis/assessment reports). Other CoEs also developed such methodological approaches inside the scope of their topical sector, and there were of course a wide cross-section of more global exchanges on these aspects between the stakeholders of the different projects.*

Patents

It is important to pin out that the focus of FETHPC projects is on pre-competitive, open research. This implies that most patents deriving from this research will occur after the completion of the projects. CoE projects, on their side, are oriented toward scientific applications. Nevertheless, at least 11 patents filed during the lifetime of "2015" projects were reported by industry FETHPC participants, plus one from a CoE project partner.

Quotes from interviewed companies:

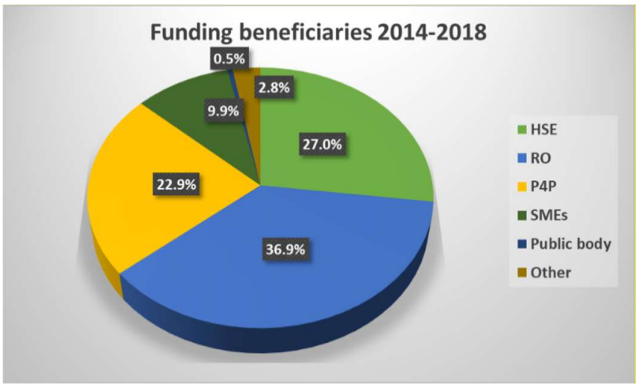
- *We expect multiple patents, but we won't know exactly what they will be until the project is finished.*
- *It's still too early for our company to begin the patent process*.

Standards

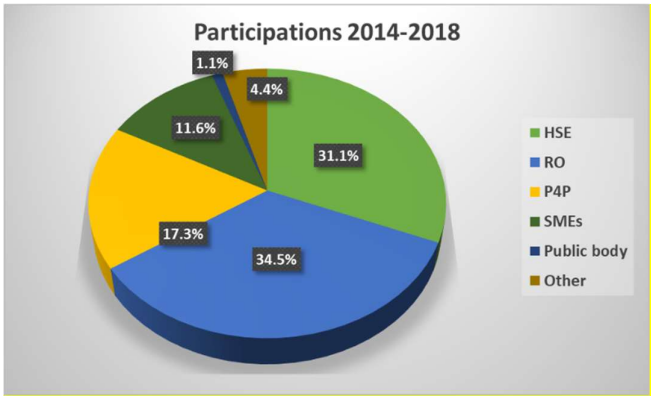
Questioning ETP4HPC member organisations (from industry as well as from research), it also appears that a number for them are represented and active in standard bodies - all of them being involved in FETHPC and/or CoE projects. These standard bodies are essentially concerned with parallel programming models or languages (MPI Forum, GASPI Forum, FORTRAN standardization committee, OpenMP ARB), software frameworks for HPC (OpenHPC), file systems (EOFS, Lustre Centre of Excellence).

3.3. Evolution over the years

Compared to the same statistics presented in 2017, additional EUR 198 million have been allocated to funding beneficiaries in 14 new R&I projects. Funding to industry (P4P), including SME, increased its share from 25.5% to 32.8%, and mostly driven by the EPI and the testbeds projects. Funding to Research Organisations (RO) remained stable in 2018 and funding to Higher and Secondary Education (HSE) grew more slowly decreasing its share by almost 5% to 27%.



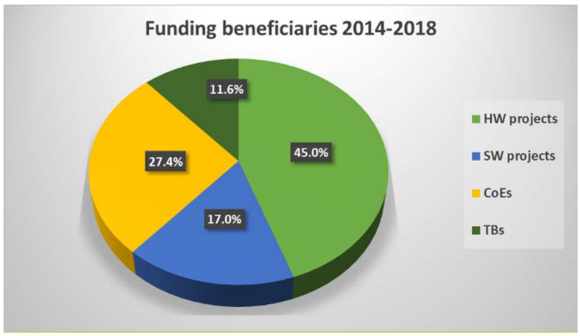
Participations by type of organization in the funded projects displayed in the next chart, broadly reflects the allocation of funding with small deviations in one direction or another.



The following table breaks down the HPC calls in the period 2014-2018 in four different classes, based on the type of projects funded. It distinguishes between hardware projects (HW), software projects (SW), Centres of Excellence (CoE) and Testbeds (TB). Hardware projects typically have considerable activities on software development, too. However, at a first instance it allows us to break down the funding in the different areas, as this is an important aspect of the implementation of the HPC strategy.

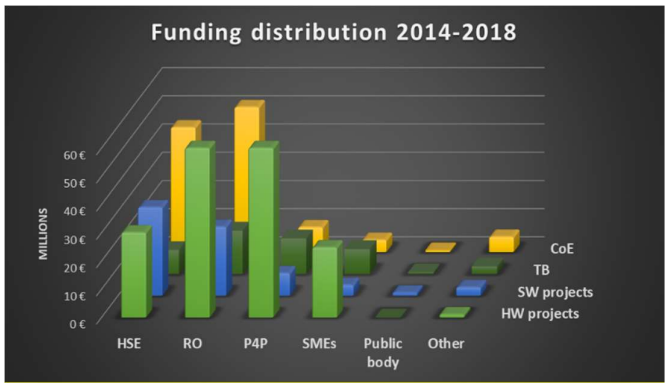
Call reference	Subtopic(s)	Project type
FETHPC-1-2014	a (architectures)	HW
FETHPC-1-2014	b,c,d (system, tools, algorithms)	SW
FETHPC-2-2014	N/A	CSA
EINFRA-5-2015	N/A	CoE
FETHPC-01-2016	N/A	HW
ICT-05-2017	N/A	HW
FETHPC-02-2017	a,b,c,d,e (system, tools, storage and I/O, data, algorithms)	SW
FETHPC-03-2017	N/A	CSA
INFRAEDI-02-2018	N/A	CoE
INFRAEDI-03-2018	N/A	CSA
ICT-11-2018-2019	N/A	TB
SGA-LPMT-01-2018	N/A	HW

Two of the three calls in 2018 were application oriented, providing a second round of funding to CoEs and starting the activities on HPC and Big Data enabled testbeds, the third call being on the EPI project. The picture that emerges is one where funding in HW on one side and SW + CoE + TB topics on the other side remains balanced, with a slight increase for software and application oriented projects. According to preliminary planning for the years 2019 and 2020, this trend is expected to be maintained.

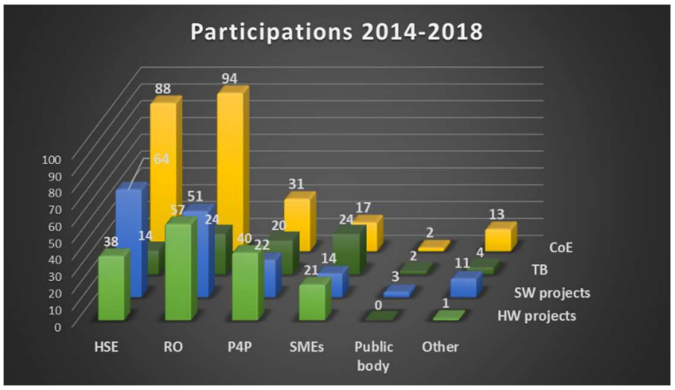


A more detailed picture of the funding distribution emerges, when it is broken down per type of organization. For HW projects, the funding is almost evenly split between public and private for profit organizations, oriented towards creating innovations in this area, in line with the HPC strategy of strengthening the European industrial supply chain. A similar situation is also encountered for the projects developing HPC and Big Data testbeds that are more oriented towards applications with industrial impact.

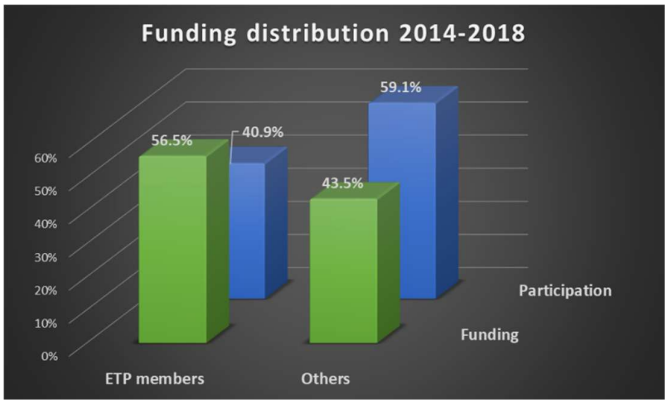
Higher or Secondary Establishments (HSE) and Research Organisations (RO) are clearly receiving a large share of the funding in projects developing solutions for the HPC software stack (SW) and for Centres of Excellence in HPC Applications (CoEs), highlighting the collaborative nature of the software development work in these areas.



The next chart presents the breakdown of participations in the different types of projects. Compared to the same type of chart pictured above, the trends are the same. One highlight is that HW projects, while absorbing almost half of the funding in the period 2014-2018, is characterized by a smaller number of participants.



An important facet of cPPPs is the openness. European industrial platforms play an important role in organizing the community around strategic priorities and European roadmaps. However their work should represent not only the interests of their members, but reflect the reality of a wider community. It is therefore important to monitor how H2020 funding is distributed among ETP4HPC members and non-members. The following chart does that for both funding and participation, showing that a majority of the beneficiaries are not members of the ETP4HPC. This is in line with the results obtained last year. The funding instead shows the opposite: while until last year it was evenly split between ETP members and non-members, the new projects funded in 2018, broke that balance in favour of ETP members, who now receive a majority of funding. This can be partly explained by the fact that of the 14 new projects granted in 2018, 9 of them were coordinated by ETP members. In addition, a large share of the funding to the EPI project went to ETP members.



4. OUTLOOK AND LESSONS LEARNT

EuroHPC Joint Undertaking is now in place and developing ramping-up activities on infrastructures as well as on R&I aspects of HPC. The HPC cPPP has been formally terminated (exchange of letter between ETP4HPC and Commissioner Gabriel in March/April 2019). EuroHPC, after dealing with the call for Hosting Entities for both Precursors to Exascale (formerly: Pre Exascale) and Petascale systems in April, published its first calls for R&I projects, replacing the H2020 cPPP calls, on July 25, 2019.

Several new calls for proposals related to the HPC strategy were implemented during 2018. Many are in the area of HPC applications such as the call for proposals for HPC Centres of Excellence, and HPC and Big Data enabled Large-scale Test-beds and Application. In addition, a call on the support to the governance of High Performance Computing Infrastructures has been implemented with the objective of establishing a communication platform for the dialogue of stakeholders involved in the implementation of the governance of HPC infrastructures across Europe. Last but not least, the consortium for the European Processor Initiative (EPI) started in December 2018. These different projects are mostly considered as not contributing to the data of this report. EuroHPC would take over for the monitoring and impact assessment of these efforts, together with the projects to be launched in 2019-2020.

The feedback received from the experts that evaluated the cPPPs for the mid-term review had been carefully analysed in 2018, and in 2019 the cPPP on HPC continued its impact assessment improvements from the lessons learnt during this process, using the new common KPIs and report template. The data collection process and methodology were mostly renewed, with some adjustments and complements, optimising efforts and focusing on the most productive actions, now better understood by experience. This does not address the well-known and persistent shortcomings: difficulty of data collection especially from private companies; limited amount and history of funding in the cPPP. However, time is on our side for this latter point, with a significant number of projects now completed – although still quite recently – and almost one half of the initially committed cPPP funding granted. This 2018 report can be seen as an intermediate one and a first testimony after 4 years of cPPP operations – with already significant innovations visible in both technology and application areas. Although the cPPP will not directly be continued as such, EuroHPC will take over and amplify efforts, which will allow a strong continuity in both implementation and impact assessment of the European HPC R&I, also with a stronger link and coordination with computing and data infrastructures - their funding, their technological equipment options and their relevance and usefulness for applications.

5. ANNEXES

5.1. Operational statistics – calls for projects

Call reference	Call title		Closing date	Selected projects
FETHPC-1-2014	HPC Core Technologies, Programming Environments and Algorithms for Extreme Parallelism and Extreme Data Applications	RIA	25 November 2014	19
FETHPC-2-2014	HPC Ecosystem Development	CSA	25 November 2014	2
E-INFRA-5-2015	Centres of Excellence for computing applications	RIA	14 January 2015	9
FETHPC-01-2016	Co-design of HPC systems and applications	RIA	26 September 2016	2
ICT-05-2017	Customised and low energy computing (including Low power processor technologies)	RIA	25 April 2017	1
ICT-42-2017	Framework Partnership Agreement in European low-power microprocessor technologies	FPA	26 September 2017	1
FETHPC-02-2017	Transition to Exascale Computing	RIA	26 September 2017	11
FETHPC-03-2017	Exascale HPC ecosystem development	CSA	26 September 2017	2
SGA-LPMT-01-2018	Specific Grant Agreement under the Framework Partnership Agreement "EPI FPA"	RIA	26 April 2018	1
INFRAEDI-02-2018	Centres of Excellence for computing applications	RIA, CSA	22 March 2018	9 + 1
INFRAEDI-03-2018	Support to the governance of High Performance Computing Infrastructures	CSA	22 March 2018	1
ICT-11-2018-2019	HPC and Big Data enabled Large-scale Test-beds and Applications	RIA	17 April 2018	4

History of cPPP related H2020 calls

# of H2020 calls implemented related to HPC	9
Avg. time-to-grant	223 days
Total H2020 funding committed	421.99 M€
# of projects	63
Projects coordinated by ETP members	29
Participating organisations	656 (RIA) + 104 (CSA)
Unique participations	292 (RIA), 49 (CSA)
non-ETP members participations	59.1%
Industry (non-SME) participations	17.3%
SME participations	11.6%

Statistics on cPPP-related H2020 projects

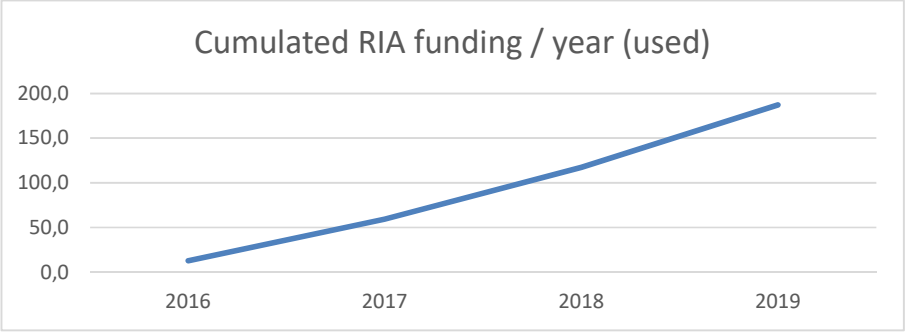
5.2. Scope, data sources and methodology

Like explained in introduction to Section 3.1, the core KPIs have mostly been assessed on the basis of projects started before Q4 of 2018 (i.e. ratios or extrapolations from our samples take into account the projects as indicated in the table below). Projects started Q4 of 2018 cannot have any significant influence yet, but account for some extra funding injected before end of 2018.

Call reference	Call title		Selected projects	Status as end of 2018	Taken into account for socio-economic KPIs
FETHPC-1-2014	HPC Core Technologies, Programming Environments and Algorithms for Extreme Parallelism and Extreme Data Applications	RIA	19	Most finished	Yes *
FETHPC-2-2014	HPC Ecosystem Development	CSA	2	Finished	Not in RIA funding
E-INFRA-5-2015	Centres of Excellence for computing applications	RIA	9	Most finished	Yes *
FETHPC-01-2016	Co-design of HPC systems and applications	RIA	2	Running	Yes
ICT-05-2017	Customised and low energy computing (including Low power processor technologies)	RIA	1	Running	Yes
ICT-42-2017	Framework Partnership Agreement in European low-power microprocessor technologies	FPA	1	Running but no budget	No
FETHPC-02-2017	Transition to Exascale Computing	RIA	11	Running	Yes
FETHPC-03-2017	Exascale HPC ecosystem development	CSA	2	Running	Not in RIA funding
SGA-LPMT-01-2018	Specific Grant Agreement under the Framework Partnership Agreement "EPI FPA"	RIA	1	Just starting	No
INFRAEDI-02-2018	Centres of Excellence for computing applications	RIA, CSA	9 + 1	Just starting	CSA not accounted for in RIA funding
INFRAEDI-03-2018	Support to the governance of High Performance Computing Infrastructures	CSA	1	Just starting	Not in RIA funding
ICT-11-2018-2019	HPC and Big Data enabled Large-scale Test-beds and Applications	RIA	4	Just starting	No

* *only calls taken into account for Innovation KPI analysis*

Since this is the last year of the cPPP, and since the common KPIs are not established since the beginning of the cPPP, we have not always analytically distinguished precise 2018 effects from cumulated effects – this would have not been very easy nor relevant. We sometimes give hints on the observed trends.



Simulation of progressive injection of H2020 HPC cPPP funding

In short:

Funding granted to projects related to the cPPP from 2014 to 2018 - RIA	400 M€
Funding granted between 2014 and 2017 - RIA (reference figure when needed, for quantified socio-economic KPIs)	213 M€
Estimated RIA funding effectively used by consortia used until end of 201	180 M€
Extra funding granted via CSAs between 2014 and 2018	11 M€

Over the years, different data sources have nourished the annual progress reports; some sources provide recurrent input, other more intermittent or demand-driven input. The main sources for current KPIs (data on 2018) were:

- data provided by the EC on the different calls (operational / implementation statistics), with also some data on directly leveraged funding (direct financial or in-kind contributions)
- ETP4HPC annual internal survey amongst ETP4HPC's Research members who benefitted from H2020 cPPP-related funding + same survey amongst extra, non-ETP-members Research organisations
- a survey addressed to 2015 Centres of Excellence
- a more focussed survey for the private-for-profit (P4P) sector, outsourced to an external and independent analyst team
- a complementary survey amongst a sample of SMEs receiving cPPP funding (for SME growth and evolutions)
- PRACE KPIs (for training and HPC use)

Data provided by the EC on the different calls mostly relate to operational aspects of the programme and general statistics like categories of participants – ETP4HPC members vs. non-members); research organisation, academic organisations, industrial companies, SMEs. This year complements on additional efforts directly declared in the project submission and reporting were also provided (first level of direct leverage beyond the 25M usual H2020 overhead).

ETP4HPC annual internal survey was sent to 20 ETP-members Research organisations ones, with questions on leverage factor, jobs, patents – 9 full answers, 15 partial were received.

Centres of Excellence (the nine ones funded in the first round in 2015-2016) were reached with a questionnaire via FocusCoE CSA, on jobs, innovations, and training efforts.

For the P4P sector, data were collected again by the contractor via interviews along a pre-submitted questionnaire. Private companies would mostly not deliver any operational nor commercial data to ETP4HPC, the confidentiality constraints were managed by the contracted analyst, using a well-established protocol and non-disclosure agreement approach which was widely accepted by the interviewed organizations. Aggregated and anonymised data only have been delivered to ETP4HPC. For most of the interviewed companies this was the third such interview and the process was smooth, and provided data on leverage factor, jobs, patents, innovations, SMEs.

In order to get representative and focused input regarding the KPIs, we selected 11 companies participating in FETHPC and projects. This sample represents the main industrial beneficiaries of the cPPP, amounting for 55% of the funding going to P4P industry sector, including SMEs. SMEs receive 50% of this share. The P4P sector in total receives ca. 24 % of the whole cPPP-related R&I funding - the interviewed industry participants reported that together they received EUR 26 million in funding under the H2020 HPC programme. The organisations interviewed are a mixture of SMEs and larger European or international companies; most are involved in more than one project. The interviewed large companies aggregated staff is above 460 000 – a minor fraction of this, not estimated, being related to HPC (although we can ensure this is several thousand). The interviewed SMEs aggregated staff is 220 (out of which ca. 100 in HPC activities).

Private investment and skills/jobs KPI estimates primarily stem from this study; other sources are also used to elaborate on SME and Innovation KPIs.

Another sample of SMEs were interviewed by the ETP4HPC/EXDCI-2 KPI team to collect extra information on their evolution and growth, how it related to H2020 funding, and some success stories – this is another sample of 10 SMEs, weighting 60% of the funding going to SMES which we included in our scope.

PRACE usual KPI update was used for training statistics and data on HPC use.

Public sources were eventually compiled (web intelligence mainly) to consolidate some extra data on dissemination or HPC specific KPIs – such as market data.

Our methodology relies upon complementary, weakly overlapping sources (mostly non overlapping). For instance Skills/training data use PRACE and Centres of Excellence independent – although mutually known and sometimes coordinated - activities statistics. Jobs KPI builds from a questionnaire to Research organisations and a series of interviews with a sample of companies. Innovation KPI uses an exhaustive interrogation of all FETHPC and CoE projects started in 2015, each project coordinating an answer for its consortium.

Data source	**2014**	**2015**	**2016**	**2017**	**2018**
ETP4HPC internal survey	x	x	x	x	x[26]
EXDCI survey (FETHPC+CoE projects)		x			
ETP4HPC Annual report	x	x	x	x	x
Analyst study (for profit organisations)			x	x	x
Specific extra SME interviews					x
PRACE KPIs	x	x	x	x	x
EC H2020 stats	x	x	x	x	x[27]
Public sources (internet, other reports and public registers)	x	x	x	x	x

Recapitulation of data sources used for the PMRs

[26] In 2018 ETP4HPC survey was restricted to Reaserch organisation receiving cPPP-related funding (a representative sample of both ETP members + non-ETP members)

[27] Including some data on direct, first level, leverage (related to extra funding declared in the project description of activity and reporting)

5.3. Some extra facts and quotes from industrial partners interviewed on their H2020 project activity

What Specifically Did the Funding Enable You to Accomplish? Importance of Future Public Funding.

The H2020 funding encourages European organizations to work together to stay globally competitive.

> *The H2020 funding accelerates the research, but it's really valuable because it enables you to collaborate within (the HPC) eco-system.*

We view the H2020 funding as a way to build skills and capacity in our organization. We can do (things) more quickly.

> *This project required things to run with commercial-level quality control. It provided a chance to build management expertise in this area.*

The H2020 funding is completely critical. It has allowed us to advance our HPC. The European program is all about building and supporting an ecosystem. We are pleased that Europe is supporting companies and as a European supplier we are benefiting.

> *It helped us broaden our product portfolio. The project work is based on technology we had and allowed us to advance it, although it wasn't completely new.*

We are a very big business, not just an HPC-related business. So, the H2020 funding is not "extremely" important from a financial perspective, but the H2020 funding is very important from a strategic perspective.

> *Our project is very risky, but if it's successful it will be highly valuable. It would give vendors and customers more heterogeneous systems. We're making progress, but we won't know how successful it is till close to the end. But thanks to this project, we know we can build this European system and now we just need to see if the applications benefit as expected.*

[SME] It's important to have this kind of funding so European HPC development can go forward, especially for an SME like us.

> *[SME] H2020 gives us early access to the latest technology and the opportunity for joint research with other European suppliers. This helps us to minimize and control financial risk.*

[SME] This funding is very important because of the nature of the opportunities put together by the EU. These opportunities are very well connected to our expertise. It's very difficult to get alternative funding from any other source for this kind of thing.

> *[SME] It's important to get H2020 funding because the market is such that a company of our size can't sustain R&D development on our own.*

Course of Action without H2020 Funding

We would have had to go slower because of the additional investment that would have been required.

> *For one project we would not have done this research, and for another one we would have had to do it on a more limited basis.*

5.4. Selection of HPC cPPP related news articles in the European press

Web Press review – Keyword : EU HPC

Title	Media+ Country	Range audience of the media	2018
« Informatica : il supercomputer CRESCO6 dell'ENEA entra nella prestigiosa TOP 500 delle infrastrutture di calcolo più potenti al mondo, grazie al raddoppio della potenza »	Corriere Nazionale IT	Between 100k and 500k	January
« Supercomputers : EU to develop high-performance data infrastructures »	Euractiv EU		
« EU investiert 1 Milliarde, um bei Supercomputern am Ball zu bleiben »	Netzwoche CH	Between 100k and 500k	
« Supercalculateurs, l'affaire des superpuissances	Paperjam LU		
« Superordinateur : l'infrastructure EuroHPC devient le pilier de l'Europe »	Silicon FR	Between 100k and 500k	
« EU bouwt eigen supercomputer: 'Een enorme stap' »	Standaard BE	More than 1M	
« Cloud et calcul à haute performance : opportunité des start-up aux grands groupes »	Journal du Net FR	More than 1M	February
« Une supra entreprise pour un supercalculateur »	Paperjam LU	Between 100k and 500k	
« Superkomputery dla Polski w Unii Europejskiej »	Michal Boni PL	N/A	June
« Lietuva galės naudotis pasaulinio lygio superkompiuteriais »	DELFI LT	More than 1M	June
« Los Veintiocho acuerdan invertir 1.000 millones en el desarrollo de superordenadores europeos »	Europa Press ES	More than 1M	September
« L'Europe se met en ordre pour avoir ses superordinateurs de « classe mondiale »	Numerama FR	More than 1M	
« Supercomputers: Επενδύει στους υπερυπολογιστές η Ευρωπαϊκή Ένωση »	Law Spot GR	Between 100k and 500k	
« ЕС инвестира €1 млрд. в суперкомпютри от световна класа »	News BG	More than 1M	
« Europa steekt miljard in supercomputers »	Ag Connect NL	Less than 100k	
« Sabias que a União Europeia está a desenvolver um microprocessador próprio? »	SAPO PT	Between 100k and 500k	
« Conselho da UE dá luz verde ao desenvolvimento de supercomputadores »	JN PT	More than 1M	
« L'UE verse un milliard pour les technologies quantiques, notamment pour Neuchâtel et Genève »	Le Temps CH	More than 1M	October
« Az uniós országok nagy teljesítményű közös számítástechnikai fejlesztésre készülnek »	InnoPortal HU	N/A	
« Atos fournit un supercalculateur ARM au CEA »	Le Monde Informatique FR	Between 500k and 1M	November
« L'Imec et le CEA-Leti unissent leurs forces sur l'intelligence artificielle et l'informatique quantique »	VIPress FR	N/A	

Title	Media+ Country	Range audience of the media	2018
« Intelligence artificielle : l'Union européenne dévoile un plan à 20 milliards € »	Le BigData FR	Between 100k and 500k	December

Related "EU HPC" links (accessed April 2019)

- « EU investiert 1 Milliarde, um bei Supercomputern am Ball zu bleiben », https://www.netzwoche.ch/news/2018-10-01/eu-investiert-1-milliarde-um-bei-supercomputern-am-ball-zu-bleiben
- « EU supersatsar på superdatorer – investerar 10 miljarder », https://computersweden.idg.se/2.2683/1.695912/eu-superdatorer
- « L'Europa investe nei supercomputer: un miliardo di euro per l'impresa comune EuroHPC », https://www.innovationpost.it/2018/09/29/leuropa-investe-nei-supercomputer-un-miliardo-di-euro-per-limpresa-comune-eurohpc/
- « Informatica: il supercomputer CRESCO6 dell'ENEA entra nella prestigiosa TOP 500 delle infrastrutture di calcolo più potenti al mondo, grazie al raddoppio della potenza », https://www.corrierenazionale.it/2018/12/21/cresco6-tra-i-500-computer-piu-potenti-al-mondo/
- « Supercomputers: EU to develop high-performance data infrastructures », https://www.euractiv.com/section/data-protection/news/supercomputers-eu-to-develop-high-performance-data-infrastructures/
- « Supercalculateurs, l'affaire des superpuissances », https://paperjam.lu/article/news-supercalculateurs-laffaire-des-superpuissances
- « L'UE verse un milliard pour les technologies quantiques, notamment pour Neuchâtel et Genève », https://www.letemps.ch/sciences/lue-verse-un-milliard-technologies-quantiques-notamment-neuchatel-geneve
- « Los Veintiocho acuerdan invertir 1.000 millones en el desarrollo de superordenadores europeos », https://www.europapress.es/economia/noticia-veintiocho-acuerdan-invertir-1000-millones-desarrollo-superordenadores-europeos-20180928160924.html
- « Mariya Gabriel : «L'Europe peut vite revenir dans la course », https://www.lesechos.fr/09/12/2018/lesechos.fr/0600301010562_mariya-gabriel----l-europe-peut-vite-revenir-dans-la-course--.htm
- « L'Europe se met en ordre pour avoir ses superordinateurs de « classe mondiale », https://www.numerama.com/politique/423750-lunion-europeenne-se-met-en-ordre-pour-avoir-ses-superordinateurs-de-classe-mondiale.html
- « Superkomputery dla Polski w Unii Europejskiej », http://michalboni.pl/pl/superkomputery-dla-polski-w-unii-europejskiej/
- « Supercomputers: Επενδύει στους υπερυπολογιστές η Ευρωπαϊκή Ένωση », https://www.lawspot.gr/nomika-nea/supercomputers-ependyei-stoys-yperypologistes-i-eyropaiki-enosi
- « ЕС инвестира €1 млрд. в суперкомпютри от световна класа », https://news.bg/world/es-investira-eur1-mlrd-v-superkompyutri-ot-svetovna-klasa.html
- « Lietuva galės naudotis pasaulinio lygio superkompiuteriais », https://www.delfi.lt/mokslas/technologijos/lietuva-gales-naudotis-pasaulinio-lygio-superkompiuteriais.d?id=78185781
- « Europa steekt miljard in supercomputers », https://www.agconnect.nl/artikel/europa-steekt-miljard-supercomputers
- « Az uniós országok nagy teljesítményű közös számítástechnikai fejlesztésre készülnek », http://www.innoportal.hu/az-unios-orszagok-nagy-teljesitmenyu-kozos-szamitastechnikai-fejlesztesre-keszulnek
- « EU bouwt eigen supercomputer: 'Een enorme stap' », http://www.standaard.be/cnt/dmf20180111_03294053
- « Sabias que a União Europeia está a desenvolver um microprocessador próprio? », https://shifter.sapo.pt/2018/09/microprocessador-uniao-europeia/
- « Conselho da UE dá luz verde ao desenvolvimento de supercomputadores », https://www.jn.pt/inovacao/interior/conselho-da-ue-da-luz-verde-ao-desenvolvimento-de-supercomputadores-9921067.html
- « Superordinateur : l'infrastructure EuroHPC devient le pilier de l'Europe », https://www.silicon.fr/superordinateur-hpc-infrastructure-eurohpc-195989.html
- « Atos fournit un supercalculateur ARM au CEA », https://www.lemondeinformatique.fr/actualites/lire-atos-fournit-un-supercalculateur-arm-au%C2%A0cea-73422.html
- « Intelligence artificielle : l'Union européenne dévoile un plan à 20 milliards € », https://www.lebigdata.fr/intelligence-artificielle-ue-plan
- « Cloud et calcul à haute performance : opportunité des start-up aux grands groupes », https://www.journaldunet.com/solutions/expert/68446/cloud-et-calcul-a-haute-performance---opportunite-des-start-up-aux-grands-groupes.shtml
- « Une supra entreprise pour un supercalculateur », https://paperjam.lu/article/news-une-supra-entreprise-pour-un-supercalculateur
- « L'Imec et le CEA-Leti unissent leurs forces sur l'intelligence artificielle et l'informatique quantique », https://www.vipress.net/limec-et-le-cea-leti-unissent-leurs-forces-sur-lintelligence-artificielle-et-linformatique-quantique/

Web Press review mentioning « ETP4HPC »

« Supercalculateurs : l'Europe tente de rattraper son retard »	Le Point FR	More than 1M	January
« EuroHPC : 1 Milliarde Euro für Supercomputer mit EU-Technologie »	Heise DE	More than 1M	
« La simulation touche désormais tous les secteurs », selon le président de Teratec Christian Saguez »	Usine Nouvelle FR	More than 1M	April
« Inria partenaire du Forum TERATEC les 19 et 20 juin à l'Ecole Polytechnique »	INRIA FR	More than 1M	June
« High performance computing als concurrentiefactor »	Computable NL	Between 100k and 500k	
« EuroHPC Joint Undertaking to Supplant EU's Horizon 2020 HPC Funding Efforts »	HPCwire USA	Between 100k and 500k	September
« Ευρωπαϊκή εταιρεία ΣΔΙΤ για ανάπτυξη υπερυπολογιστών »	Naftemporiki GR	More than 1M	
« L'université de Reims Champagne-Ardenne inaugure son nouveau cluster pétaflopique, Romeo »	Le Margit FR	Between 100k and 500k	October
« Download the New European HPC Handbook »	Inside HPC USA	Less than 100k	November
"A clarifying look at the ETP4HPC role in EuroHPC and opportunities for European SMEs" "New ETP4HPC Steering Board elected in Dublin"	Primeur Magazine		

Related "ETP4HPC" links (accessed April 2019)

- « High performance computing als concurrentiefactor », https://www.computable.nl/artikel/expertverslag/overheid/6385349/4573232/high-performance-computing-als-concurrentiefactor.html
- « Download the New European HPC Handbook », https://insidehpc.com/2018/11/download-new-european-hpc-handbook/
- EuroHPC Joint Undertaking to Supplant EU's Horizon 2020 HPC Funding Efforts, https://www.hpcwire.com/2018/09/07/eurohpc-joint-undertaking-to-supplant-eus-horizon-2020-hpc-funding-efforts/
- « Inria partenaire du Forum TERATEC les 19 et 20 juin à l'Ecole Polytechnique », https://www.inria.fr/actualite/mediacenter/inria-partenaire-du-forum-teratec-les-19-et-20-juin
- « La simulation touche désormais tous les secteurs », selon le président de Teratec Christian Saguez », https://www.usinenouvelle.com/editorial/la-simulation-touche-desormais-tous-les-secteurs-selon-le-president-de-teratec-christian-saguez.N679969
- « Supercalculateurs : l'Europe tente de rattraper son retard », https://www.lepoint.fr/politique/emmanuel-berretta/supercalculateurs-l-europe-tente-de-rattraper-son-retard-29-01-2018-2190383_1897.php
- « L'université de Reims Champagne-Ardenne inaugure son nouveau cluster pétaflopique, Romeo », https://www.lemagit.fr/actualites/252449889/Luniversite-de-Reims-Champagne-Ardennes-inaugure-son-nouveau-cluster-Petaflopique-Romeo
- « Ευρωπαϊκή εταιρεία ΣΔΙΤ για ανάπτυξη υπερυπολογιστών », https://www.naftemporiki.gr/finance/story/1397287/europaiki-etaireia-sdit-gia-anaptuksi-uperupologiston
- « EuroHPC: 1 Milliarde Euro für Supercomputer mit EU-Technologie », https://www.heise.de/newsticker/meldung/EuroHPC-1-Milliarde-Euro-fuer-Supercomputer-mit-EU-Technologie-3939361.html

5.5. KPI Part 1 - Common Priority Key Performance Indicators

	Key Performance Indicator (KPI)	Value in 2017	Baseline at the start of H2020 (latest available)	Target (for the cPPP) at the end of H2020	Comments
1	Mobilised Private Investments	Estimated leverage factor of 4.6 for industry	Not defined	In leveraged investments, four-fold effect in industrial effort per public euro in the PPP.	
2	New skills and/or job profiles	End of 2018: at least industry 100 direct jobs during project lifetimes in s/w and h/w industry (hardware, system, application development) + more than 250 direct jobs in research (partly temporary jobs) Many training events/sessions/material (20000+ person*days of training)	Not defined	Direct jobs: 400 by 2017, and 1000 by 2020. Indirect jobs, 10000 in technology companies and 100000 in HPC end-users organisations by 2020	The first cPPP call projects ended (and not all of them) QA of 2018 Effects on permanent jobs still not measurable (but estimated Global effects beyond the scope of projects on applications not measurable (CoE projects do not fully represent user communities)
3	Impact of a cPPP on SMEs	At least 4 new successful start-ups/spinf-offs/spin-outs between 2014 and 2018, at least 3 remaining in HPC sector	Not defined	4 successful new SMEs in the PPP by 2017, and 10 by 2020	Observed positive impact of H2020 funding on turnover of SMEs
4	Significant Innovations	In HPC hardware and software building blocks, HPC system architecture, application codes	Not defined		Many innovative hardware and software building blocks for HPC solutions, as well as the evolution and improvement of many HPC applications. In particular several system prototypes with innovative architectures or features have stemmed from FETHPC projects, while Centres of Excellence have contributed to many significant evolutions of community codes (in terms of features and/or portability and/or performance improvement and scaling). See section 3.2.4

5.6. KPI Part 2 - Specific Key Performance Indicators for the cPPP

	KPI domain	Key Performance Indicator (KPI)	Value in 2018	Baseline at the start of H2020 (latest available)	Target (for the cPPP) at the end of H2020	Comments
1	Global market share of European HPC	HPC systems, components and tools based on technologies developed and built in Europe, volume (in generated income) of HPC technology exported from Europe (European HPC technology developers) to the rest of the world.	2014 = 4.1% 2015 = 4.6% 2016 = 4.9% **2018 = 5.0%**	4.4% in 2013	Reach a global market share of at least 7.5% by 2017, and 12.5% in 2020	Source for values: Hyperion Research (EU suppliers' share of EU HPC server market)
2	HPC additional investments	The level of high-tech investment generated by the PPP, and the additional investments leveraged in the HPC value chain; relation to the investments made into European HPC companies by private investors and venture capital funds	Leverage factor = 4.6 (industrial effort per public euro in the cPPP; mostly in indirect leverage, post-project industrialisation)	No baseline	In direct R&I activities, matching the Community funding in the PPP (~EUR 700 million by 2020). In leveraged investments, four-fold effect in industrial effort per public euro in the PPP.	
3	Jobs	Direct, sustainable jobs out of HPC research programmes recommended by the PPP, and indirect jobs in technology companies further downstream and in end-user organisations of HPC technologies and applications	100+ jobs in industry during projects life times More than 250 new jobs in research in 2018	No baseline	direct jobs: 400 by 2017, and 1000 by 2020. Indirect jobs, 10000 in technology companies and 100000 in HPC end-users organisations by 2020	The first cPPP finished projects stopped in Q4 2018 – no consolidated feedback on permanent jobs beyond project life times
4	Innovation environment in HPC	European HPC start-ups (not just those arising from H2020 projects) Number of new SME start-up companies created out of HPC research programmes in the PPP (only successful SMEs with a sustainable business) Unsuccessful HPC start-ups Growth of existing European HPC start-ups	At least 4 new SMEs between 2015 and 2018 3 still on HPC business 1 in other sectors now 0 At least 6 existing SMEs increased business and turnover	No baseline	4 successful new SMEs in the PPP by 2017, and 10 by 2020	2 start-ups creation related to projects in FP7 & ICT advanced computing scope

5	Research programme effectiveness and coverage	• Coverage of the R&I roadmap by calls topics • Number of co-ordinated calls launched • Number of responses to calls • Number of active research projects • Geographical coverage of project participation • Additional leverage and Impact in other related programmes (e.g. areas such as nano-electronics, photonics, microelectronics, software, storage in other parts of Horizon2020	• See sections 2.1 and 0 • 3 in 2018 • 33 to the 3 calls launched in 2018 • 35 at the end of 2018 • All MSs except EE, LV, LT overall • Impact on application areas developed by CoEs and on microelectronics for the EPI project			2014-2018 calls reflect the ETP4HPC SRA topics; the SRA is directly mentioned in the calls as detailed technical reference
6	Performance of HPC technologies developed	• Range of architectures available in Europe • Number of new prototypes made available per year via the PPP	• 6 • 1 per year			Projects concerned: NextGenIO, SAGE, Mango, Mont-Blanc, DEEP-EST, EuroEXA
7	People, education, training and skills development	Showing the European HPC knowledge base providing high-skilled HPC profiles and curricula developed in the PPP	From CoEs: -33 training workshops -10 topical schools -More than 50 webinars -ca. 100 others training events -More than 8 'coding sessions' PRACE courses were also attented by 1800+ participants.			
8	HPC use	Use of the HPC technologies developed in academia and industry (in particular SMEs)	At least 17 projects making available open source software packages			
9	HPC software ecosystem	Impact of software ecosystem (number of applications, number of users, etc.). Large scale scientific and industrial applications adapted to the next computing generation addressing key economic areas and societal challenges	CoEs and FETHPC use cases addressing at least 12 application areas with economic and societal relevance.			

10	Patent, inventions and contributions to standards in HPC by H2020 funded projects	Patent, direct contributions and activities leading to standardisation, and invention-submissions out of HPC research programmes recommended by the PPP	At least 11 (2015-2018)		40 per year by 2017, 80 per year by 2020	See KPI 1 & 2 in Annex 5.7: KPI Part 3
11	Efficiency, openness and transparency of the PPP consultation process	• Monitoring the number of participants contributing to the strategy and implementation workshops • Analysis of ETP4HPC members to provide evidence for representation of the HPC community • Monitoring of the decision making process during the consultation	ETP4HPC Strategic Research Agendas involved 200 experts ETP4HPC has grown to 96 members end of 2018, incl. 1/3 of EU SMEs; members are technology suppliers but also application owners, service providers, ISVs…			ETP4HPC SRAs elaboration also involved PRACE, Centres of Excellence, BDVA (Big Data Value Association) ETP4HPC membership: see http://www.etp4hpc.eu/membership.html and http://www.etp4hpc.eu/ETP4HPC-2017-annual-report/#section-4
12	Dissemination and awareness	Make HPC visible to the general public in Europe and to a broad range of stakeholders.	See section 0 and Annex 5.4			

5.7. KPI Part 3 - Contribution to Programme-Level KPIs

	Key Performance Indicator	Definition/Responding to question	Type of data required	Data	Baseline at the start of H2020	Target (for the cPPP) at the end of H2020	Comments
1	Patents		Number of patent applications Number of patents awarded	More than 11 N/A	n.a. [new cPPP under H2020]	**H2020:** 3 patent applications per EUR 10 million funding	
2	Standardisation activities (project level) Contributions to new standards (PPP level)		Number of activities leading to standardisation Number of working items in European Standardisation Bodies Number of pre-normative research files – prEN - under consultation in ESBs	See report section 3.2.4		No target	Projects participants involved in 6 different HPC standardisation entities
3	Operational performance	Time-to-grant		223 days on average			9 calls, 63 projects granted (1 FPA, 56 RIA, 6 CSA)