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COVER NOTE

From:	Secretary-General of the European Commission, signed by Mr Jordi AYET PUIGARNAU, Director
date of receipt:	29 May 2017
To:	Mr Jeppe TRANHOLM-MIKKELSEN, Secretary-General of the Council of the European Union
No. Cion doc.:	SWD(2017) 221 final - PART 3/16
Subject:	COMMISSION STAFF WORKING DOCUMENT INTERIM EVALUATION of HORIZON 2020 ANNEX 1

Delegations will find attached document SWD(2017) 221 final - PART 3/16.

Encl.: SWD(2017) 221 final - PART 3/16

EUROPEAN
COMMISSION

Brussels, 29.5.2017
SWD(2017) 221 final

PART 3/16

COMMISSION STAFF WORKING DOCUMENT

INTERIM EVALUATION of HORIZON 2020

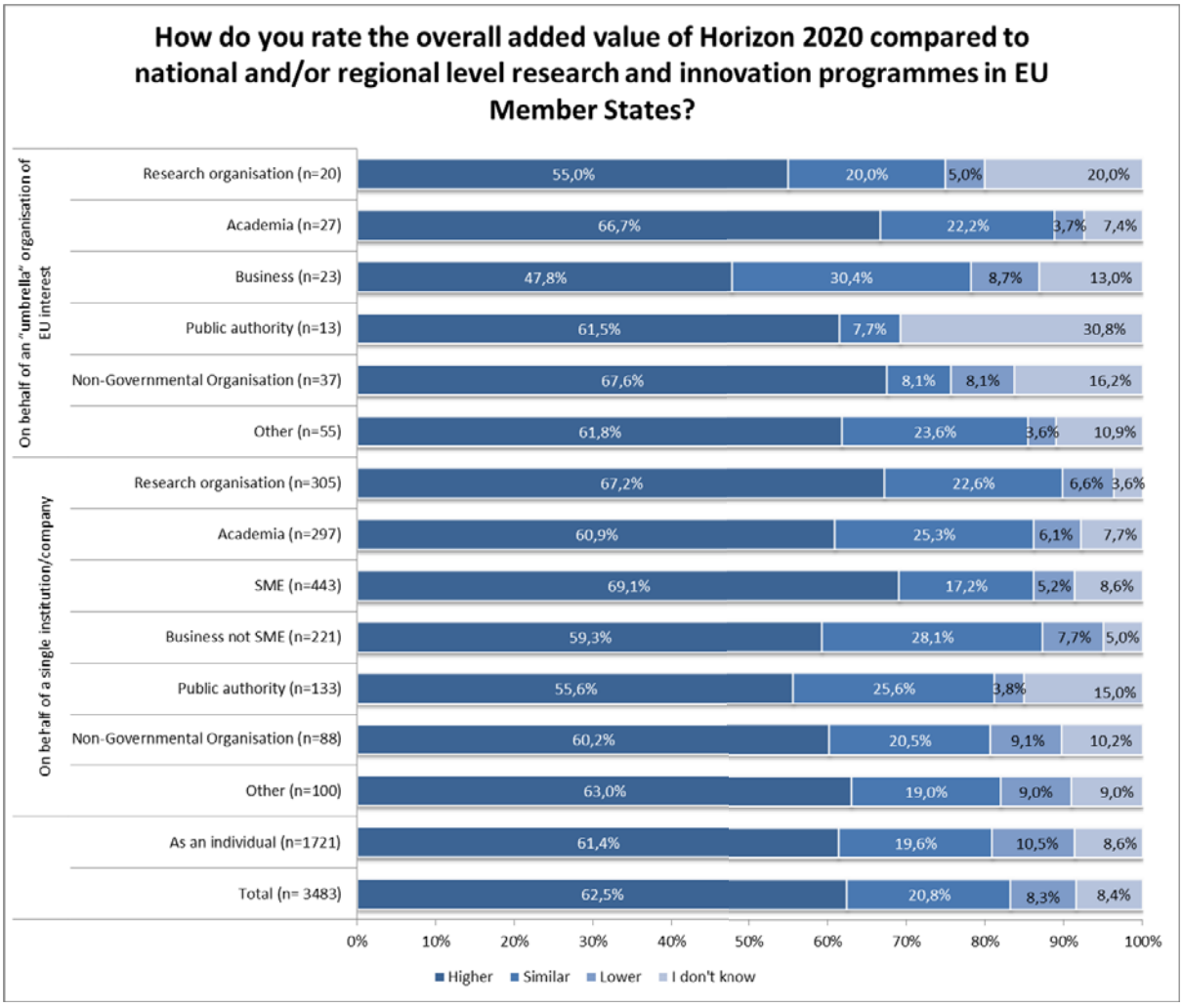
ANNEX 1

{SWD(2017) 220 final}
{SWD(2017) 222 final}

B.6. EU added value

For 63% (2176) of the respondents the added value of Horizon 2020 is higher than that of national and/or regional programmes for research and innovation (see Figure 38 below). Research organisations and business respondents have the highest rate of agreement (66% and 65% respectively), while the agreement rate is lowest for public authorities (56%) also because many note that they "don't know".

Figure 38 How do you rate the overall added value of Horizon 2020 compared to national and/or regional level research and innovation programmes in EU Member States?



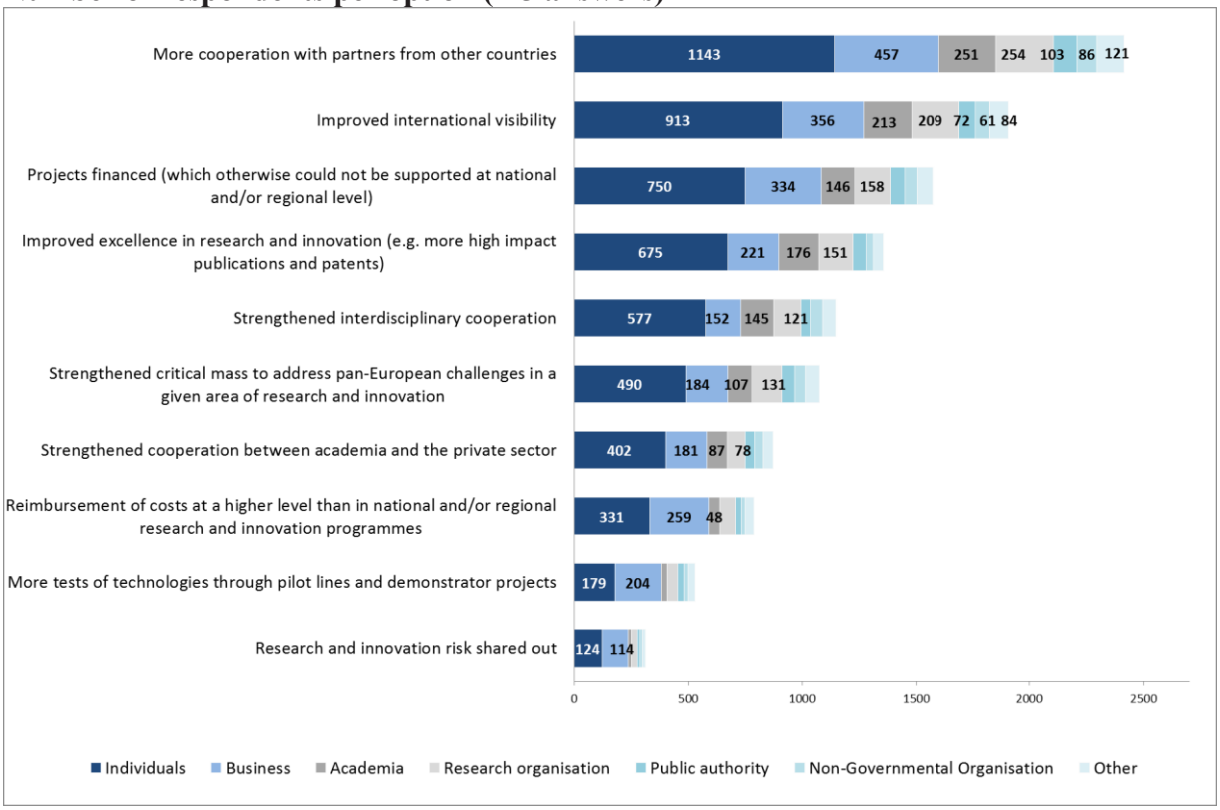
Source: Replies to stakeholder consultation questionnaire launched in the framework of the Interim Evaluation of Horizon 2020, October 2016-January 2017, N=3483

Furthermore, out of the 835 respondents who did not participate in Horizon 2020, a rather low number prefer participating in other regional/ national programme (63 respondents) or in other European or international programmes (30 respondents).

For respondents, the main added value of participating in Horizon 2020 compared to national and/or regional research and innovation programmes is cooperation with partners from other

countries, followed by improved international visibility and the financing of the projects that otherwise would not be supported (see below).

Figure 39 What are the main expected benefits of participating in Horizon 2020 compared to national and/or regional research and innovation programmes in EU Member States? Number of respondents per option (1-5 answers)



Source: Replies to stakeholder consultation questionnaire launched in the framework of the Interim Evaluation of Horizon 2020, October 2016-January 2017, N=3483

In terms of effectiveness, respondents strongly agree with statements suggesting that Horizon 2020 strengthens the quality and visibility of research in the EU. For 1908 respondents, the programme contributes to improving international visibility and 1,357 are confident it improves excellence in research and innovation. In their open comments, respondents also outline the visibility and reputation they gain from being selected for funding. Horizon 2020 is qualified as a "prestigious" programme that set high standards for research and innovation in Europe and could lead to career development or help organisations to attract top researchers.

In terms of efficiency, for 1,076 respondents, the programme strengthens critical mass to address pan-European challenges. In their open comments, respondents go as far as saying that Horizon 2020 promotes trust between partners and a more coherent and integrated Europe through shared goals and joint work. 1,574 respondents highlights that it finances projects that otherwise could not be supported at national or regional level. 788 respondents state that European funding is all the more important given that the reimbursement of costs is higher than in national / regional programmes. Within the open responses, some respondents also outline that 100% cost funding for SMEs is a major incentive to participate (although it should also be noted that a few comments were against full reimbursement of costs).

In terms of synergy, Horizon 2020 is said to contribute to strengthening interdisciplinary cooperation (by 1147 respondents) as well as cooperation between academia and the private sector (873 respondents). Additional comments provided by respondents suggest that the

programme offers opportunities (qualified by some respondents as "unique opportunities") to access new partners and new expertise, and to work with the best and internationalise their activities. It promotes a more integrated vision of the research and innovation system, one that links together academia, business and SMEs. Working with different types of organisations and across different countries fosters cross-cultural experiences (to the benefit of young researchers more particularly), thus encouraging the confrontation of different points of views, stimulating ideas and fostering creativity and the emergence of disruptive ideas.

To provide a further analysis of the programme's added value and additionality, respondents were asked what would be the impact if EU support to research and innovation (Horizon 2020 and its possible successor) were to be discontinued. According to the basic analysis that was carried out, very few of the respondents judge that a discontinuation of the framework programme would only have a limited impact on their organisation and most of the ones who do are NGOs and public authorities (a few businesses, very few academia organisations). Overall, the discontinuation of the programme would be judged as "catastrophic", "devastating" "a nightmare", or a significant "drawback".

Potential negative impacts are numerous and vary based on the dependence of the organisation to Horizon 2020 funding:

- The impacts would be worst for business whose activities are very much dependent on EU funding, as a programme's discontinuation would result in a reduction in scope or even in a discontinuation of research and innovation activities, less or slower product development and it could reduce business activities and staff (one business even indicates this would mean moving its research activities outside of the EU and, for another, that it would question its viability as a business).
- For academia and research organisations, it would mean less funding for fundamental, interdisciplinary, risky and disruptive research, less drive to cooperate and less international contacts, less exposure to new knowledge and more limited capacity to anticipate new trends, less learning and exchange of ideas, less ability to carry out high level research and a withdrawal into national research capacities hence losing the ability to create critical mass at the European level. It could lead to the disappearance of existing networks since a stable framework would no longer be available to support joint work. Ultimately, this could be a drawback for research and innovation in the EU, affecting the ability of Europeans to carry out top research and to address global challenges, thus resulting in a loss of competitiveness and international visibility of the EU on the international research and innovation stage.

B.6.1. Key points / Areas for improvement

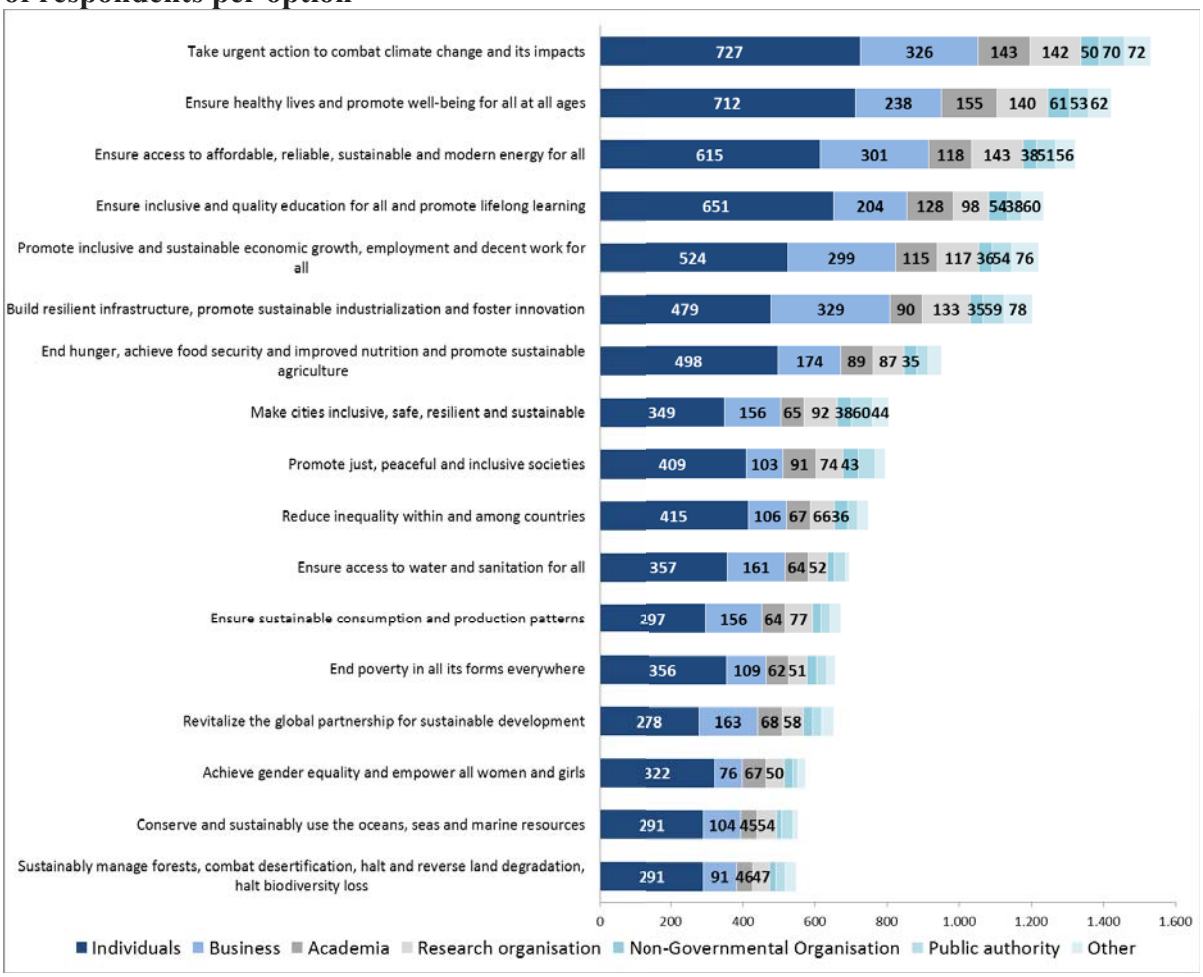
To conclude, the respondents to the stakeholder consultation generally:

- Judge the added value of Horizon 2020 to be higher than that of national and/or regional programmes for research and innovation.
- Indicate that the cooperation with international partners is a key feature of Horizon 2020's added value.
- Agree that the additionally of the programme is strong and feel that a possible discontinuation of the programme would have strong negative impacts, which would extend far beyond a simple reduction of research and innovation funding for their organisations.

B.7. EU added value

Stakeholders were asked to choose up to 5 Sustainable Development Goals on which the future EU framework programmes for research and innovation should focus. Six areas top the list where each area is selected by more than 1,000 respondents: i) Combat climate change and its impacts; ii) Healthy living and well-being at all ages; iii) Affordable, reliable, sustainable and modern energy for all; iv) Inclusive and quality education for all and lifelong learning; v) Inclusive and sustainable economic growth, employment and decent work for all; and vi) Resilient infrastructure, sustainable industrialisation and innovation.

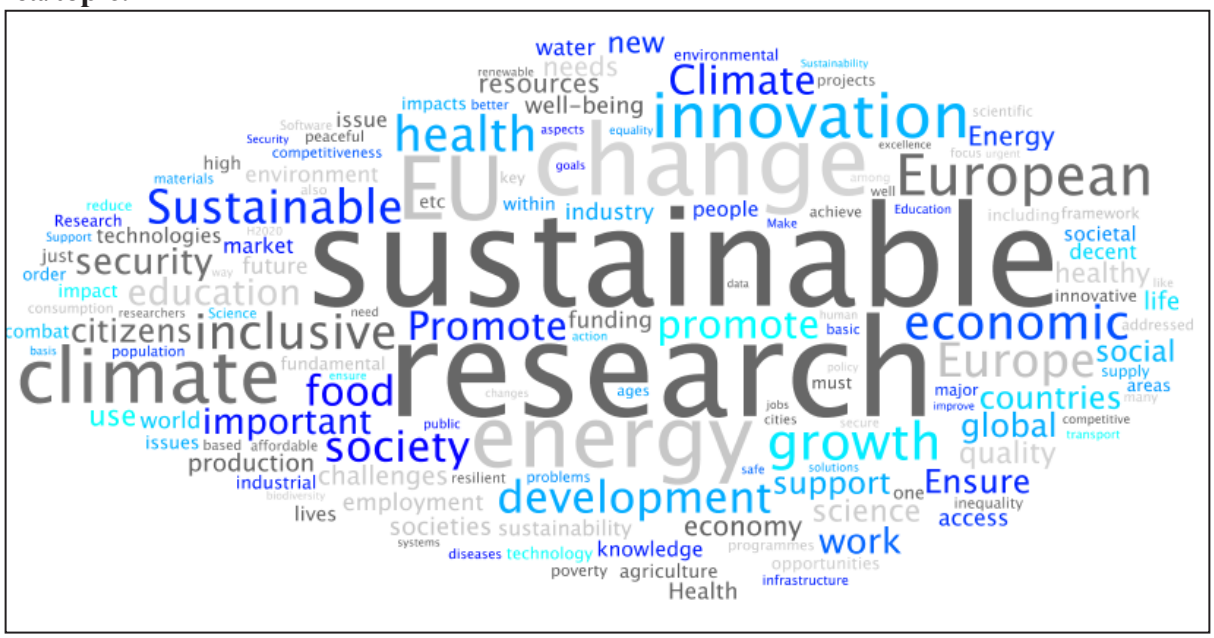
Figure 40 Please choose up to 5 Sustainable Development Goals on which, in your opinion, the future EU framework programmes for research and innovation should focus. Number of respondents per option



Source: Replies to stakeholder consultation questionnaire launched in the framework of the Interim Evaluation of Horizon 2020, October 2016-January 2017, N=2648

Respondents were also asked to state what is for them the most important area/ topic to be addressed by the EU framework programmes for R&I. The results are broadly in line with the above findings. The most frequent words quoted are climate change (190 times), health (188 times), society/ societal (139 times) and social (73 times), inclusive (100 times), growth (99 times), education (87 times), and environment (83 times). The topics of safety (69 times) and security (59 times) also emerge strongly.

Figure 41 In your opinion, what is the most important issue/problem/opportunity to be addressed by the EU framework programmes for research and innovation? Indicate one area/topic.



Wordle®, Source: Replies to stakeholder consultation questionnaire launched in the framework of the Interim Evaluation of Horizon 2020, October 2016-January 2017, N=191

B.8. Position Papers

387 position papers were received as part of the stakeholder consultation exercise. After the first screening and the removal of duplicates and documents that were not addressing the Horizon 2020 programme directly (e.g. promotional material), 296 papers were retained and analysed internally by the European Commission services.

The analysis followed a qualitative method of approach. Based on a sample of 20 position papers, a coding frame of 18 broad themes was constructed. Based on the frame, the European Commission developed a template to ensure a systematic and comparative analysis across the group of officials reading the papers. Each piece of text of every position paper was then categorised under one or more of the 18 broad themes. The final analysis per theme and any emerging sub-themes was conducted by a stakeholder group: academia, research organisations, public authorities, businesses, NGOs, individuals, international stakeholders (i.e. non-EU Member States) and others.

More than 7,000 pages were submitted by stakeholders in the form of position papers.

The figure below shows the most common words used in the analysed stakeholders' input.

Figure 42 Most common words used in the analysed stakeholders' input

Source: Position papers, N=296.

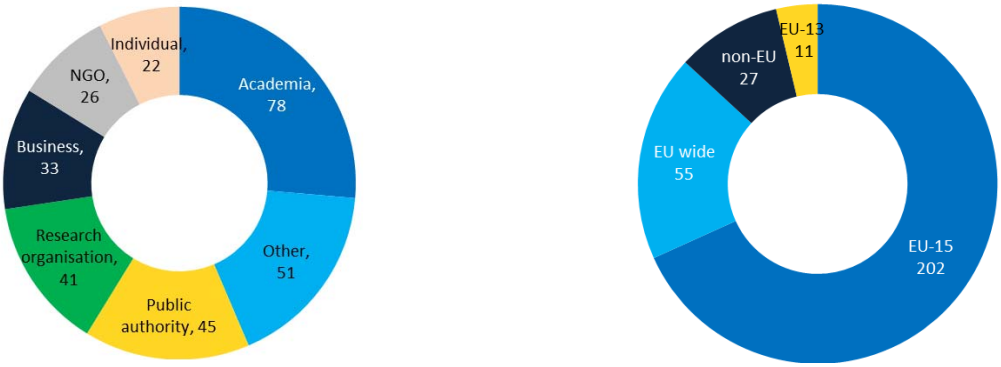
The analysed position papers submitted by stakeholders for the Interim Evaluation of Horizon 2020 include:

- 89 (30%) position papers submitted on behalf of an "umbrella" organisation of EU interest;
- 185 (63%) position papers submitted on behalf of a single institution or a company; and
- 22 (7%) position papers submitted by individuals.

The majority of the position papers were submitted by stakeholders from EU15 countries 68% (202 position papers), whereas from the EU13 only stakeholders from Poland, Estonia and Slovenia submitted their position papers (4%, 11 position papers). 9% (27 position papers) were received from international stakeholders including Norway, Switzerland, Israel, Chile, Turkey, USA and international organisations.

The representation of the position papers according to the stakeholder group (self-reported) and country is provided in figure below.

Figure 43 Overview of stakeholder groups (left) and countries (right) represented in the selected 70 position papers



The remainder of the section summarises main views expressed in position papers with the following structure:

- The role of Horizon 2020 in policy priorities;
- Design of Horizon 2020;
- Implementation of Horizon 2020;
- EU added value;
- Views or recommendations specific to a future European Innovation Council; and
- Overall comments regarding impact, openness (3Os) or excellence.

B.8.1. Role of Horizon 2020 in policy priorities

Horizon 2020 is addressing policy priorities of Europe but there is room to increase programme flexibility.

The majority of stakeholders representing different stakeholder groups commented on the role of Horizon 2020 in policy priorities. More than half of those who commented depict a positive view of the contribution of Horizon 2020 to current policy priorities. For instance, stakeholders note that:

- Horizon 2020 is tackling Europe's current challenges by contributing directly to competitiveness which leads to increased jobs and growth. They wrote that Horizon 2020 is "key", "crucial" and "a step towards" the implementation of the Europe 2020 strategy.
- A few respondents highlighted the contribution of Horizon 2020 to the realisation of the European Research Area (ERA) by funding collaborative research, trans-national infrastructure and mobility.
- Businesses that addressed this point specifically highlighted that the (societal) "challenge driven" research and innovation approach of Horizon 2020 and the fact that the programme covers the whole innovation chain is crucial for a competitive European industry.

- The international stakeholders that addressed this point also mention that Horizon 2020 plays a role that and should be further strengthened in addressing challenges that are of a global nature (i.e contributing to COP21, the UN Agenda for Sustainable Development). Similarly a few research organisations noted that there is a potential for Europe to become a stronger global actor if Europe manages to properly address Sustainable Development Goals or concentrate its research efforts into few/less priorities.

A few stakeholders also commented on the programme's flexibility and stated that improvements are needed mainly regarding Horizon 2020's flexibility with respect to changing priorities. One research organisation noted that the rapid response to emerging areas such as migration, Ebola and Zika is a good practice example of the flexibility of the programme that could be applied to other parts of the programme. An NGO suggested parts of the budget could be reserved for such changing priorities.

B.8.2. Design of Horizon 2020

The current pillar structure improves the clarity of the programme but linkages among the pillars should be enhanced.

Almost half of the stakeholders commented on the current programme structure. Half of those commenting have a positive view of the three pillar structure. They see it as a pragmatic and easy way to clarify the goals of different programme priorities.

Others indicated that the coherence and linkages between activities and projects under the three pillars could be strengthened. In particular, they mentioned a need for better links between the excellent research supported under Pillar 1 and topics in Pillars 2 and 3. To enhance such linkages, one representative of academia, for instance, suggested to extend the principle of ERC proof of concept grants across the entire programme. It was suggested that cross-pillar innovation should be enabled and ensured by the Work Programmes by, for example, giving a preferential score for proposals that build on previous project results.

Grants should remain the primary funding instrument of Horizon 2020. Funding should not divert to loan based financing under the EFSI.

A few stakeholders including those representing academia, research organisations, public authorities, international stakeholders as well as businesses, explicitly stated that grants should remain the primary funding instruments under Horizon 2020. In their opinion:

- Horizon 2020 funding should not be used for loans under the EFSI;

- Not all R&D is viable on a short to medium term despite high potential for long term impacts. Grants are the most suitable government support instruments for risky cutting edge programmes with long term pay back. For instance an industry representative noted that manufacturing companies participate in Horizon 2020 because of their desire to share this risk; and

- Research entities such as academia and research organisations are legally not allowed to take loans.

The programme is complex and there is a need to streamline. Several instruments under Horizon 2020 work particularly well such as the ERC and MSCA grants. Some new instruments could be further improved.

A few stakeholders expressed their concerns about the complexity of the Framework Programme. They believe that the policy mix of the overall programme should be simplified: the number of instruments should be limited, their intervention logic clearly defined, and complementary/synergies with other instruments well stated.

Public authorities that commented on the instruments mainly noted that the collaborative projects and grants were preferred over other types of projects and loans. Some of them had a positive view specifically of instruments bringing together states and regions such as the public-public partnerships, cofund schemes and ERANETs, INNOSUP and MSCA.

Some stakeholders from academia and research organisations also depict a very positive view of the current set of instruments fostering excellent science in particular the ERC and MSCA grants. For instance, a representative from academia wrote that "the ERC is the single most successful EU research funding instrument ever" due to reputational effects and the recognition of bottom-up science.

Furthermore some representatives of the business community specifically commented on the Joint Technology Initiatives (JTIs), Joint Undertaking (JUs) and the contractual Public Private Partnerships (cPPPs). They noted that Horizon 2020 provides a ring-fenced budget to PPPs, JTIs and other industry initiatives which is in particular beneficial for the industries that are represented by, or are a member of, such initiatives. Besides giving access to a reserved budget, these initiatives also enable the respective industries to be closely involved in the definition of the research and innovation priorities of the initiative through the drafting of the Strategic Research Agenda and in the definition of the call topics. The initiatives are seen as promising tools to increase the introduction of a R&D&I application in real markets. Other benefits mentioned are the fruitful collaboration possibilities between the different players in the respective industries (bringing together both SMEs and large companies) and the creation of scientific networks amongst them.

In addition, some SME and business representatives commented on and welcomed the inclusion of innovation activities in Horizon 2020. They see the introduction of the SME Instrument as a good opportunity for high-innovative and market ready SMEs. However, one research organization noted that the SME instrument should be opened up to allow for collaboration with universities.

A few international stakeholders included comments and suggestions regarding the financial instruments, on average being relatively critical and requesting improvements.

Finally, a small number of stakeholders discussed the Seal of Excellence (SoE) initiative[1]. A few stakeholders praised the initiative, whereas others pinpointed the need to review its effectiveness. NCPs in particularly highlighted that the SoE is difficult to put into practice. One of the major obstacles is the state-aid rules and the different funding principles within the Member States.

[1] This quality label is awarded to project proposals which were submitted for funding under Horizon 2020 and have passed stringent selection award criteria but could not be funded due to budget constraints. As such the SoE aims to highlight proposals which deserve funding from alternative sources such as public, private, national, regional, European or international.

Horizon 2020 needs to ensure a good balance between research and innovation support (in Technology Readiness Levels). Concerns are voiced over the perceived increase in the funding of higher TRL levels to the detriment of collaborative lower TRL research.

Almost half of the stakeholders commented on the balance between research and innovation support. The majority of those who commented stated that the programme needs to ensure a good balance between research and innovation. By stakeholder group, the majority of stakeholders from academia, research organisations and public authorities, indicated that currently Horizon 2020 seems to be moving away from funding basic, collaborative and frontier research. They believe there is a need to close the gap in funding lower technology readiness levels (TRL) to create the ground breaking technological foundation for innovation. Only business representatives are positive about the shift towards innovation that took place under Horizon 2020. But still, a few pointed to the current lack of projects at the level of TRLs 3 to 5 under Horizon 2020.

Research organisations that commented on these issues were critical about the emphasis on higher TRLs and the 'unbalanced' relation between basic and applied research funding. They urge the European Commission to keep the number of calls and budget allocated to basic research at the current level. Similarly, academic stakeholders unanimously denounced a shift towards innovation that they do not see as justified for two main reasons: higher TRL research is funded by companies and relies on other forms of finance; and public research grants and funding for 'high TRL' research will result in less disruptive, radical innovation.

More than half of the public authorities commented on the TRL levels. Of those who commented half noted that more support should be given to lower TRLs. Only one Swedish region advocated strongly for higher TRLs e.g. for close-to-market activities.

There is also a clear message from international stakeholders that expressed an opinion that the inclusion of innovation activities in Horizon 2020 (as opposed to the previous Competitiveness and Innovation Programme, which ran from 2007 to 2013 in parallel to FP7) is in the right direction but that it should not be done at the expense of funding for basic research. Therefore, it is requested that the focus be on lower TRL levels, closer to basic research.

Half of the business respondents that expressed a view are positive about the shift towards more innovation funding that took place under Horizon 2020. Still, a few business respondents pointed out the current lack of TRL 3-5 projects under Horizon 2020.

Social science and humanities (SSH) need to be better integrated in the programme design.

Some stakeholders representing different types of organisations mentioned that social science and humanities (SSH) are currently not adequately integrated into the programme specifically in Pillar 2 and 3. Some stakeholders stressed that the SSH have an equal capacity to solve the challenges of society today as the natural sciences. In their opinion, the SSH need to be better integrated into the design of work programmes, into the description of calls and into project evaluation (i.e. ensure at least one evaluator has an SSH expertise). None of the position papers submitted by businesses addressed this issue.

The transnational and multi-sectorial approach for excellent research and innovation is working well.

Some stakeholders including academia, research organisations, public authorities and NGOs commented on the transnational and multi-sector collaborative approach for excellent research and innovation and perceive it as an "attractive" and "successful" method and "the backbone" of Horizon 2020.

A few research organisations that commented on collaborative approaches depict a positive view. For some of them, the links between natural sciences and the human and social sciences seem to be very important. Others highlighted the benefits of research involvement in, for instance, risk detection and development and validation of standards. Similarly, a few public authorities that commented on the interdisciplinary approach in Horizon 2020 noted that it is welcomed and should be continued, even in the case where some participants (e.g. SMEs) may need help to deal with such an approach. Almost half of the NGOs appreciate the integration of the collaboration and several positions from academia remarked on the benefits of collaborative research.

Very few representatives from the business community commented on the topic of collaboration and their opinions differ. On the one hand a few business representatives expressed a positive opinion and the need for collaborative and interdisciplinary projects to bring solutions to societal challenges. On the other hand, few suggested that these large collaborative projects need new tools to manage and to safeguard relationships between partners that are created.

Furthermore, a few international stakeholders mention that the streamlining of international cooperation in Horizon 2020 is not effective and that the participation of third countries in the programme should be enforced.

Stakeholders have different opinions on the degree and appropriateness of their involvement in the design of Horizon 2020.

Some stakeholders commented on the degree of their involvement in the design of Horizon 2020 and its activities, but their opinions differ:

Of those commenting, some stakeholders representing different types of stakeholder groups have a positive view on the current level of involvement and see the agenda-setting process as contributing to a comprehensive and widely-supported programme;

Several others, however, noted that the current design of the Work Programmes is not transparent and that processes vary in different parts of the programme. In general, organisations found the involvement of stakeholders from their particular field to be lacking. For instance, among others, the following issues were highlighted:

Inadequate coordination with the Member States specifically mentioned by Germany and France but also from stakeholders in academia;

Estonia as well as one SME noted that larger players seem to have more influence on the research programme and the call topics; and

A few stakeholders that commented on this issue from industry and the business community noted they are not well represented in the Horizon 2020 projects, working groups, advisory groups and committees (below 20%).

B.8.3. Implementation of Horizon 2020

Oversubscription is one of the most commonly quoted issues of Horizon 2020.

The majority of stakeholders touch upon the issue of oversubscription in Horizon 2020. In general they consider that oversubscription discourages participation, reduces the quality of evaluations, 'wastes' too many resources and leaves a number of high quality proposals unfunded.

Stakeholders proposed a variety of solutions on how to reduce oversubscription rates:

- Increase budget specially for the bottom-up calls to better meet the demand;
- Reduce scope of calls;
- Improve and expand the two-stage proposal procedure with the success rates at the second stage reaching 30% to 50%. Increase the time between the first and the second step so that proposers receive negative feedback before preparing their submission to the second step. Make the first step lighter. Evaluators between the two stages should remain the same to ensure continuity and coherence in the evaluation process. A few respondents noted that the current introduction of a two-stage proposal procedure to manage oversubscription in certain calls is welcomed, but that the process is not selective enough in the first stage.

The quality of current evaluation process of Horizon 2020 calls should improve.

Some stakeholders from academia, research organisations as well as public authorities and business commented on the evaluation process and noted that the quality of the current process should be improved. A variety of issues was highlighted, in particular:

- The Evaluation Summary Reports are reportedly too short and provide generic and not tailored feedback. In particular, applicants would like to receive better feedback in between steps in two-stage procedures. Some stakeholders suggested that a lack of feedback partially caused the oversubscription issue of the programme.
- A few business representatives further noted that the selection rules of expert panels should be clarified and made transparent.

Excellence should remain the main driver of Horizon 2020 and subsequent programmes.

Some stakeholders representing different stakeholder groups underlined that excellence should remain the highest priority and the driving principle of Horizon 2020.

Widening participation is crucial, but should not come at expense of excellence.

Some stakeholders representing different stakeholder groups commented on the need for a more balanced participation of different stakeholders in the Horizon 2020 programme and in general welcomed the "Spreading excellence and widening participation" activities of the programme.

Most commonly, stakeholders mentioned low participation rates of EU-13 countries due to their lower research and innovation capacities. However, there seems to be an agreement that this issue should not be addressed by changing the nature of the current research funding which is based on excellence. Some other solutions were proposed such as:

- Greater use of European Structural and Investment Funds (ESIF) for capacity building in research and innovation or for financial incentives to catch up with research systems;
- Follow-up and opening of the twinning and teaming mechanisms;
- Introduction of a milestone prize mechanism;
- Extension of the ERA Chairs to early stage researchers; and
- Introduction of a bottom-up networking instrument for experienced researchers across Europe.
- Furthermore, a few representatives of research organisations and public authorities noted that more could be done to attract SMEs and newcomers to the programme.

In addition, almost all business respondents stating their opinion on the topic of participation believe that industry is under-represented in Horizon 2020 projects, although they see their participation as essential for turning ideas into value in the market. Furthermore, they noted that among the top-100 beneficiaries of Horizon 2020 funding, few are from the private sector.

Sharp decline in the participation of international partner countries is worrying.

A few organisations from different stakeholder groups are worried about the observed drop in international partners' participation in Horizon 2020 and noted the issue should be addressed strategically.

Some recommended that rules for participation and the regulatory framework should be simplified, for instance through a standard contract with global acceptance and guarantee of IP rights. Others noted that the programme should introduce topics that explicitly flag international collaboration, have a ring-fenced budget or a separate pillar for international collaboration.

In a White Paper[2] submitted to the public consultation, the USA offered some lessons learnt to facilitate international cooperation, based on their own experience. For instance, they note that the programme should further reduce the procedural burden and administrative and bureaucratic requirements for participants, permit a greater range of options for governing law and choice of

[2] United States Feedback on Horizon 2020 and Suggestions for Framework Programme 9, January 19 2017

courts in agreements, limit liability for third parties and allow for secondary recipients of funds to negotiate the terms of their cooperation directly with their European partners.

Information exchange between National Contact Points (NCPs) and the European Commission could improve.

A few stakeholders representing different stakeholder groups noted that information exchange processes between National Contact Points (NCPs)[3] and the European Commission should be strengthened.

According to a few representatives of research organisation, the current quality of NCP services differs. One business representative noted that NCPs need to be better briefed to avoid the submission of irrelevant proposals. This view was also shared by a representative from academia who noted that the quality of communication varies depending on the thematic programme and the Commission Directorate-General. One NCP network made the same observation in its position paper and added that some struggle to get adequate and timely programme information, specifically in relation to externalised programmes such as JTIs.

There needs to be a balance between small, medium and large projects.

Some stakeholders commented on the current project size in Horizon 2020. The majority of those commenting noted that a better balance between small, medium and large projects should be achieved within the programme. However, stakeholders do not seem to agree on what such a balance should look like. For instance, it was noted that the effectiveness of very large size consortia in some projects should be reviewed. At the same time, a few stakeholders noted that larger projects are more efficient. A few others stated that smaller projects allow for higher participation of SMEs and newcomers into the programme and can be as effective as large projects.

Simplification is welcomed but further steps are needed.

Some stakeholders that commented on the simplification measures under Horizon 2020 have a positive view. In particular, they see the Research Participant Portal and shorter time to grant as important improvements.

However, they also noted that further simplification efforts are needed for instance related to preparation and submission of proposals, reimbursement rules, cost declarations and recognition of nationally accepted and audited accounting practices.

B.8.4. EU added value

Horizon 2020 brings an EU added value.

Many different types of stakeholders make comments reflecting the EU added value and the majority of the views depict that Horizon 2020 brings an EU added value through:

[3] The network of National Contact Points is the main structure to provide guidance, practical information and assistance on all aspects of participation in Horizon 2020.

Collaborative cross-sectorial, interdisciplinary and international projects and associated networking effects;

- Faster and large scale implementation which is not possible on national or bilateral level; and
- Scientific excellence.
- Business respondents specifically mentioned the following areas of EU added value:
- Opportunity to leverage financial investment;
- Opportunities for SMEs to globalize through their cooperation with large companies; and
- Access to international/ European supply chain.

B.8.5. EIC specific views or recommendations

The current approach to building up the EIC seems to address the key challenges in innovation support to SMEs.

Some stakeholders from different types of organisations except the NGOs, expressed specific views related to a future European Innovation Council (EIC), an initiative in the making that could encourage breakthrough, market-creating innovation that helps European start-ups grow into world-beating companies.

The majority of those who commented support for the current approach to build up the EIC. In particular, they highlighted:

- An EIC will seem to address the key challenges in innovation support to the best SMEs: bottom-up calls, market creating innovations, face-to-face interviews, access to mentoring and coaching and access to scale-up money;
- A few representatives of the business community noted that the industry should be in the steering board of the EIC to integrate the market and industry vision in the selection of start-ups and to facilitate their future partnership with the manufacturing industry;
- The financial allocation for the EIC should not be detrimental for fundamental research and it should not come from Horizon 2020;
- Both stakeholders from business community and research organisations noted that the EIC should not contribute to a rigorous split between research and innovation. Collaboration among different stakeholders should be encouraged;
- The EIC could function as a 'trademark' similar to the European Research Council; and
- Coherence and complementarity of the EIC with the existing instruments needs to be ensured.

B.8.6. Other comments

More sophisticated measures are needed to monitor impact.

Some stakeholders from different types of organisations commented on the monitoring system and, for the most part, noted that it needs to improve. Most of those commenting believe the current interpretation of programme impact is narrow and too short-term focused and a more "sophisticated" approach should be adopted. Some other stakeholders call for better monitoring of downstream impacts.

A few NGOs in particular stressed a need for better measurement of impact. Similarly, one public authority stressed that the interpretation of impact specifically related to societal challenges should be broader in scope to account for a wide range of effects including social, economic, environmental and cultural.

One business respondent stated that Horizon 2020 and the future Framework Programme should be at the forefront of practice in monitoring, evaluation and impact assessment.

Views on the Open Data initiative diverge.

Some stakeholders commented on the Open Data initiative, on which views diverge:

- Some stakeholders in particular NGOs, research organisations and academia welcome the Open Data initiative and call for greater transparency and open access;

- Yet others including representatives of businesses and industry, but also academia, underline that the new emerging 3Os policy (Open Science, Open Innovation, Open to the World) will need to be flexible to allow industry participation rather than being a disincentive. In particular, open access should not apply by default to research data from private-sector research, nor from public-sector research performed in collaboration with industry.

C. METHODS AND ANALYTICAL MODELS USED

C.1. Main data sources

Contrary to the ex-post evaluation of FP7, the predecessor Programme, the interim evaluation of Horizon 2020 has not been carried out by one external expert group, but has been coordinated by the Evaluation Unit of the Commission's Directorate-General for Research & Innovation, with the support of a Working Group drawn from the services of the R&I family DGs and an Inter-Service Group also comprising other Commission services. The interim evaluation of Horizon 2020 started in 2016 and has been guided by Terms of Reference adopted by the Commission after a vote by the Member States' Programme Committee[4].

It has been based on the following data sources:

- Monitoring reports of Horizon 2020 and statistical data mainly from the Commission's internal IT Tools as well as Eurostat/OECD data;
- Extensive analysis carried out by the responsible Commission services on specific objectives of Horizon 2020 ('thematic assessments'), cross-cutting issues, the Horizon 2020 funding model and various Horizon 2020 instruments/actions (Article 185/187 initiatives, Fast Track to Innovation, SME Instrument EIT). Most internal assessments benefitted from the support from external expert groups/studies as well as dedicated surveys of beneficiaries;
- External horizontal studies covering the entire Horizon 2020 programme on publications and networking ('Elsevier study') based on Scopus data, EU Added Value ('PPMI study') which included a detailed counterfactual analysis and macro-economic modelling and work of a Methodologies Expert Group on relevance and impact using text- and data mining tools;
- Data from other EU Institutions such as the Conclusions on the Interim Evaluation of the Council, work of the ITRE committee of the European Parliament, relevant Court of Auditors' reports and reports/evaluations of the European Economic and Social Committee.

Input from various stakeholder consultations was used to triangulate the findings, in particular the NCP surveys launched in the context of the Horizon 2020 Annual Monitoring reports, the simplification survey, the Call for Ideas on the European Innovation Council and the stakeholder consultation on the Interim Evaluation of Horizon 2020 to which more than 3,500 stakeholders replied and the input received through more than 300 stakeholder position papers.[5]

While detailed descriptions of the models and methods used in the external assessments on which the interim evaluation draws upon are available in each respective external study or report and, in the case of internal assessments, in dedicated sections of this Annex, below is a short overview.

[4] C(2016)5546.

[5] A full analysis of the stakeholder consultation (both the questionnaire and the position papers) is provided in Annex – Part B. The SWD summarised key stakeholder input to dedicated topics. Input received from stakeholders in position papers is highlighted in blue boxes throughout the SWD.

C.2. Overall limitations of the interim evaluation

The main limitation of this interim evaluation concerns its timing: it is taking place only three years after the beginning of Horizon 2020, when most projects have only just started. It is too early to present a complete picture of results and impacts. Whereas for most innovation instruments some effects may be expected in a five-year period, such as an increase in private investment, this period is too short for wider impacts to emerge. Some lower risk actions have many incremental and short term effects – easier to capture and to report on - whereas long term or high risk actions (such as fundamental research) might bear more radical effects in the longer term (e.g. 20-30 years) and have effects more difficult to capture through usual indicator systems (e.g. the general advancement of knowledge).

Limitations include limitations on data availability and measurability of outcomes (for example, most Horizon 2020 indicators focus on input/results but not on impact; in particular the indicators to track progress on the societal challenges are not challenge specific, i.e. they relate to classical outputs from R&I projects - publications, patents, prototypes - but not to their impacts on e.g. decreasing CO2 emissions, improving health of citizen, or their security), aggregation (for example most indicators are collected for specific programme parts only and not for the whole programme and monitoring data covering the entire programme comes from various data sources, which are difficult to aggregate) and reliability of certain monitoring data (for example data on patents and publications are based on self-reporting by project coordinators; data on the cross-cutting issues gender and social sciences and humanities is based on flagging by project officers). It has not always been possible to validate findings from external studies/expert groups, for example through a peer-review of macro-econometric modelling results.

Another limitation is the lack of benchmarks to compare performance. Worldwide there is no programme similar to Horizon 2020 in terms of size, thematic coverage and depth: the EU Framework Programmes are rather unique in their form, covering R&I aspects from fundamental research to close-to-market innovation, from programmed topics in specific thematic areas to fully bottom-up blue-sky science. Also, the R&I performance of countries is influenced by many other factors than Horizon 2020 only. The performance of Horizon 2020 should thus be seen in the context of its role in the wider R&I support system in particular as regards its positioning against (and impact on) the national and regional policy initiatives.

As regards the stakeholder consultation, the views represented by the respondents are not random and representative of the EU population due to self-selection bias. In addition, whereas qualitative data and analysis enabled a deeper look into the areas of the consultation, the methods are very prone to bias. An attempt was made to minimise such bias with the use of a word cloud function and a coding frame.

To overcome/mitigate these limitations, the interim evaluation is transparent in indicating its data sources and all underlying data sources are made publicly available. The analysis of the evidence by Commission services has allowed identifying data availability/quality problems that could already be overcome over the course of the evaluation. Conclusions are drawn based on the systematic triangulation of evidence from various data sources. All evaluation results have been systematically checked against input from stakeholders. Whenever possible (i.e. in the case of the analysis of participation patterns), FP7 was used as a benchmark.

C.3. Monitoring data

The Horizon 2020 Interim Evaluation focuses on the implementation of Horizon 2020 from 1 January 2014 to 1 January 2017. It follows the approach of reporting as implemented in the Annual Monitoring Reports[6]. The included data is based on data collected directly from the Common Research Data Warehouse (CORDA) Portal, using Commission's internal reporting tools provided by the Common Support Centre in the Directorate-General for Research and Innovation (DG RTD).

The scope of the Staff Working Document includes all calls with a closure deadline on and grants signed by 1 January 2017. It includes grants to named beneficiaries under Horizon 2020 (and under Euratom, unless specifically stated). The overall report includes 1-stage calls and second stage in 2-stage calls, producing results aggregated at programme's part level. It includes calls from the Work Programmes of the Public-Private Partnerships (PPPs, Joint Undertakings), while data on Public-Public Partnership (P2Ps) is collected separately but excluded from the overall calculation. Special analysis has been made on 1 stage of 2-stage proposals. Calls from the Innovative Medicines Initiative (IMI2) Joint Undertaking are not accounted for because IMI2 is not currently integrated in the CORDA database, while three calls from Clean Sky 2 (CS2) Joint Undertaking are excluded since full integration to CORDA is to be finally implemented: nonetheless, available figures regarding the implementation of IMI2 and CS2 are provided in a dedicated annex on Funding for PPPs and P2Ps.

The horizontal analysis in the Staff Working Document does not include data on European Institute of Innovation and Technology (EIT)'s Knowledge and Innovation Communities (KICs), however statistics on the EIT are presented separately in Section K of this annex, but excluded from the overall calculation. Direct actions from the Joint Research Centre are also excluded. Calls belonging to the Research Fund for Coal and Steel do not belong to Horizon 2020, therefore are outside the scope of this Staff Working Document. Regarding some specific types of action, the Framework Partnership Agreements (FPA) are excluded because there are no grants associated to them, while prizes are reported separately where appropriate.

The statistics on applications and proposals excludes 2,063 non-eligible proposals (ex. duplicates, withdrawals, inadmissible, etc.), which represent 2% of the total number of proposals submitted, while statistics on participations and projects are also based on grants agreements signed before 1 January 2017. Calculations regarding participants are limited to beneficiaries who are signatories to the grant agreement, thus being real consortia members. Other categories of participants, such as "Third Parties", "Partner Organisations" or others do not receive funding directly from the EU, but indirectly from the beneficiaries, and are not computed in the horizontal analysis.

Differences in reimbursement of indirect costs under Horizon 2020 imply, that beneficiaries no longer report the real indirect project costs (i.e. under Horizon 2020 indirect costs are calculated automatically as a share of direct costs). As a result, the reported total project cost to the Commission under the Horizon 2020 programme is lower than the actual total project cost. To allow a comparison of co-funding rates between Horizon 2020 and FP7 at programme level, the indirect costs in Horizon 2020 were estimated for all beneficiaries of Research and Innovation

[6] Annual Monitoring Reports 2014 and 2015: https://ec.europa.eu/research/evaluations/index_en.cfm?pg=monitoring

Actions (RIA) and Innovation Actions (IA) on the basis of the ratio between the real indirect and direct costs for participants in FP7 collaborative projects[7].

The interim evaluation of Horizon 2020 includes statistics related to outputs of funded projects, in particular publications, patent applications and patent awarded. It should be noted that output data is collected through the continuous project reporting made by beneficiaries under their own responsibility. At this early stage of data reporting, no systematic data quality check has been performed by the Commission services, hence data on publications and patents is solely based on self-declarations of project coordinators.

C.4. The economic impact and the European added value of the programme

Several of the **quantifications of European Added Value** in this interim evaluation are drawn from a study[8] that performed a counterfactual analysis (based on a regression discontinuity and propensity matching) of FP7 top-scoring applicants who happened to be just above and below the funding threshold. This FP7 evidence is corroborated in the study with a survey of a sample of Horizon 2020 beneficiaries (for which not enough time has elapsed to carry out the same analysis) and several in-depth case studies of European Added Value.

Within the same study, macro-econometric simulations based on the NEMESIS[9] model were used to assess the **economic impact** of the Framework Programmes. The simulations estimated the contribution of FP7 and Horizon 2020 to growth and jobs on the basis of the difference between the EU economic performance with and without the implementation of the Framework Programmes. In the context of this study, the reference scenario was based on the assumption that, at the end of the respective predecessor programme, FP7 and Horizon 2020 would have not existed. The reference scenario is based on the extrapolation of past trends and different forecasts at medium and long term, notably the EPC/DG ECFIN Ageing Report.[10]

It should be recalled that a similar assessment was done in the context of the ex-ante Impact Assessment of Horizon 2020[11], in which four options were analysed reflecting different situations: business as usual (mainly continuing FP7), Horizon 2020 (more focused, innovation oriented programme), renationalisation (lower MS contribution to EU budget, increased MS R&I budget) and Framework Programme discontinuation (gradual decrease in total GBAORD). The later was assimilated to the cost of non-Europe. The main differences between scenarios were the amount and evolution of the European contribution through the Framework programme (EC contribution), national investments in R&I, type of research (basic, applied), sectoral allocation of funding, crowding-in and multipliers for national and EU R&I funding as well as spill-overs (intersectoral, international). The coefficients used in the scenarios were based either on academic literature or on deductions and analogies reflecting the implementation logic and programme structure.

The key parameters of the simulations are the following:

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[7] The methodology identifies a coefficient (funding intensity) for each type of organisations (distinguishing SMEs and large entities) calculated as the real indirect cost/direct cost (IC/DC) ratio for FP7 collaborative projects. The coefficient is then applied to the equivalent types of organisations in Horizon 2020 RIA and IA projects and multiplied to their direct cost.

[8] PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming

[9] http://www.erasme-team.eu/modele-economique-econometrie-nemesis-vp14.html

[10] http://ec.europa.eu/economy_finance/publications/european_economy/2014/pdf/ee8_en.pdf

[11] http://ec.europa.eu/research/horizon2020/pdf/proposals/horizon_2020_impact_assessment_report.pdf#view=fit&pagemode=none

- Reference scenario: in the ex-ante Impact Assessment, the business as usual scenario was used as benchmark for the comparisons, while for the Interim Evaluation the reference scenario is based on the discontinuation of the Framework Programme.

- Actual allocation by country: while in the ex-ante Impact Assessment, the EC contribution to Member States was based on projections of FP7 data, in the Interim Evaluation the analysis was based on a real allocation of Horizon 2020 funds during the first years of Horizon 2020 (grants signed by 1 August 2016) and then projected for the remaining years of Horizon 2020 implementation.

- Crowding in factors: while it is not possible to identify the real indirect leverage of the programme (i.e. the additional venture capital or public/private investments that project results are able to attract), this is estimated on the basis of the assumption that the elasticity of R&D intensity is constant with respect to the output of the sector. Therefore, it is a function of the direct crowding-in coefficients: they were calculated as the contribution by the type of actor to the total costs of the projects. Different estimates were established for basic (mainly pillar 1) and applied research (pillars 2 and 3) as well as for private and non-private beneficiaries. Different values for crowding-in factors were used in the sensitivity analysis: in the pessimistic scenario, the crowding-in factor was calculated on the basis of Corda data and it resulted in EUR 0.16 per each EUR of EU contribution; in the optimistic scenario, the crowding-in was estimated on the basis of a methodology to calculate real indirect project costs, which beneficiaries no longer report in Horizon 2020 and it resulted in EUR 0.40 per each EUR of EU contribution.

- Multipliers: for the study, a standard assumption used is that the European Framework Programmes are 15% more efficient than national research activities. This value was reinforced by a counter-factual analysis, which found that this figure is relatively conservative considering the European Added Value of Framework Programmes. A sensitivity analysis was carried out with the assumptions that the EU economic performance is equivalent (0%) or higher (21%) compared to that of national research activities: the economic impacts vary within the range of about 10% to 12%.

- Sectoral allocation of funds: given that in Horizon 2020, data regarding NACE codes are not systematically collected at participant level, the sectoral allocation (which is important to establish how the EU funds are distributed at sectoral level in the Member States) is based on FP7 Corda data (grandfathering principle). These data correlate well with the Eurostat BERD (2014) sectoral allocation, therefore the FP7 sectoral allocation can be considered still relevant.

C.5. Analysis of participation and publication networks, including interdisciplinarity

Collaboration patterns were explored using two different approaches: through the analysis of projects' participation networks and through the analysis of publications from projects funded through the Framework Programme.

The analysis of projects' participation networks at institution type, sector or country level is based on projects' participations as of 1 January 2017. The networks have been mapeed using

the Tool for Innovation Monitoring run by the Joint Research Centre[12], an interface tool for collaboration mapping, which is, based on data from EU Open Data Portal[13].

As regards the analysis of interdisciplinarity scientific publications, an external study[14] analysed the EU-funded publication output of both FP7 and Horizon 2020 through a citation-based analysis. The basic principle of this approach is that an article is going to be interdisciplinary if it cites papers that are 'far away' from each other in terms of the similarity of the journals they appear in (based on how often those journals are cited together in a certain period). On the other hand, if it cites papers in journals that are cited together very frequently, it is likely to be a mono-disciplinary article. By thus focusing on the outcomes of research (i.e. journal publications and citations), this approach does not take into consideration the underlying processes of knowledge integration in cross-disciplinary research (research teams whose members have a variety of disciplinary backgrounds). It also takes into consideration that the research landscape is dynamic: what is considered interdisciplinary today may be disciplinary tomorrow.

Indicators used for this analysis are:

- **Institutional, national and international collaboration:** all authors are from the same institution (Institutional collaboration), authors are affiliated with at least two institutions within a country (National collaboration), at least one author is from an institution outside of the country (International collaboration), single-authored publications are used as a benchmark. The indicators include for each type of collaboration: Absolute numbers, Share relative to country/institution's output and growth expressed by CAGR (Compound Annual Growth Rate).

- **Inter-geographical dimension collaboration:** international collaboration counts between members of the geographical dimension.

- **Collaboration networks:** the more intensive the collaboration, the more closely the two countries/institutions are plotted to each other on a collaboration network map.

- **Interdisciplinary research publications:** interdisciplinary research output as measured by volume of publications (i.e. articles, reviews and conference proceedings). This indicator includes: absolute numbers of interdisciplinary research output; interdisciplinary research output growth per year as compound annual growth rate (used to identify the trend in the volume of interdisciplinary research publications).

- **Field Weighted Citation Impact[15] (FWCI) of interdisciplinary research publications:** this is a widely recognized proxy for research quality which normalizes the citations received using the world benchmark of citations received in the same subject area, by publications

[12] http://test.technologymonitoring.eu/TimCordis/main.jsp
[13] https://data.europa.eu/euodp/en/data/dataset/cordisHorizon 2020projects
[14] Elsevier, Study on overall output of select geographical group comparators and related FP7- and Horizon 2020-funded publication output, forthcoming
[15] Field-weighted citation impact (FWCI) is an indicator of mean citation impact, and compares the actual number of citations received by an article with the expected number of citations for articles of the same document type (article, review or conference proceeding paper), publication year and subject field. When an article is classified in two or more subject fields, the harmonic mean of the actual and expected citation rates is used. The indicator is therefore always defined with reference to a global baseline of 1.0 and intrinsically accounts for differences in citation accrual over time, differences in citation rates for different document types (reviews typically attract more citations than research articles, for example) as well as subject-specific differences in citation frequencies overall and over time and document types. It is one of the most sophisticated indicators in the modern bibliometric toolkit.

published in the same year and with the same document type (e.g., articles, reviews and conference proceedings). The indicators include for each type of collaboration: Absolute numbers Share relative to country/institution's output growth expressed by compound annual growth rate.

C.6. Stakeholder consultation

The stakeholder consultation on the interim evaluation of Horizon 2020 was based on an online questionnaire and the submission of position papers.

The online questionnaire included 25 questions and several sub-questions. The majority of the questions were of a closed type, but there were also 8 open questions where the respondents had an opportunity to elaborate on their views. In total the Commission received 3,483 responses to the questionnaire. Basic analysis of closed questions was performed by stakeholder groups to explore differences in opinion between different stakeholders. The affiliations of respondents (e.g. SME, academia, public authority) are self-reported, and were not verified. The analysis of the open questions followed a qualitative method of approach. The questions were analysed either with the use of basic qualitative analysis (i.e. grouping respondents into broad stakeholder groups and reading the responses to get an overview of the key themes) or with the use of word cloud function (the function is used to indicate the most frequently used words in the qualitative responses and present the results graphically).

In addition to the online questionnaire, 386 position papers were received as part of the stakeholder consultation exercise, After the compilation of all the position papers and the first screening and the removal of duplicates, campaigns and documents that were not addressing the Horizon 2020 programme directly (e.g. promotion material), 295 papers were analysed internally by the Commission services. Those position papers are also published on the interim evaluation website. The analysis followed a qualitative method of approach. Based on a sample of position papers, a coding frame of broad themes was constructed. The final analysis per theme and any emerging sub-themes was conducted by stakeholder group: academia, research organisations, public authorities, businesses, NGOs, individuals, international stakeholders (i.e. non-EU Member States) and others.

C.7. Estimation of the costs of writing proposals

In order to evaluate the cost of the programme, not only the expenses held by the European Commission and its executive agencies should be included. In the first three years of Horizon 2020 about 74,769 distinct universities, private companies, research organisations, public entities and others have applied for Horizon 2020 funding. The expenses related to processes on writing, coordinating consortia and administrative questions vary greatly on the types of proposal, single beneficiary vs. collaborative projects, salary level of participants involved, administrative support needed etc.

Competition is an essential element of the scientific life, inextricably linked to cooperation and openness. Researchers are therefore expected to apply for and compete for research funding, including from the EU framework programmes as a part of their day to day jobs. Studies have shown that depending on their age and position researchers spend between 5 – 10% of their time applying for research funding.[16] A study on the effects of participating in a project under the

[16] E.g. see page 15 http://www.eui.eu/Documents/MWP/Publications/20111012MWP-ACOSurveyResearchFunding-Full.pdf

Framework programme (FP) from a human resource perspective showed that researchers that participate in FPs strengthen almost all skills and capacities.[17] Another study suggested that the simplification efforts implemented in FP7 compared to FP6 had saved each participant EUR 8 668[18]. In 2015 the Commission launched an online survey on the perception of the simplification measures by stakeholders, addressed to all beneficiaries in ongoing Horizon 2020 grants. The results cover the first 20 months of Horizon 2020 implementation and were published on 30 May 2016. In total 4,185 beneficiaries responded. 75% of those respondents with experience in FP7 and Horizon 2020, confirmed that, overall, the processes in Horizon 2020 are much simpler than in FP7. The survey looked at the time spent on preparing proposals:

- For coordinators in a multi-partner project 52.3% of the respondents say that they spend more than 30 days, 32% stated that they spent between 15-30 days preparing a proposal.

- For partners in multi-partner projects 14.3% spend more than 30 days, 52.6% that they spend between 15 and 30 days.

- For single beneficiary projects (non SMEs) 19.3% state they spend more than 30 days, and 60.4% between 15 and 30 days.

- For the SMEs in mono-partnered projects 59.8% state that they spend more than 16 days and 27.7% say that they spend less than 15 person days. [19]

The European University Association (EUA) states that these numbers are in line with costs reported by their members. EUA estimates the cost per proposal to range from EUR 10 000 to 100 000 and applies these numbers to the overall proposals numbers and numbers of retained proposals in the first year of Horizon 2020 to calculate the cost of unfunded projects: between EUR 268 million and EUR 2.68 billion[20].

Based on these studies, a rough estimation was made by Commission services, based on a division of four levels of average estimated expenses depending on the complexity of the proposals from EUR 5 000 for phase/stage 1 proposals (stage 1 not included in the EUA assessment), EUR 10 000 for single beneficiary smaller proposals, EUR 20 000 for medium size collaborative proposals and more complex single beneficiary proposals and finally EUR 50 000 for large collaborative proposals. The calculations account for resubmission for bottom-up calls.[21] The estimation shows that the share of Horizon 2020 funding spent on proposal writing is 8.4% in the first three years of Horizon 2020. This is roughly EUR 1.9 billion or EUR 633 million annually. In total EUR 1.7 billion is spent on proposals that are not funded. Out of this, the expense of writing high quality proposals that are not funded is estimated at EUR 643 million. Further details on this assessment are provided in the table below.

[17] Study on assessing the contribution of the framework programmes to the development of human research capacity: http://ec.europa.eu/research/evaluations/pdf/archive/other_reports_studies_and_documents/fp_hrc_study_final_report.pdf
[18] Budgetary impact of the changes in the cost calculation regime in FP7 (EC and Euratom) as compared to FP6 (EC and Euratom) and its effects on the administrative burden for participant: https://ec.europa.eu/research/evaluations/pdf/archive/other_reports_studies_and_documents/budgetary_impact_fp6-fp7.pdf
[19] Report on the Horizon 2020 Simplification Survey, page 20. http://ec.europa.eu/research/participants/data/ref/h2020/other/events/survey/h2020_simplification-survey_final-report_en.pdf
[20] EUA MEMBER CONSULTATION A CONTRIBUTION TO THE HORIZON 2020 MID-TERM REVIEW, page 32 http://www.eua.be/Libraries/publications-homepage-list/eua-membership-consultation-2016-a-contribution-to-the-horizon-2020-mid-term-review.pdf?sfvrsn=4
[21] From 2014-2016: MSCA-ITN 42.9%, MSCA-IF 15.4%, MSCA-RISE 27.9%, ERC 27%. SME-instrument 40%

Table 2 Estimation of proposal writing costs

*Full number of proposals / excluding resubmission	Number of eligible proposals	Number of high-quality proposals	Number of retained proposals	EU funding to retained proposals (EUR million)	Cost of writing all propo-sals (EUR million)	Cost of writing non-funded proposals (EUR million)	Cost of writing non-funded high-quality proposals	Share of funding spent on proposal writing
High expense level: EUR 50 000 Instruments included: RIA and IA COFUND-EJP/PCP/PPI/ERA.NET	22338 / 22267	10246 /10189	2643 / 2616	13870.7	1113.4	982.6	378.7	**8.0%**
Medium expense level: EUR 20 000 Instruments included: CSA, ERC ADG/COG/LVG/ POC/STG, MSCA Cofund/ITN/RISE	32849 / 24571.7	15182 / 11176	4587 / 3621	7451.6	491.4	419.0	151.1	**6.6%**
Low expense level: EUR 10 000 Instruments included: MSCA-IF and SME-2	24737 / 18774	16706 / 13235	2973 / 2397	1244.9	187.7	163.8	108.4	**15.1%**
Very low expense level: EUR 5000 SME-1	22152 /13291	3498 / 2099	1864 /1118	93.2	66.5	60.8	4.9[22]	**22.3%**
Stage 1 applications in two stage applications (not included in total number of eligible proposals)	(10001)	(3203)	(3100)	N/A	50.0	N/A	N/A	**N/A**
Total	102076	45632	12067	22660.5	**1908.7**	**1661.5**	**643.0**	**8.4%**

Source: CORDA, Signed Grants cut-off date by 1/1/2017 (calculating cost, excludes resubmissions)

C.8. Text mining on the relevance of the programme

A dedicated expert group appointed by the European Commission on evaluation methodologies for the interim and ex-post evaluations of the Framework programmes[23] developed and applied several methodologies to investigate the relevance of Horizon 2020. This was primarily done by comparing the degree of matching between keywords extracted from the establishing act and the

[22] No including stage 1proposals
[23] European Commission Expert group on evaluation methodologies for the interim and ex-post evaluations of Horizon 2020, Applying relevance-assessement methodologies to Horizon 2020 (forthcoming report).

work programmes against keywords extracted from international and EU policy documents, social media, and patents and publications.
The assessment of relevance was defined as the process determining whether the original objectives of the Framework Programme are still relevant and how well they still correspond to present needs and challenges. The analysis was structured around three basic questions concerning the institutional perspective, the citizens' perspective, and the scientific and technological perspective:

- Is the programme in line with EU and International priorities?
- Is Horizon 2020 in line with the needs of EU citizens?
- How well adapted is Horizon 2020 to the subsequent technological or scientific advances?

These questions guided the development of four methodologies for the assessment of the relevance: an expert exploratory approach using computer-based content; an expert exploratory approach using human-based content; a text mining approach; and a social media approach.

When applied to Horizon 2020, the following texts were considered as the basis for keyword matching:

- Council Decision of 3 December 2013 establishing the specific programme implementing Horizon 2020 - (2013/743/EU);
- The 2014 – 2015 Horizon 2020 Work Programme;
- The 2016 – 2017 Horizon 2020 Work Programme.

The following texts were used to identify relevant keywords for the EU and International priorities:

- European Commission (2010). Europe 2020, A strategy for smart, sustainable and inclusive growth, Communication from the Commission, Brussels, COM (2010) 2020 final.
- Juncker, J.-C. (2014). A New Start for Europe: My Agenda for Jobs, Growth, Fairness and Democratic Change. Political Guidelines for the next European Commission. Opening Statement in the European Parliament Plenary Session. Strasbourg, 15 July 2014.
- European Commission (2015). Communication from the Commission to the European Parliament and the Council, The Paris Protocol – A blueprint for tackling global climate change beyond 2020. /COM/2015/081 final/2. Brussels, 4.3.2015.
- Gurría, A. (2015). "21-21": A Proposal for Consolidation and Further Transformation of the OECD.
- United Nations, General Assembly, Seventieth session. (2015). Transforming Our World: The 2030 Agenda for Sustainable Development (A/RES/70/1).

- World Health Organisation (2015). Health in 2015: from MDGs, Millennium Development Goals to SDGs, Sustainable Development Goals. ISBN 978 92 4 156511 0. World Health Organization 2015.

- G7 Leaders (2016). G7 Ise-Shima Leaders' Declaration, G7 Ise-Shima Summit, 26-27 May 2016.

Several social media sources were used to identify the needs of EU citizens: Twitter, Facebook, Wikipedia and YouTube.

In order to assess keywords relevant for subsequent technological and scientific advances, the analysis used Google Scholar.

D. MONITORING DATA ON HORIZON 2020 STATE OF IMPLEMENTATION

D.1. Overall

Table 3 Overall proposal and project data

	Number	Applications	Applicants	EU Contribution Requested (EUR million)
Eligible Proposals	102076	379169	74769	172748.1
High Quality Proposals	45632	203308	41161	85006.1
Retained Proposals	12067	54466	19233	22660.5
	Number	**Participations**	**Participants**	**EU Contribution allocated (EUR million)**
Signed Grants	11108	49090	16679	20400.1

Source: CORDA, cut-off date by 1/1/2017 (including grants to named beneficiaries)

D.2. Type of organisations

Table 4 Summary table of applications per type of organisation

	Applicants	Applications	Success rate of applications	Newcomer applicants	Newcomer applications
Universities (HES)	5022	140900	12.3%	3024	7973
Other (OTH)	5376	14492	19.2%	4309	8460
Private Sector (PRC)	55296	141880	13.0%	46034	84462
Public Bodies (PUB)	3925	13551	24.8%	2815	5480
Research Organisations (REC)	5150	68346	17.0%	2464	5341
(SME's)	35288	99434	12.0%	28551	58646
Total	74769	379169	14.1%	58646	111716

Source: Corda, cut-off date by 1/1/2017 (including grants to named beneficiaries, success rate is calculated excluding grants to named beneficiaries

Table 5 Summary of participations table by type of organisation

	Participants	Participations	Nr of Projects Coordinators in Signed Grants	EU contribution (EUR million)	Newcomer participants	Share of newcomer participants	Average participation per participant	Average EU contribution per participant (EUR million)
Universities (HES)	1421	16153	5266	7840.2	205	14.4%	11.4	5.5
Other (OTH)	1593	2599	211	689.2	1057	66.4%	1.6	0.4
Private Sector (PRC)	10367	16298	3017	5653.5	6352	61.3%	1.6	0.5
Public Bodies (PUB)	1315	3090	225	804.2	668	50.8%	2.4	0.6
Research Organisations	1983	10950	2389	5413.0	408	20.6%	5.5	2.7
(SME's)	6979	10147	2625	3270.3	4291	61.5%	1.5	0.5
Total	**16679**	**49090**	**11108**	**20400.1**	**8690**	**52.1%**	**2.9**	**1.2**

Source: Corda, cut-off date by 1/1/2017 (including grants to named beneficiaries)

D.3. Per programme part

Table 6 Proposals and success rates per programme part

	Number of eligible proposals received	Number of high Quality Proposals	Success rate proposals	EC Funding requested in eligible proposals	Success rate funding
Excellent Science	48128	27832	12.9%	71977.6	10.9%
European Research Council (ERC)	22832	8394	12.1%	40255.4	11.4%
Future and Emerging Technologies (FET)	3199	1506	4.1%	11133.7	4.7%
Marie-Skłodowska-Curie Actions (MSCA)	21644	17592	14.9%	18290	10.6%
Research Infrastructures (RI)	453	340	29.7%	2298.5	33.9%
Industrial Leadership	20436	6549	9.7%	34308.7	17.8%
Leadership in Enabling and Industrial Technologies (LEIT)	19746	6031	8.9%	33684.3	13.7%
Information and Communication Technologies	12772	3867	8.1%	21334.1	13.4%
NMBP[24]	5640	1493	9.2%	10455	13.7%
Space	1334	671	15.7%	1895.2	17.5%
Access to Risk Finance (ARF)	47	21	7.0%	79.2	9.3%
Innovation in SMEs	643	497	43.5%	545.2	15.3%
(The SME Instrument[25])	30901	7145	7.6%	15462.1	5.7%
Societal Challenges	29865	9819	11.1%	58873.8	14.7%
Health, demographic change and wellbeing (SC1)	6461	1928	9.1%	17912.6	9.0%
Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy (SC2)	3489	1233	13.0%	6424.3	19.5%
Secure, clean and efficient energy (SC3)	5824	1515	11.6%	11688.8	15.7%
Smart, green and integrated transport (SC4)	4507	1766	18.0%	6280.7	30.6%
Climate action, environment, resource efficiency and raw materials (SC5)	3765	1216	10.0%	5810.8	18.9%
Europe in a changing world - inclusive, innovative and reflective societies (SC6)	3653	1221	5.4%	4953.1	6.6%
Secure societies protecting freedom and security of Europe and its citizens (SC7)	2166	940	9.9%	5803.5	10.1%
Spreading excellence and widening participation (SEWP)	826	487	14.3%	1281.1	20.5%
Science with and for Society (SWAFS)	771	414	9.0%	1540.2	9.5%
Euratom	67	56	33.3%	688.3	37.6%
Pilot: Fast-track to Innovation	1983	475	4.7%	4078.3	4.9%
TOTAL HORIZON 2020	102076	45632	11.6%	172748.1	12.7%

Source: CORDA, cut-off date by 1/1/2017 (including grants to named beneficiaries, except for calculation of success rates)

[24] NMBP stands for Nanotechnologies, Advanced materials, Biotechnology and Advanced manufacturing and processing.
[25] The figures are presented within brackets because, while belonging to the Innovation in SMEs Programme Part in the legal basis, the SME Instrument is implemented in both Industrial Leadership and Societal Challenges.

Table 7 Number of signed grants and EU Contribution to signed grants per programme's part

	Number of signed grants	Share in total signed grants	EU contribution to signed grants (EUR million)	Share in total EU contribution to signed grants	Project total cost	Time to grant in days	Share of grants signed within 8 months	Budget (EUR million)[26]	Share of budget allocated
Excellent Science	5964	53.7%	7514.4	36.8%	7856.3	208.8	90.3%	24232.1	31.0%
European Research Council (ERC)	2440	22.0%	3874.2	19.0%	3879.5	377.8	8.0%	13094.8	29.6%
Future and Emerging Technologies (FET)	129	1.2%	654.4	3.2%	701.6	230.3	96.9%	2585.4	25.3%
Marie-Skłodowska-Curie Actions (MSCA)	3246	29.2%	2114.9	10.4%	2303.9	280.5	91.1%	6162.3	34.3%
Research Infrastructures (RI)	149	1.3%	870.9	4.3%	971.3	264.1	67.6%	2389.6	36.4%
Industrial Leadership	1933	17.4%	4539.9	22.3%	6139.7	177.2	95.1%	16466.5	27.6%
Leadership in Enabling & Industrial Technologies (LEIT)	1728	15.6%	4462.2	21.9%	6058.7	175.3	96.3%	13035	34.2%
Information and Communication Technologies	1005	9.0%	2600.6	12.7%	3828.2	174.3	97.0%	7423	35.0%
NMBP[27]	512	4.6%	1505.3	7.4%	1823.4	154.9	98.2%	4242	35.5%
Space	211	1.9%	356.3	1.7%	407.1	182.3	88.3%	1403	25.4%
Access to Risk Finance (ARF)	7	0.1%	7.9	0.0%	8	272.5	0.0%	2842.3[28]	-
Innovation in SMEs	198	1.8%	69.8	0.3%	73	242.4	55.3%	589.2[29]	-
(The SME Instrument[30])	2090	18.8%	781.7	3.8%	1087.5	112.8	98.9%	-[31]	-
Societal Challenges	2941	26.5%	7351.5	36.0%	9693.2	177.9	92.3%	28629.6	25.7%

[26] http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32015R1017&from=EN
[27] NMBP stands for Nanotechnologies, Advanced materials, Biotechnology and Advanced manufacturing and processing.
[28] Around EUR 994 million of this amount may go towards the implementation of the Strategic Energy Technology Plan (SET Plan) projects. Around one third of this may go to SMEs.
29 Within the target of allocating a minimum of 20 % of the total combined budgets for the specific objective "Leadership in enabling and industrial technologies" and the priority "Societal challenges" for SMEs, a minimum of 5 % of those combined budgets will be initially allocated to the dedicated SME instrument. A minimum of 7 % of the total budgets of the specific objective "Leadership in enabling and industrial technologies" and the priority "Societal challenges" will be allocated to the dedicated SME instrument averaged over the duration of Horizon 2020.
[30] The figures are presented withing brackets because, while belonging to the Innovation in SMEs Programme Part in the legal basis, the SME Instrument is implemented in both Industrial Leadership and Societal Challenges.
31 Within the target of allocating a minimum of 20% of the total combined budgets for the specific objective "Leadership in enabling and industrial technologies" (LEIT) and the priority "Societal challenges" for SMEs, a minimum of 5% of those combined budgets will be initially allocated to the dedicated SME instrument. A minimum of 7% of the total budgets of the specific objective LEIT and the priority "Societal challenges" will be allocated to the dedicated SME instrument averaged over the duration of Horizon 2020.

Health, demographic change and wellbeing (SC1)	570	5.1%	1705.8	8.4%	2010.5	160.8	96.8%	7256.7	23.5%
Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy (SC2)	365	3.3%	832.1	4.1%	1082.3	157.6	97.0%	3707.7	22.4%
Secure, clean and efficient energy (SC3)	640	5.8%	1735.2	8.5%	2333.7	179.2	94.2%	5688.1	30.5%
Smart, green and integrated transport (SC4)	655	5.9%	1376.8	6.7%	2152.4	192.3	86.4%	6149.4	22.4%
Climate action, environment, resource efficiency and raw materials (SC5)	340	3.1%	912.6	4.5%	1202.8	161.9	93.5%	2956.5	30.9%
Europe in a changing world - inclusive, innovative and reflective societies (SC6)	194	1.7%	342.1	1.7%	411.6	187.2	85.0%	1258.5	27.2%
Secure societies protecting freedom and security of Europe and its citizens (SC7)	177	1.6%	446.9	2.2%	499.9	209.1	88.6%	1612.7	27.7%
Spreading excellence and widening participation (SEWP)	118	1.1%	209.1	1.0%	213.7	233.9	91.3%	816.5	25.6%
Science with and for Society (SWAFS)	53	0.5%	108.9	0.5%	112.5	267.4	52.1%	444.9	24.5%
Euratom	24	0.2%	514.9	2.5%	989.4	278.1	65.2%	-	-
Fast-track to Innovation Pilot	75	0.7%	161.2	0.8%	215.1	230.8	78.7%	-[32]	-
TOTAL HORIZON 2020	11108	100%	20400.1	100%	25220	192.2	91.6%	**74828.3**[33]	27.3%

Source: CORDA, cut-off date by 1/12/2017 (including grants to named beneficiaries, time to grant excludes grants to named beneficiaries and excludes ERC in overall calculations, as ERC is exempt from time to grant)

[32] The Fast Track to Innovation (FTI) pilot actions will be funded from the specific objective "Leadership in enabling and industrial technologies" and from the relevant specific objectives of the priority "Societal challenges". A sufficient number of projects will be launched in order to allow a full evaluation of the FTI pilot.'

[33] Includes EUR 1855.7 million earmarked for EIT and EUR 2383 earmarked for Non-nuclear direct actions of the Joint Research Centre (JRC)

D.4. Type of instrument

Table 8 Summary table - proposals per type of instrument

	Number of eligible propo-sals	Number of applica-tions	Number of high quality propo-sals	EC funding requested by eligible proposals (EUR million)	Success rate propo-sals	Success rate funding	New-comer applica-tions	Private sector applica-tions	SME appli-cations
COFUND-EJP	3	178	3	524.5	100%	100%	18	8	7
CSA	4706	34600	2459	6832.4	20.7%	19.5%	11236	8714	6400
ERA-NET-Cofund	49	1073	47	391.7	95.9%	99.0%	70	24	15
ERC-ADG	5931	6838	2562	14392.0	7.8%	7.9%	306	114	133
ERC-COG	6782	7417	2384	12856.7	14.5%	15.2%	288	97	129
ERC-LVG	2	2	2	0.1	100%	100%	1	0	1
ERC-POC	1150	1232	609	170.8	31.8%	32.0%	44	52	42
ERC-STG	8947	9605	2827	12816.3	10.6%	11.3%	507	145	191
IA	6090	52937	2374	24758.6	13.2%	17.5%	19858	29152	16826
MSCA-COFUND	207	1219	158	590.3	25.1%	25.7%	178	162	82
MSCA-IF	15988	17993	13059	2899.8	15.6%	15.7%	1946	402	305
MSCA-ITN	4282	47926	3645	13968.1	7.8%	7.9%	7256	12933	7456
MSCA-RISE	927	8018	588	787.4	27.7%	27.6%	2574	1926	1189
PCP	35	283	21	138.4	42.9%	45.5%	105	59	24
PPI	5	31	3	37.1	60.0%	84.5%	13	2	2
RIA	15989	154472	7664	66105	10.8%	12.5%	35858	53765	32040
SGA	82	385	82	16.7	100%	100%	227	96	37
SME-1	22152	23895	3498	1107.5	8.4%	8.4%	21819	23371	23626
SME-2	8749	11065	3647	14354.6	5.5%	5.5%	9412	10858	10929
Total	102076	379169	45632	172748.1	11.6%	12.7%	111716	141880	99434

Source: Corda, cut-off date by 1/1/2017 (including grants to named beneficiaries except for calculating success rates)

Table 9 Summary table – signed grants and participations per type of instrument

	Number of signed grants	Share of signed grants	EU contribution to signed grants (EUR million)	Share of EU contribution to signed grants	Partici-pations	Newcomer participa-tions	Private sector partici-pation	SME parti-cipati on
COFUND-EJP	3	0.0%	494.6	2.4%	99	3	1	0
CSA	923	8.3%	1212.8	5.9%	7379	1596	1426	1076
ERA-NET-Cofund	44	0.4%	340.5	1.7%	992	36	14	3
ERC-ADG	468	4.2%	1096	5.4%	563	6	6	7
ERC-COG	693	6.2%	1329.8	6.5%	773	5	4	2
ERC-LVG	2	0.0%	0.1	0.0%	2	1	0	0
ERC-POC	320	2.9%	47.7	0.2%	346	12	21	17
ERC-STG	950	8.6%	1397	6.8%	1027	7	3	4
IA	684	6.2%	3513.8	17.2%	7491	2295	4151	2169
MSCA-COFUND	55	0.5%	163.7	0.8%	55	1	0	
MSCA-IF	2444	22.0%	450.5	2.2%	2467	14	16	8
MSCA-ITN	389	3.5%	1259.8	6.2%	3195	293	739	415
MSCA-RISE	265	2.4%	223	1.1%	1718	364	466	345
PCP	12	0.1%	47.9	0.2%	100	23	16	6
PPI	2	0.0%	5.4	0.0%	15	7	2	1
RIA	1680	15.1%	8018.2	39.3%	20046	3481	6996	3726
SGA	82	0.7%	17.6	0.1%	489	304	106	38
SME-1	1670	15.0%	83.5	0.4%	1817	1534	1815	1817
SME-2	422	3.8%	698.2	3.4%	516	393	516	513
Total	11108	100.0%	20400.1	100.0%	49090	10375	16298	10147

Source: Corda, cut-off date by 1/1/2017 (including grants to named beneficiaries except for calculating success rates)

D.5. Member States

Table 10 Summary table - applications by Member States

	Number of applicants	Share of applicants	Number of applications	Share of applications	EU contri-bution requested	Share of EU contribution requested	Success rate (applications)	Share of private sector applications	Share of SME application	Share of newcomer applications
Austria	1668	2.2%	9316	2.5%	4199.5	2.4%	16.6%	37.1%	27.3%	25.3%
Belgium	2397	3.2%	14080	3.7%	6185.1	3.6%	17.0%	31.5%	22.9%	23.9%
Bulgaria	1018	1.4%	2594	0.7%	716.1	0.4%	9.0%	47.1%	41.0%	60.7%
Croatia	632	0.8%	2020	0.5%	549.6	0.3%	10.6%	38.0%	26.8%	48.8%
Cyprus	362	0.5%	2082	0.5%	738.9	0.4%	10.7%	44.8%	41.6%	29.6%
Czech Republic	975	1.3%	4149	1.1%	1426	0.8%	13.3%	35.7%	26.7%	31.8%
Denmark	1382	1.8%	8382	2.2%	4488.8	2.6%	14.8%	33.5%	24.3%	24.6%
Estonia	501	0.7%	1961	0.5%	727.8	0.4%	12.1%	41.6%	36.9%	41.6%
Finland	1649	2.2%	8300	2.2%	4657.5	2.7%	12.9%	35.3%	34.0%	30.1%
France	5149	6.9%	28702	7.6%	15315.9	8.9%	16.5%	39.0%	23.6%	24.0%
Germany	7438	9.9%	42637	11.2%	22492.8	13.1%	15.6%	36.4%	23.1%	22.6%
Greece	1801	2.4%	12383	3.3%	4788.3	2.8%	12.2%	37.3%	26.1%	24.0%
Hungary	1478	2.0%	4740	1.3%	1650.8	1.0%	10.4%	52.5%	45.9%	48.8%
Ireland	1072	1.4%	6043	1.6%	3069.6	1.8%	15.0%	38.9%	26.7%	26.6%
Italy	9040	12.1%	43222	11.4%	18036.5	10.5%	11.4%	44.7%	31.9%	34.0%
Latvia	441	0.6%	1384	0.4%	384.5	0.2%	11.0%	42.3%	34.2%	51.8%
Lithuania	471	0.6%	1572	0.4%	404.6	0.2%	11.1%	37.3%	28.2%	45.2%
Luxembourg	216	0.3%	1045	0.3%	425.2	0.2%	15.8%	50.2%	29.5%	28.8%
Malta	154	0.2%	641	0.2%	182.6	0.1%	13.3%	52.6%	40.1%	48.2%
Netherlands	3527	4.7%	21174	5.6%	11161.1	6.5%	16.1%	36.7%	24.6%	24.6%
Poland	2227	3.0%	7630	2.0%	2414.4	1.4%	11.0%	41.3%	31.8%	44.2%
Portugal	1625	2.2%	9148	2.4%	3391.2	2.0%	12.4%	37.0%	29.9%	29.8%
Romania	1217	1.6%	4099	1.1%	1187	0.7%	11.3%	39.4%	22.3%	45.6%
Slovakia	613	0.8%	1842	0.5%	652.4	0.4%	13.2%	47.5%	34.9%	48.7%
Slovenia	1091	1.5%	4351	1.1%	1419.1	0.8%	10.0%	44.9%	39.6%	44.1%
Spain	7206	9.6%	40361	10.6%	16536.2	9.6%	13.3%	42.3%	30.8%	30.4%
Sweden	1912	2.6%	10843	2.9%	5899.2	3.4%	15.2%	32.0%	20.5%	24.4%
UK	7053	9.4%	45757	12.1%	24981.2	14.5%	14.4%	30.9%	22.2%	23.1%
EU-28	64178	85.8%	340458	89.8%	158081.9	92.1%	14.0%	38.1%	27.1%	28.5%
EU-13	11177	14.9%	39065	10.3%	12453.8	7.3%	11.1%	43.0%	34.2%	44.6%
EU-15	53013	70.9%	301393	79.5%	145628.1	84.8%	14.4%	37.5%	26.2%	26.5%
Associated Countries (16 in total)	6310	8.4%	26997	7.1%	12128.5	7.1%	13.7%	37.1%	23.9%	33.3%
Third Countries (144 in total)	4340	5.8%	11671	3.1%	1514.9	0.9%	18.3%	17.2%	5.5%	47.3%
Total (188 countries)	**74769**	**100.0%**	**379169**	**100%**	**171725.4**	**100%**	**14.1%**	**37.4%**	**26.2%**	**29.5%**

Source: CORDA, Cut-off date by 1/1/2017 (including grants to named beneficiaries, except for calculation of success rate, where they are excluded)

Table 11 Country performance summary table (participations, participants, EU contribution, number of coordinators, success rates, newcomers)

	Number of Participants	Share of Participants	Number of participations	Share of participations	Number of coordinators	Share of coordinators	EU contribution to Participation (EUR million)	Share of EU contribution to Participation	Success rate of applications	Share of private sector participations	Share of SME participations	Share
Austria	463	2.8%	1404	2.9%	279	2.5%	576.2	2.8%	16.6%	37.7%	22.6%	20.5%
Belgium	713	4.3%	2194	4.5%	377	3.4%	965	4.7%	17.0%	26.9%	20.9%	19.6%
Bulgaria	150	0.9%	246	0.5%	18	0.2%	29.8	0.1%	9.0%	24.0%	18.7%	37.4%
Croatia	108	0.6%	208	0.4%	15	0.1%	32.1	0.2%	10.6%	26.0%	12.5%	38.5%
Cyprus	73	0.4%	230	0.5%	44	0.4%	61.8	0.3%	10.7%	36.1%	30.9%	18.3%
Czech Republic	201	1.2%	506	1.0%	49	0.4%	129.2	0.6%	13.3%	32.2%	20.6%	23.3%
Denmark	347	2.1%	1157	2.4%	326	2.9%	497	2.4%	14.8%	30.3%	20.1%	20.5%
Estonia	106	0.6%	241	0.5%	65	0.6%	66	0.3%	12.1%	34.0%	29.0%	27.8%
Finland	327	2.0%	995	2.0%	208	1.9%	430.3	2.1%	12.9%	32.0%	19.7%	22.3%
France	1394	8.4%	4409	9.0%	1013	9.1%	2097	10.3%	16.5%	36.2%	19.2%	18.5%
Germany	1974	11.8%	6280	12.8%	1281	11.5%	3464.4	17.0%	15.6%	35.5%	18.7%	17.6%
Greece	396	2.4%	1426	2.9%	211	1.9%	434.7	2.1%	12.2%	32.4%	21.7%	17.2%
Hungary	206	1.2%	439	0.9%	80	0.7%	108.8	0.5%	10.4%	36.7%	30.8%	33.3%
Ireland	254	1.5%	855	1.7%	253	2.3%	356.3	1.7%	15.0%	36.8%	24.9%	19.4%
Italy	1672	10.0%	4675	9.5%	996	9.0%	1663.6	8.2%	11.4%	40.3%	25.0%	23.4%
Latvia	72	0.4%	147	0.3%	18	0.2%	21.6	0.1%	11.0%	22.4%	17.0%	29.3%
Lithuania	81	0.5%	172	0.4%	26	0.2%	21	0.1%	11.1%	33.1%	20.9%	40.1%
Luxembourg	70	0.4%	165	0.3%	27	0.2%	54.2	0.3%	15.8%	44.8%	21.8%	29.7%
Malta	34	0.2%	84	0.2%	13	0.1%	15.6	0.1%	13.3%	27.4%	21.4%	39.3%
Netherlands	933	5.6%	3109	6.3%	770	6.9%	1565.5	7.7%	16.1%	32.9%	20.5%	17.9%
Poland	376	2.3%	784	1.6%	110	1.0%	184.5	0.9%	11.0%	27.3%	18.8%	28.6%
Portugal	389	2.3%	1091	2.2%	206	1.9%	342.9	1.7%	12.4%	31.4%	24.1%	23.3%
Romania	233	1.4%	439	0.9%	32	0.3%	77.2	0.4%	11.3%	25.1%	12.8%	37.6%
Slovakia	124	0.7%	239	0.5%	28	0.3%	50.3	0.2%	13.2%	40.2%	22.2%	37.2%
Slovenia	187	1.1%	419	0.9%	66	0.6%	109.4	0.5%	10.0%	37.2%	28.4%	30.3%
Spain	1781	10.7%	5006	10.2%	1344	12.1%	1812.8	8.9%	13.3%	38.8%	25.6%	23.1%
Sweden	474	2.8%	1517	3.1%	291	2.6%	703.8	3.4%	15.2%	32.0%	16.2%	20.4%
UK	1641	9.8%	6289	12.8%	2153	19.4%	3082.5	15.1%	14.4%	27.2%	19.4%	17.0%
EU-28	14779	88.6%	44726	91.1%	10299	92.7%	18953.4	92.9%	14.0%	33.9%	21.3%	20.8%
EU-13	1951	11.7%	4154	8.5%	564	5.1%	907.4	4.4%	11.1%	31.1%	21.8%	31.2%
EU-15	12828	76.9%	40572	82.6%	9735	87.6%	18046	88.5%	14.4%	34.2%	21.2%	19.7%
Associated Countries (16 in total)	1241	7.4%	3436	7.0%	805	7.2%	1332.1	6.5%	13.7%	30.3%	17.0%	22.5%
Third Countries (87 in total)	659	4.0%	928	1.9%	4	0.0%	114.7	0.6%	18.3%	11.0%	6.0%	33.3%
Total (131 countries)	**16679**	**100%**	**49090**	**100%**	**11108**	**100%**	**20400.1**	**100%**	**14.1%**	**33.2%**	**20.7%**	**21.1%**

Source: CORDA, Signed Grants cut-off date by 1/1/2017 (including grants to named beneficiaries, except for calculation of success rate, where they are excluded)

D.6. Benchmarking with FP7

Figure 44 FP7 vs Horizon 2020 benchmarking

		FP7 2007-2013, € 55 billion	Horizon 2020 2014-2020, € 74.8 billion Status as of 01/01/2017	Difference
Eligible proposals submitted (number)		134 535	102 076	-
EC Contribution requested in eligible proposals (EUR million)		216 358	172 748	-
High Quality Proposals submitted (number)		No info	45 632	-
EC Contribution requested in High Quality Proposals (EUR million)		No info	85 006.1	-
Signed grants (number)		25 781	11 108	-
EC Contribution to signed grants (EUR million)		45 452	20 400.1	-
Applications in proposals (number)		563 079	379 169	-
Open Access (share of peer-review publications provided in open-access)		61.8%	60.8%	↓1 pps
Peer reviewed publications (number)		219 620	4 043	-
Patent applications (number)		2 669	153	-
Newcomers (share of participants)		Above 70%	52.1%	↓19.9 pp
Collaborative projects (% of total EC contribution)		72%	76%	↑4pps
Time to grant in number of days (excl. ERC)		303 days	192.2 days	↓110.8
Funding rate (EC contribution as % of total project costs)		70%	70%	stable
Concentration of funding to top 100 beneficiaries (% of EC contribution)		34.6%	32.9%	↓1.7 pps
Yearly (2007-2013 for FP7; 2014-2016 for Horizon 2020)	.. EU contribution to signed grants (EUR million)	6 493.1	6 800.0	↑4.7%
	.. EU contribution requested in eligible proposals (EUR million)	31 111.1	57 582.7	↑85.1%
	.. eligible proposals submitted	19 219	34 025	↑77.0%
	.. participations supported	19 736	16 363.3	↓17.1%
	.. signed grants	3 683	3 703	↑0.5%
	.. participants supported	4332	5 559.6	↑28.3%
	.. applications submitted	80 440	126 390	↑57.1%
	.. applications submitted from private sector	20 443	47 293	↑131.3%
	.. applications submitted from SMEs	19 027	33 145	↑74.2%
Private sector (PRC)	.. share of applications	25.4%	37.4%	↑12.0 pps
	.. share of participations	30.4%	33.2%	↑2.4 pps
	.. share of EU contribution	24.2%	27.7%	↑3.5 pps
SME	.. share of applications	23.7%	26.2%	↑2.5 pps
	.. share of participations	18.4%	20.7%	↑2.3 pps
	.. share of EU contribution	14.4%	16.0%	↑1.6 pps
EU-13	.. share of applications	9.6%	10.3%	↑0.7 pps
	.. share of participations	7.9%	8.5%	↑0.6 pps
	.. share of EU contribution	4.2%	4.4%	↑0.2 pps
Associated countries	.. share of applications	8.4%	7.1%	↓1.3 pps
	.. share of participations	8.2%	7.0%	↓1.2 pps
	.. share of EU contribution	9.0%	6.5%	↓2.5 pps
Third countries	.. share of applications	5.6%	3.1%	↓2.5 pps
	.. share of participations	3.6%	1.9%	↓1.7 pps
	.. share of EU contribution	1.3%	0.6%	↓0.7 pps
Success rate	.. of projects' proposals	18.4%	11.6%	↓6.8 pps
	.. of total funding requested	19.9%	12.7%	↓7.2 pps
	.. of total applications	21.8%	14.1%	↓7.7 pps
	.. for private sector (applications)	23.3%	13.0%	↓10.3 pps
	.. for SMEs (applications)	20.2%	12.0%	↓8.2 pps
	.. of EU-13 countries (applications)	18.0%	11.1%	↓6.9 pps
	.. of Third Countries (applications)	23.8%	18.3%	↓5.5 pps
	.. of Associated Countries (applications)	21.7%	13.4%	↓8.3 pps
Proposals' evaluation	Number of proposals evaluated per year	~20 000	~33000	↑65%
	Time spent per evaluator per proposal	0.8 day	0.7 day	↓0.1 day

Source: CORDA, cut-off date 1/1/2017 and EMM2

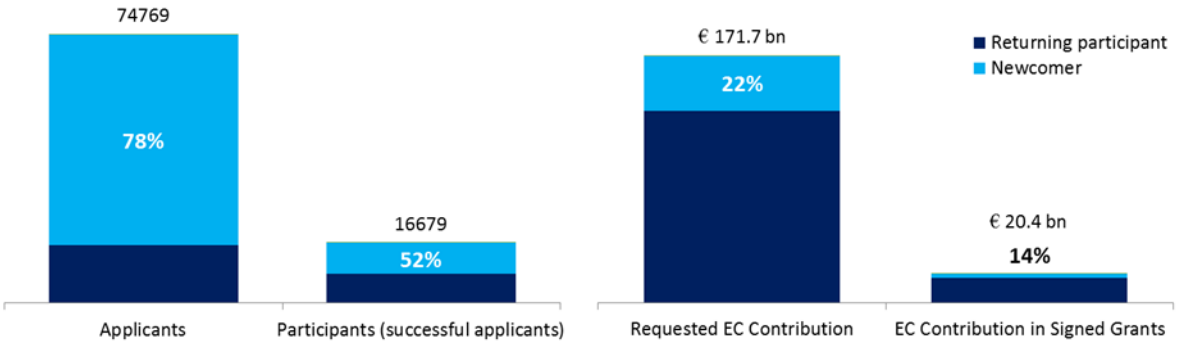
D.7. Newcomers

78% of all organisations that applied to Horizon 2020 funding in the first three years of programme implementation where newcomers (i.e. have not received funding under FP7) requesting 22% of the overall requested EC funding. Each returning participant applied for Horizon 2020 funding 17 times on average whereas each newcomer applied for Horizon 2020 funding 2 times on average during the first three years of the programme implementation.

53.4% of the returning participants applying to the programme were successful with at least one submitted proposal being selected, whereas only 18.1% of the newcomers were successful with at least one submitted proposal being retained. This is in part explained by the fact that the returning participants submitted many more proposals and as such increased their probability to be selected. At the same time, the success rate of proposals submitted by returning participants is still considerably higher (13.9%) when compared to newcomers (9.2%).

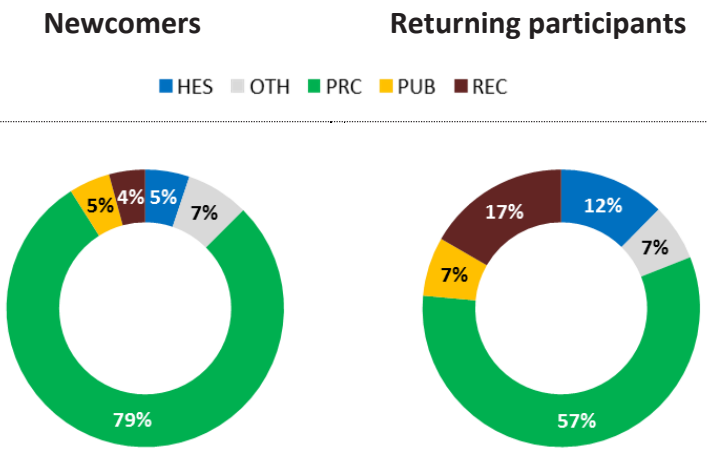
As a result, newcomers represent 52% of all organisations participating in Horizon 2020 but their share of obtained funding is only 14% of the total Horizon 2020 budget implemented in the first three years of the programme.

Figure 45 Number of applicants and participants (left) for newcomers and returning participants to Horizon 2020 (compared to FP7) and total requested and obtained EC contribution in signed grants (right)

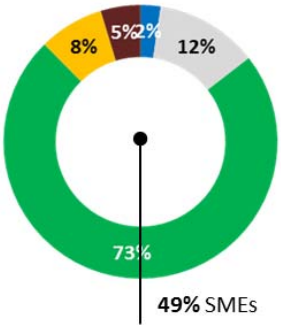


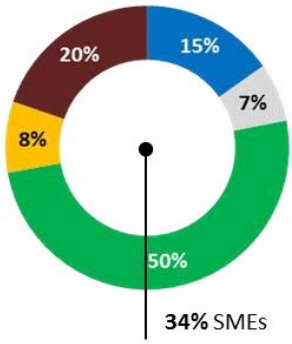
Note: The percentages refer to newcomers. The figures above the bar refer to total numbers for the programme as a whole. Source: CORDA cut-off date 1.1.2017

The highest share of newcomers and returning participants that applied to Horizon 2020 is from the private sector: 79% of newcomers and 57% of the returning applicants were from the private sector.

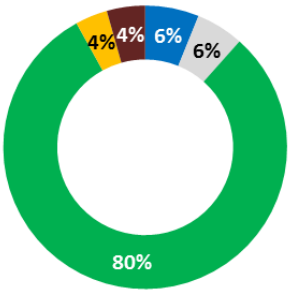


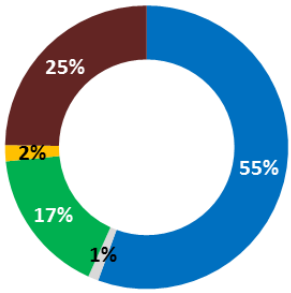
The highest share of newcomers and returning participants that signed grants in Horizon 2020 is also from the private sector: 73% of the newcomers are from the private sector, compared to 50% of the returning participants. The success rates among the different types of organisations differ from 26.2% for public bodies to 12.5% for universities.



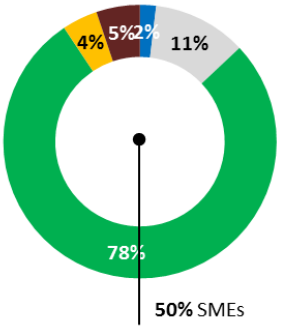


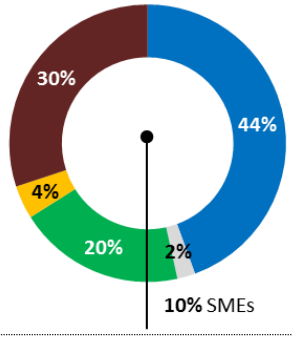
The highest share of requested EC contribution among the newcomers is also from the private sector (80%), but a few applicants (29% or 4684) from research organisations and universities requested 80% of the overall funding requested by returning participant. On average each returning participant from research organisation or university submitted 42 proposals to the Horizon 2020 programme in the first three years of implementation.





Amongst newcomers, the highest share of the funding goes to the private sector (78%). Amongst returning participants, the largest share of the funding of goes to research organisations and universities.



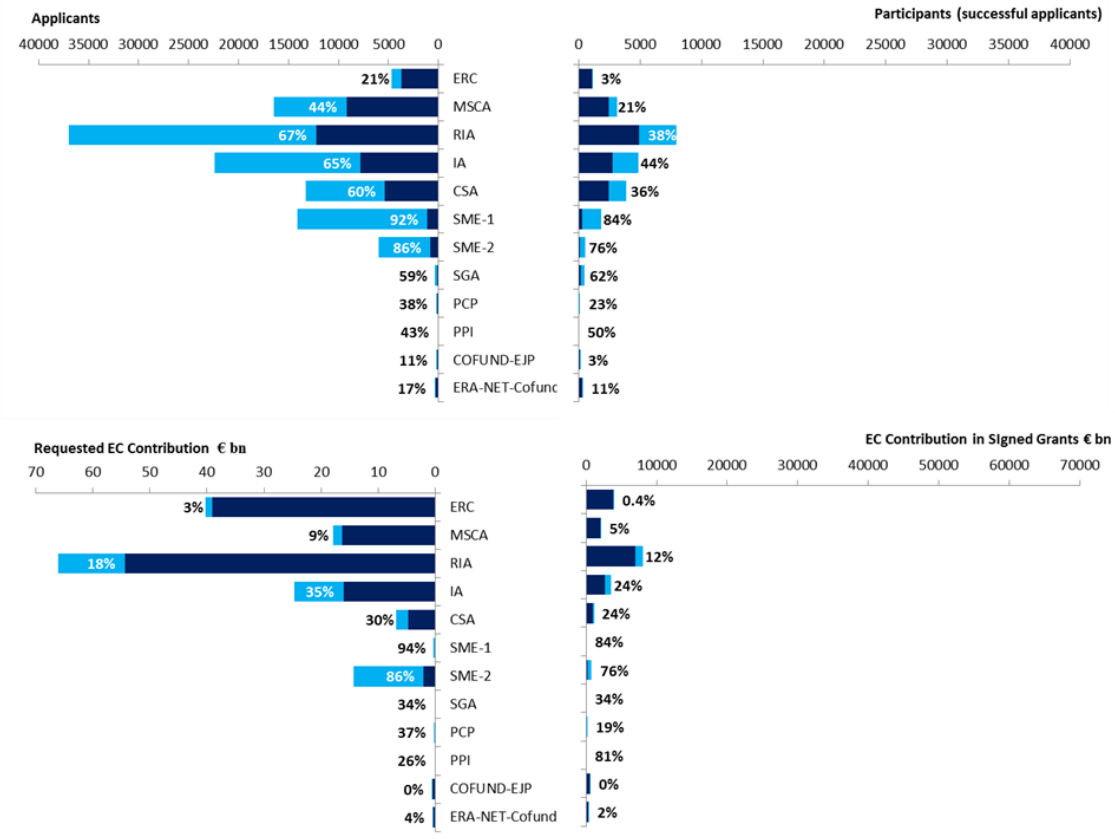


Looking at different types of actions implemented under Horizon 2020, Research and Innovation Actions (RIA) and Innovation Actions (IA) attracted the highest number of newcomer applicants (53% of all newcomer applicants applied to this type of support) followed by the SME Instrument (25% of all newcomer applicants). Consequently 54% of all newcomers participating in Horizon 2020 do so through RIA and IA actions, 33% through the SME Instrument. 64% of the EC contribution to newcomers came through RIA and IA actions, 21% through the SME Instrument.

Looking at the balance between newcomers and returning participants within each type of action the European Research Council, the Cofund-EJP and the ERA-NET-Cofund are least attractive to newcomers (less than 21% of all applicants to these actions are newcomers). However the

SME Instrument seems to attract almost exclusively newcomers to the Framework Programme (91% of all applicants to these actions were newcomers, ie. did not participate to FP7) and as a result 77% of the EC Contribution under the SME Instrument also went to newcomers.

Figure 46 Number of applicants and participants per action (above) for newcomers and returning participants to Horizon 2020 (compared to FP7) and total requested and obtained EC contribution in signed grants per action (below)



Note: The percentages refer to newcomers. Source: CORDA cut-off date 1.1.2017

E. SUCCESS STORIES FROM PREVIOUS FRAMEWORK PROGRAMMES

FP7 projects outcomes provide an illustration of the types of effects that can be generated by R&I projects. The box below lists four projects and their main outcomes[34]. These projects have outcomes or results that have had a significant added value, impact on the society and potentially on the economy.

Textbox 1: Examples of impacts from FP7 projects

HYPE[35]

Based on the work conducted during HYPE (nine partners from four countries) and also during previous FP and nationally funded projects one partner built an advanced biorefinery demonstration plant at the port of Kalundborg in Denmark. The consolidated process developed during HYPE was tested in this plant. By the end of 2010 the demonstration plant was fully commissioned and went into the production phase. The first 2nd generation ethanol has been sold to Statoil and is now distributed in 100 filling stations all over Denmark as Bio95 2nd generation gasoline. Lignin pellets are also produced there and are sold to DONG Energy and used as high-quality solid biofuel in power plants.

METOXIA[36]

This 11 partner project studied regulatory mechanisms which help cancer cells survive under micro-environmental conditions. The interviewed partners of the consortium state that the outcomes of this project were significant advancements in the area and led to new research projects, trials and commercialisation opportunities. One partner reported that his research group attracted more than EUR 20 million in grants and investment. The products developed during METOXIA are still at a very early stage, however, the impact could be large, as the drugs could address half of the population of patients with solid cancers that include breast, lung, prostate, cervix and brain tumours.

HIVE[37]

In 2013, the first computer mediated brain-to-brain communication was achieved using the knowledge and capabilities developed during the HIVE project. This 'hyperinteraction' communication achieved to send single words between one person in France and another in India using brain stimulation. The results of the experiment are considered a critical proof-of-principle demonstration of the possible development of conscious brain-to-brain communication technologies.

REBIOFOAM[38]

The academia-industry collaboration between this 10 partners project developed an environmentally friendly biodegradable packaging material that can be used across a variety of industries, even for the packaging of heavy objects. The packaging material produces no waste; its production reduces energy use by more than 50% and cuts CO2 emissions. The REBIOFOAM project was the first eco-friendly packaging initiative with such a wide range of possible applications across industries.

[34] For details and additional success stories please see Annex Part 2.
[35] http://cordis.europa.eu/project/rcn/88489_en.html
[36] http://cordis.europa.eu/project/rcn/91061_en.html
[37] http://cordis.europa.eu/project/rcn/87676_en.html
[38] http://cordis.europa.eu/project/rcn/90452_en.html

To showcase the longer term impact of previous Framework Programmes, the 'Expert Group on evaluation methodologies for the interim and ex-post evaluations of Horizon 2020'[39] delineated several portfolios of projects spanning from FP5 to Horizon 2020. Projects from these five portfolios were scrutinized for impact through an analysis of corresponding policy documents, publications, patents, pilots and demonstrators in order to evince the economic, environmental and social impacts of previous Framework Programmes.

The patents developed within the portfolio analysing the effects of applying the Life Cycle Assessment technique to the circular economy confirmed the high market value of results. Successful production, pilots and demonstrators from this portfolio led to: a 40% better performance in terms of global warming for multilayer composite decking boards; a 80% better performance of raw materials with recycled cellular concrete for subfloors in all impact categories; recycled gypsum consuming less than 65% of the energy required to produce natural gypsum and emitting less than 65% of greenhouse gases; a reduction of carbon dioxide emissions of 0.3 kg CO2-eq. for every kg of broiler feed using a novel mix diet, with the net results of a total avoidance of 0.62 million tons of CO2 emissions to the atmosphere each year. A further analysis on policy documents related to this projects' portfolio revealed that in one instance, the agreement between local companies and a regional public waste agency resulted in meeting the ambitious goal of 30,000 tons of cellular concrete recycled in high-end applications in 2014.

Looking at the economic impacts of fuel cells related projects one project managed to lower the commercial cost of modular heating systems, after the deployment of 80 fuel cell Combined Heat and Power (micro-CHP) systems across a number of Member States. Numerous spin-offs were generated out of the projects, such as the company Plant-e.

Considerable environmental impact was also achieved through FP projects, such as a single FP5 project managing to replace 945,000 liters of Diesel fuel and avoid 2.5 tons of CO2 emissions by using 27 Hydrogen-powered buses to transport four million people for more than one million kilometres in nine European cities.

39

European Commission Expert group on evaluation methodologies for the interim and ex-post evaluations of Horizon 2020, Applying relevance-assessement methodologies to Horizon 2020 (forthcoming report).

F. EUROPEAN ADDED VALUE CASE STUDIES[40]

F.1. European added value case study 1: Antimicrobial resistance

F.1.1. Overall context

(a) Definition and expected impact of the area

Antimicrobial resistance is the ability of microorganisms to resist antimicrobial drugs. Various pathogens, including bacteria, viruses, fungi and parasites can evolve to be resistant to antimicrobial drugs due to gene mutations over time.[41] Generally, gene mutation is a naturally occurring phenomenon. However, due to certain factors the evolution of microbes happens faster than the development of new antimicrobial drugs. Excessive and inappropriate use of antimicrobial medicines on humans and animals, and poor infection control practices, are both speeding up the evolution of resistant strains of microbes and transforming antimicrobial resistance into a worldwide public health threat.

Antimicrobials are used in various settings for different purposes. They are used to treat infectious diseases (e.g. pneumonia, tuberculosis, malaria, HIV/AIDS) and hospital-acquired infections (HAI) (e.g. methicillin resistant *Staphylococcus aureus* (MRSA). They are also used in complex medical interventions, such as hip replacements, organ transplants, chemotherapy and the care of premature babies that are at a higher risk of infection. In addition, antimicrobials are used in veterinary medicine and in animal husbandry for non-therapeutic purposes (e.g. disinfectants, preservatives, and food and feed additives). Hence, antimicrobial resistance cuts across a wide range of areas that affect human health both directly and indirectly.

The misuse of antimicrobials can also occur at different levels. It can occur due to individual misuse at patient level or inadequate prescription patterns by health professionals. In addition, lack of clear antimicrobial drug prescription policies at national level and their monitoring also contribute to the misuse of drugs. Finally, extensive promotion or pressure to sell large quantities of drugs at industry level can influence the overuse of antimicrobials.

Although the rates of resistance to various antimicrobials are increasing, the discovery of new antimicrobial drugs has decreased. The pressure to reduce the use of antimicrobials, together with weak market incentives and increasing difficulty and costs related to the development of new antibiotics have discouraged investment in this area. As a consequence, only a few new antibiotics are currently under development by pharmaceutical industry.

(b) Rationale for public intervention: key trends in the area, main challenges and indicators

Antimicrobial resistance is a global public health concern involving many different sectors (e.g. medicine, veterinary medicine, animal husbandry, agriculture, environment and trade). antimicrobial resistance cannot be successfully tackled through isolated, sectoral efforts. The fact that resistance may spread from country to country when people and animals travel, or when food and feed are traded, stresses the need for coordinated efforts across borders. In addition,

[40] The seven case studies of EU added value were developed within the following study: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming

[41] Communication from the Commission to the European Parliament and the Council - Action plan against the rising threats from Antimicrobial Resistance. COM (2011) 748 final.

new antimicrobials, diagnostic tools or treatment guidelines are global public goods that should be available to everyone in order for collective efforts to combat the resistance to be effective.

Antimicrobial resistance also carries a significant economic cost for countries' healthcare budgets. Several reports have produced estimates of mortality rates, productivity losses, societal costs per patient and other associated expenditures related to antimicrobial resistance (see Table 1 for the full list of indicators). According to a report produced by ECDC and EMEA, a subset of multidrug-resistant bacteria in Europe are responsible for about 25 000 of human deaths annually.[42] In addition to the avoidable deaths, this also translates into extra healthcare costs and productivity losses of at least EUR 1.5 billion each year. In 2007, infections caused by antibiotic-resistant bacteria resulted in approximately 2.5 million extra hospital days, which translated into EUR 900 million hospital costs.

According to a report commissioned by the UK Government in collaboration with the Wellcome Trust, 700 000 people die of resistant infections every year.[43] If by 2050 the misuse of antimicrobials does not decrease, approximately 10 million lives a year and USD 100 trillion of economic output will be at risk due to the rise of drug resistant infections. If these projections materialise, the mortality attributed to antimicrobial resistance would be higher than cancer related deaths.

Table 12. List of key indicators related to antimicrobial resistance

Indicator	Indicator values/examples
Antibiotic consumption	Between 2000 and 2010, consumption of antibiotic drugs increased by 36% (from 54 083 964 813 standard units in 2000 to 73 620 748 816 standard units in 2010).[44]
Deaths attributable to antimicrobial resistance	10 million people die annually due to antimicrobial resistance.[45] 25 000 persons may have died in 2011 due to ARM in the EU.[46] 214 500 neonatal sepsis deaths are attributable to resistant pathogens each year.[47]
Antimicrobial resistance cost	Hospital expenditure is on average an additional USD 10 000 to 40 000 to treat a patient infected with antimicrobial resistance[48]
Antibiotics consumed without prescription	An estimated 20-30 % in Southern and Eastern Europe.[49]
Antibiotic use in animal production	Global consumption of antimicrobials in food animal production was estimated at 63,151 (±1,560) tons in 2010 and is projected to rise by 67%, to 105,596 (±3,605) tons, by 2030.[50]

[42] EMEA and ECDC Joint Technical Report. The bacterial challenge: time to react. 2009.
[43] Tackling drug-resistant infections globally: final report and recommendations. The review on Antimicrobial resistance chaired by Jim O'Neill. (2016).
[44] Van Boeckel, T. P., Gandra, S., Ashok, A., Caudron, Q., Grenfell, B. T., Levin, S. A., Laxminarayan, R. (2014). Global antibiotic consumption 2000 to 2010: an analysis of national pharmaceutical sales data. *Lancet Infectious Diseases,* Vol. 14, pp: 742–50.
[45] Tackling drug-resistant infections globally: final report and recommendations. The review on Antimicrobial resistance chaired by Jim O'Neill. (2016).
[46] EMEA and ECDC Joint Working Group (2009). *The bacterial challenge: time to react. A call to narrow the gap between multidrug-resistant bacteria in the EU and the development of new antibacterial agents*. Joint Technical Report
[47] Laxminarayan, R., Matsoso, P., Pant, S., Brower, C., Røttingen, J. A., Klugman, K., Davies, S. (2015). Access to effective antimicrobials: a worldwide challenge. *Lancet Special Series.*
[48] Cecchini, M., Langer, J. and Slawomirski, L. (2015). Antimicrobial Resistance in G7 Countries and Beyond: Economic Issues, Policies and Options for Action. OECD.
[49] Morgan, D.J., Okeke, I.N., Laxmanirayan, R., Perencevich, E.N., Weisenberg, S. (2011). Non-prescription antimicrobial use worldwide: a systematic review, *Lancet Infectious Diseases*, Vol. 11, No. 9, pp: 692-701.
[50] Van Boeckel, T. P., Brower, C., Gilbert, M., Grenfell, B. T., Levin, S. A., Robinson, T. P., Teillant, A. and Laxminarayan, R. (2014). Global trends in antimicrobial use in food animals. *PNAS,* Vol. 112, No. 18, pp: 5649-5654.

Indicator	Indicator values/examples
	Denmark has a highly productive farming system with levels of antibiotic use of less than 50 mg / kg. From 2010 to 2030, global consumption of antimicrobials in livestock production will increase by two thirds, and that it will double in the rapidly growing economies of Brazil, Russia, India, China, and South Africa.[51]
EUROBAROMETER data	
Levels of knowledge on the use of antibiotics	Measure the levels of public knowledge about the nature and effectiveness of antibiotics and the risks associated with their unnecessary use. Based on 4 statements: Antibiotics kill viruses (FALSE) Antibiotics are effective against colds and flu (FALSE) Unnecessary use of antibiotics makes them become ineffective (TRUE) Taking antibiotics often has side-effects, such as diarrhoea (TRUE) On average, only around a quarter (24%) of Europeans answered all four questions correctly, while around half (51%) gave at least three correct answers, and 94% gave at least one correct answer.
Use of antibiotics during the last year	A third of Europeans have taken antibiotics in the last 12 months
Ways of obtaining antibiotics	93% say that they obtained their last course of antibiotics from their health care provider

Source: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming).

In order to tackle antimicrobial resistance the EU employed a "One Health" approach and also initiated coordination efforts between countries and international organisations. In 2011 the European Commission adopted an action plan against the rising threats of antimicrobial resistance.[52] It contains 12 actions (see Table below) for implementation within EU Member States, with seven key areas identified as most in need of practical measures:

- making sure antimicrobials are used appropriately in both humans and animals
- preventing microbial infections and their spread
- developing new effective antimicrobials or alternatives for treatment
- cooperating with international partners to contain the risks of antimicrobial resistance
- improving monitoring and surveillance in human and animal medicine
- promoting research and innovation

[51] Robinson, T. R., Wertheim, H. F. L., Kakkar, M., Kariuki, S., Bu, D., Price, L. B. (2015). Animal production and antimicrobial resistance in the clinic. *Lancet Special Series.*

[52] Communication from the Commission to the European Parliament and the Council - Action plan against the rising threats from Antimicrobial Resistance. COM (2011) 748 final.

Table 13. Actions outlined in the EC action plan against the rising threats of antimicrobial resistance

No	Actions
1	Strengthen the promotion of the appropriate use of antimicrobials in all Member States.
2	Strengthen the regulatory framework on veterinary medicines and on medicated feed via the review package foreseen for 2013.
3	Introduce recommendations for prudent use in veterinary medicine, including follow-up reports, using the same approach as 2002 Council Recommendation on prudent use of antimicrobial agents in human medicine.
4	Strengthen infection prevention and control in healthcare settings.
5	Introduction of the new Animal Health Law, which will focus on prevention of diseases, reducing the use of antibiotics and replacing current Animal Health provisions based on disease control.
6	To promote, in a staged approach, unprecedented collaborative research and development efforts to bring new antibiotics to patients.
7	Promote efforts to analyse the need for new antibiotics into veterinary medicine.
8	Develop and/or strengthen multilateral and bilateral commitments for the prevention and control of antimicrobial resistance in all sectors.
9	Strengthen surveillance systems on antimicrobial resistance and antimicrobial consumption in human medicine.
10	Strengthen surveillance systems on antimicrobial resistance and antimicrobial consumption in animal medicine.
11	Reinforce and co-ordinate research efforts.
12	Survey and comparative effectiveness research.

Through its research framework programmes (e.g. FP7, Horizon 2020) the European Commission contributed to several of these areas by funding research activities in the fields related to antimicrobial resistance. Research projects directly or indirectly related to antimicrobial resistance were conducted under different themes, including Health, Nanosciences, Nanotechnologies, Materials & New Production Technologies (NMP), Knowledge Based Bioeconomy (KBBE), Information and communication technologies (ICT) and others. A Joint Programming Initiative on antimicrobial resistance (JPIAMR) was also established to create a common research agenda and to integrate research efforts across national borders via alignment and research funding.[53] Since 2012 the JPIAMR is supported by the EC via a Coordination and Support Action grant of EUR 2 million. The strategic research agenda of JPIAMR was launched on 3 April 2014, and provides a framework for future investment and research priorities.[54] So

[53] http://ec.europa.eu/research/health/index.cfm?pg=area&areaname=amdr
[54] Commission Staff Working Document: progress report on the Action plan against the rising threats from Antimicrobial resistance. SWD(2015) 59 final

far, the initiative has brought together 22 members to coordinate their research in order to allow greater impact in the field and avoid effort duplication.[55]

In order to promote adequate use of antimicrobial drugs, the European Commission launched a EUR 1 million challenge prize to develop a rapid diagnostic test for upper respiratory tract infections that can be safely treated without antibiotics.[56] To foster the engagement of industry in antibiotic research, several antimicrobial resistance related projects were launched under the Innovative Medicines Initiative (IMI). IMI was launched in 2008 and is currently one of the largest public-private partnership between the EU and the European Federation of Pharmaceutical Industries and Associations (EFPIA).

(c) Defining the scope of the European added value case study

The EU has contributed more than EUR 1 billion towards combating antimicrobial resistance over the years.[57] More than EUR 600 million was allocated through FP7 to foster research and innovation (see Table below for more information). The FP7 Health theme and Joint Technology Initiative (JTI) 'Innovative Medicines Initiative' received the largest proportion of the funding, around EUR 406 million and EUR 337 million respectively. The Health programme also had the highest number of projects. In total, 85 projects related to antimicrobial resistance were funded under the FP7 Health theme. Under IMI, nine projects related to antimicrobial resistance were funded.

Antimicrobial resistance-related projects conducted under the Knowledge Based Bioeconomy (KBBE) programme as well as Nanosciences, Nanotechnologies, Materials & New Production Technologies (NMP) have also received significant funding under FP7. These projects received approximately EUR 109 million and EUR 48 million respectively. There were 26 projects funded under KBBE and eight projects funded under NMP. Nineteen projects related to antimicrobial resistance were also conducted under ICT, Regional potential and Research for the benefit of SMEs. Together these projects received around EUR 40 million of EU funding.

Table 14. Projects related to the area of antimicrobial resistance and their allocated EU contribution

Programme	Number of projects	EU contribution, EUR million
FP7 Health	85	406 180 902,2
FP7 ICT	4	20 410 712
FP7 Regional potential	2	5 218 112
FP7 NMP	8	47 802 599
FP7 KBBE	26	108 974 798
FP7 Research for the benefit of SMEs	13	14 227 801
FP7 JTI IMI	9	335 767 601
Total	147	602 814 924,20

Source: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming , based on CORDA data

[55] Matthiessen, L., Bergström, R., Dustdar, S., Meulien, P., Draghia-Akli, R. (2016). Increased momentum in antimicrobial resistance research. *Lancet*, Vol 388, pp: 865.
[56] http://ec.europa.eu/research/index.cfm?pg=newsalert&year=2015&na=na-260215
[57] Matthiessen, L., Bergström, R., Dustdar, S., Meulien, P., Draghia-Akli, R. (2016). Increased momentum in antimicrobial resistance research. *Lancet*, Vol 388, pp: 865.

As antimicrobial resistance cuts across different areas, in this case study a choice was made to include projects that were indirectly or directly related to antimicrobial resistance research. Projects in the areas of infection control, diagnostics, public health, drug development and clinical trials were included. As antibiotics are used in humans and animal husbandry, projects related to both human and animal health were selected.

F.1.2. Key findings

(a) Factors/mechanisms of influence fostering European added value

Reduction of commercial/research risks

In terms of commercial and research risks, **many interviewees agreed that risks are reduced or shared between the partners in European FP projects**. Small and Medium-sized Enterprises (SMEs) that are working in the late development and close to market phases face more risks compared to basic research projects. In addition, compared to academic researchers companies need to deliver specific products and might need to take higher risks to achieve that. Therefore, EU funding can help to mitigate those risks with upfront payments. Some funding for companies might also be available at local levels. Many researchers said that national governments are moving towards the implementation of different funding mechanisms for SMEs. However, the situation still depends on the country and research funding policies. The support available nationally might not be as substantial as provided through EU funding mechanisms.

Regarding research risks, the fact that in the FP projects researchers work in consortia helps to mitigate risks to a large extent. As stated by a number of interviewees, some projects are successful and others might encounter obstacles in reaching their results or delivering results that are different from what was initially planned. This is part of the overall research process. The fact that there are different teams and work packages involved in projects helps to secure that research progress is made, irrespective of possible setbacks. Also, FP projects in the antimicrobial resistance field often involve different levels of research advancement, from basic to applied and clinical research. This approach also helps to spread risks compared to a focused project conducted by one research group.

Leverage of private and public investment

The interview participants agreed to a large extent that the participation in European FP projects helps to attract further research funding. Regarding public investment, some researchers stated that participation in a large international collaborative project is seen as a benefit by funders, although this differs between countries and funding agencies. Depending on the country, some national agencies (as stated by respondents from Norway, Sweden, the UK) value participating in FP projects more and others (as stated by interviewees from Spain and Austria) do not differentiate between research experience gained nationally or through European collaborative projects.

In terms of leveraging private funding, the Innovative Medicines Initiative (IMI) programme New Drugs for Bad Bugs (ND4BB) has fostered the industry's participation in the antimicrobial resistance area and generated significant in kind contribution from the industry. The programme was started with an aim to research and tackle the scientific, regulatory and business challenges that lay in the development of new antibiotics. Through the partnership between industry, academia and biotech organisations, seven large projects were funded. The total budget of the

programme was EUR 700 million, with industry contributing half of this sum in-kind (personnel costs).

However, a few projects also mentioned the problem of attracting funding from the pharmaceutical industry for the commercialisation of their project results. The projects are facing a 'valley of death' where their formulations or technologies produced cannot be further developed due to a lack of funding from companies. Although, the outcomes of the projects are ready for commercialisation or licensing, finding industrial partners interested in conducting clinical trials and continuing with development is proving difficult.

Pooling resources and building critical mass

The majority of interviewees confirmed that there was resource sharing or pooling in the EU projects they participated in. In some cases, it included equipment, but mostly researchers pooled and shared samples, animal models, patient data, research protocols or bacterial strains. Most of the interviewees said that such resource pooling could be done nationally. Some researchers also stated that doing it at national level could be easier due to faster communication and lower transportation costs. However, the scale of the material available or collaboration opportunities would be much smaller. For example, one project has established a network of 700 clinical trial sites across 42 countries in Europe and this would not be possible on a national scale. The existence of such a network means that clinical sites are already identified and the preparation phase for clinical trials is shortened to a minimum. Hence, clinical trials can be initiated much faster.

The most commonly emphasised aspect of FP projects compared to national projects was the pooling of scientific expertise and collaboration with the experts working in the antimicrobial resistance area from other EU or third countries. Since resistance patterns are different across the globe and human behaviours in antibiotic use also differ, working across country borders helps to pool knowledge and expertise. Since antimicrobial resistance can spread easily across borders, employing diverse expertise can help to build the knowledge base quicker and more effectively.

Some respondents stated that **due to the broad scope of FP projects, they require the engagement of diverse interdisciplinary and inter-sectoral expertise**. This is the case for IMI projects that often involve more than 20 partners from academia and the private sector, and also for regular FP7 projects. For example, they analyse different bacteria, several types of nano-carrier systems, several drug formulations or are conducting clinical trials. These types of projects require pooling various lines of work, including transcriptomics, microbiology, proteomics, epidemiology and others. Gathering all the competencies and capacities needed for such broad projects in one country would not be possible in any single Member State.

Another aspect of European added value emphasised by researchers was **the larger sums of funding available in FP projects compared to nationally funded projects**. According to some researchers, the amount awarded to some projects would not be feasible for some governments. Support available from the EU helps to ensure longer term funding for projects focused on research questions that cannot be addressed by individual laboratories or research groups.

Interviewees also said that **large funding brings another dimension and size to project activities and helps to build the critical mass needed for research in certain areas of antimicrobial resistance.** Some estimates state that it costs over USD 1 billion (EUR 0.9 billion) to bring a pharmaceutical to the market. Large scale projects are particularly needed

when running clinical trials. It also becomes cheaper and more effective to run clinical trials, as the required levels of resistance and number of patients are much easier to reach when collaborating across countries.

Increased international and/or inter-sectoral mobility of researchers

International and inter-sectoral mobility of students was emphasised by some beneficiaries as a pertinent aspect of FP funded projects. There were PhD students and postdoctoral exchanges between different academic centres, between academia and industry, and between labs in different countries. However, the relevance of this aspect depended on the specific area of the antimicrobial resistance research. Whereas some research groups saw it as a great opportunity, others appreciated other aspects of EU projects more. For example, in clinical trials mobility and exchange was not always seen as crucial:

Interviewed scientists said that in many countries student exchange is also funded by national or regional funding agencies. Although in these instances mobility can take place only on a national level or bilaterally. In European projects, mobility occurs across country borders and contributes to networking, idea exchange and capacity building among young scientists. According to some interviewees, collaboration between researchers from different parts of Europe promotes capacity building as well. Particularly in countries where research funding is lower (Eastern European or Southern European countries) FP projects allow them to come on board and improve their research capacities.

(b) Better results achieved because of European added value

Improved research capabilities/excellence

Through the interviews with the beneficiaries, there are a few aspects of FP funding that were found to improve research capabilities and excellence in the area of antimicrobial resistance. All researchers agreed that **FP funding gives many opportunities to network and exchange ideas with the best scientists across the EU**. It also provides opportunities to engage with new expertise, new methodologies, techniques and instruments. Also, EU projects are multidisciplinary and thus allow collaborations to happen across different fields. According to the interviewees, the spill overs of knowledge and ideas that occur through such collaborations can advance antimicrobial research.

Since EU funding is usually much larger than nationally available funding, **bigger research bottlenecks in the antimicrobial resistance can be addressed.** This is of particular relevance in the field where no new antibiotics have been developed for decades. Respondents said that to change this situation, efforts across a spectrum of research activities are needed. From identification of molecules, implementation of the formulations, pre-clinical in vitro testing, to in vivo testing and clinical studies. These are large efforts in terms of the development phases they include. Compared to EU projects, national research agencies fund much more focused, targeted and smaller activities. They are also needed to complement EU projects but the scale and scope of research questions they can address are much lower.

Through interviews, there were some distinct views found when comparing national research capacities in the antimicrobial resistance field to capacities available at the European level. Most of the scientists (although there were exceptions) working in the UK, France, Belgium, Sweden and the Netherlands stated that for many research areas, nationally existing expertise would be sufficient to implement projects of such broad scope as FP projects.

Scientists from Norway, Austria, Switzerland and Italy, and researchers working in epidemiology or conducting clinical trials, said that national expertise would not be sufficient. Particularly, in large comparative multicentre studies or, as one respondent said, in a very specific field of science.

The opinions of interviewed scientists also differed on whether or not EU funding helps to increase scientific capabilities better than national funding. Many interviewed researchers stated that this was possible due to the large amount of funding available. But many Member States, particularly in the North West of Europe, also have large R&D budgets and provide funding for PhD and postdoctoral students. In certain cases, interviewed researchers suggested that EU research funding could help certain countries to build up their research capacities. Mostly, for the MS from the South and East of Europe, this can improve their research capabilities due to collaboration and exchange opportunities offered by FP funding.

Wider availability and dissemination of knowledge

Some of the interviewed researchers agreed that European efforts to promote open access and data sharing and wider dissemination of research results are stronger compared to national level efforts (Sweden). Others stated that both national and EU efforts are at the same level or that national research agencies are catching up and also include requirements for open access publishing (Belgium, Norway, the UK). However, not all of the interviewees saw open access publishing as the best way to disseminate one's research results. The facts that it is costly and that the open access journals are usually low ranked were named as significant drawbacks of open access publishing.

Some of the researchers stated that with or without open access, disseminating research outcomes and reaching wider audiences is becoming more and more difficult. With increasing numbers of publications, it gets harder to draw attention of academia and the public. European collaborative projects are seen to have an advantage here. Since there are many partners involved and publications are usually co-authored, it helps to widen dissemination and strengthen the impact of research results:

However, apart from open access publications, **researchers emphasised the importance of opening and depositing research data in online repositories**. In the area of antimicrobial resistance, this was stressed as a crucial factor to advance research and provide some urgently needed answers. Interviewees stated that having more data openly available would make research easier and more efficient, help to advance new treatment strategies and develop new drugs faster. As data is not published or is not available, there is duplication of research efforts and a subsequent waste of resources. When data is not open, scientists might be working on the same discoveries that were already made. For example, when studying toxicity, there is a strong probability that many models were tested for toxicity previously but the data is not published openly. Conducting trials in this area would results in a significant waste of research money. Openly depositing data would save time and resources but also would provide opportunities to analyse data from different angles and perspectives. One project funded by FP7 (already described above) is working to develop such a database of tuberculosis patient data. It will comprise data from older and recent clinical tuberculosis trials and will provide ample possibilities for further research.

Researchers also see **a need for more guidance and stewardship in developing and setting up one platform that would facilitate data storing**. There is already a lot of data collected, analysed and stored by ECDC on epidemiology, surveillance, resistance levels and antibiotic use.

Still, for new drug developments, more advanced techniques and the omics technologies, a data depository is still missing. Having a common platform where publication associated original data could be stored safely and accessed by peers was seen as a real benefit by the interviewed researchers. In projects with industry involvement, a single platform and clear data publishing rules in EU funded projects would help to open more data that companies are not always willing to reveal. Feedback from researchers stated that currently there are many questions arising data ownership and issues of intellectual property rights when working with private industry.

Economies of scale and scope

Although this aspect was not extensively addressed by respondents, **some reported several factors on why carrying out antimicrobial research through pan-European collaborations can reduce research costs.** Conducting smaller projects that have the same aim and scope in different institutions and countries reduces the possibilities to pool the results and increases the overall cost of running such projects. On the other hand, running several research lines in one project might be more efficient. Also, the fact that antimicrobial resistance related projects are complex in terms of the different disciplines and phases of development they encompass was mentioned by many researchers. This complexity translates into projects that are very expensive for national funders. By combining expertise and funds and running collaborative projects, funders make the best use of resources and prevent that two or more expensive studies are conducted simultaneously.

Better coordination of national research policies and practices at the EU level

Overall, researchers saw national and European projects in antimicrobial resistance differently due to the much larger scale and scope of the later projects. **Both types of research activities were seen as complementary rather than fragmented or as duplications of a research effort.** This is because, according to researchers, there are many knowledge gaps in the antimicrobial resistance area that need to be filled in by both smaller, more focused studies as well as large scale projects. Also, rates of infections, levels of resistance and prescription and consumption of anti-infective drugs are diverse across Europe and the world. Hence, conducting studies with similar goals or validating results in different regions is seen as valuable to generate stronger evidence.

Regarding research coordination, **most of interviewed participants saw a need for a macro level coordination between the EU, other big funding agencies (e.g. BARDA) and international organisations such as WHO or EU organisations such as ECDC.** This type of coordination could help to align strategies and organise data management more efficiently. Regarding coordination of national and EU research policies, not all researchers were aware of the already existing mechanisms. As one of the interviewees put it that few results of these mechanisms are disseminated. The researchers who knew or had participated in calls for ERA-NETs and JPIAMR projects stated that these efforts do not provide equal opportunities for all European research groups to participate but favour certain clubs. Some researchers also stated that this kind of coordination is not always effective since resources are used to manage the interests of the Member States.

Some researchers see a lack of coordination and communication between projects conducted under FP7. They stated that projects should put more effort on aligning their research activities and collaborate more in result dissemination. Particularly in projects where data can be pooled together to validate the results or in projects that are funded under the same calls. This might need a different leadership from the EC and possibly a different outcome-based

funding strategy for antimicrobial resistance related projects. According to some of the researchers, more communication between projects themselves and between projects and project officers would help to avoid duplication of research efforts. It would also ensure that the funding is spent effectively and would help to maximise the uptake of the results and outcomes of FP projects. Such close communication could also better inform further policy or research agenda setting.

Although there were researchers saying that more coordination between FP projects is needed, there are also examples of well-coordinated research activities. For instance, the FORMAMP, PNEUMONP and NAREB projects funded under Nanosciences, Nanotechnologies, Materials and New Production Technologies theme in FP7. They work towards unifying methods and uniting efforts to disseminate their work to the general audience, industry and decision-makers. There are challenges in management and result sharing due to IPR issues, according to the coordinator of one of the projects. But the cluster of the three projects aims to overcome them and foster collaborative and synergistic approaches.

(c) Long-term impacts resulting from European added value

Addressing societal/ pan-European challenges

Most researchers believed that European collaborative projects address infectious diseases and the antimicrobial challenges better than national level projects. **Pan-European projects can have bigger impacts as they reach much wider audiences across Europe**. National level projects are still needed though, as they are complementary to European or international projects. However, they are not equipped to produce as significant impacts in the antimicrobial resistance area as FP projects since their scope is usually narrower, their funding is considerably lower and the funding policies are more vulnerable to political circumstances.

In addition, to address antimicrobial resistance, very broad studies are needed that deal with different levels of antimicrobial resistance, including prevention, infection diagnostics, epidemiology and treatment strategies. Conducting such studies nationally would be less efficient and more expensive. According to some researchers, 15 or more years are needed to find a new drug and bring it to the market. Many different actors are involved in this process. EU funding allows to address several aspects of the R&D chain of drug development in one project.

The interviewees also reported that **FP funding has contributed to a significant change in antimicrobial research through the IMI programme New Drugs for Bad Bugs**. Industry's involvement is crucial in order to develop new anti-infective drugs and bring them to patients. However, the monetary incentives for pharmaceutical companies to work in this area are very low as the field is not profitable. The Innovative Medicines Initiative showcases a new collaboration model between academia and industry to advance the developments in the antimicrobial resistance field. The programme has already helped to generate more interest from the industry to engage in this field of research.

Also, **projects conducted under FP7 will contribute to overcoming several challenges in antimicrobial resistance.** The possibility to deliver new drug compounds to the market could save many lives of patients that cannot be treated with currently available anti-infectives. Other areas, such as immunization, epidemiology, new diagnostics or better surveillance could have economic impacts. Healthcare costs and treatment costs that are very high, particularly for multidrug resistant pathogens, could be reduced. Patient stays in hospitals or sick days could also be reduced. Several projects also reported that they actively collaborate with policy makers, such

as the European Medicines Agency and that their results have had an effect on antibiotic stewardship policies and infection control policies.

European research in the antimicrobial area has a good track record, according to the interviewed participants. **Due to already invested large amounts of funding and the expertise that has been built up within the continent, Europe could take the lead in coordinating the antimicrobial resistance research efforts globally.** Compared to other continents, Europe is ahead in many sub fields. Some of the researchers also emphasised that European wide perspective might not be sufficient in the antimicrobial resistance field and that a broader view spanning the globe would help to address the issue more effectively.

F.1.3. Stories of impact

Through research carried out for this case study several areas and projects were identified that are examples of successful initiatives of FP7 funding. They include the IMI ND4BB programme, advancement in diagnostic practices and product development, as well as the interdisciplinarity of research conducted in European projects.

The Innovative Medicines Initiative (IMI), according to some of the beneficiaries, has helped **to attract the interest of the pharmaceutical industry and generate more research in the antimicrobial resistance field.** The industrial partners contributed more than EUR 360 million in-kind. The programme has also helped to bring larger scale and scope to the European antimicrobial research. The projects in ND4BB have addressed a continuum of issues in the antibiotic resistance research cycle. The topics of funded projects ranged from early discovery and development, to preclinical as well as clinical phases. Also, one of the projects, DRIVE-AB, was conducted in the area of new economic models to reward the antimicrobial development while de-linking it from return on investment from sales volume. **The results of these projects will contribute to overcoming barriers that lay in antibiotic drug design, in delivery of new leads in the antibacterial candidate pipeline, in clinical trials and in return on investment models for antibiotic development**.

One of the challenges that contributes to increasing antimicrobial resistance is the incorrect diagnosis of diseases. This can lead to the wrong drugs being prescribed for treatment. Tests to diagnose a specific disease or infection are not always available and doctors might rely on symptoms to make a diagnosis and prescribe drugs. Some European FP projects addressed this challenge and worked on **developing diagnostic tests for various infections**.

In one of those projects, NIDIAG, a large international consortium conducted research in several low-income countries and developed a test for sleeping sickness (Human African Trypanosomiasis), an infectious disease caused by a parasite. According to the World Health Organisation, the estimated number of infections currently is below 20 000 and the estimated population at risk is 65 million people. The Rapid Diagnostic Test developed by NIDIAG is available on the market and will be particularly useful for remote rural settings where this disease mostly occurs. The project focused not only on developing the specific test but also on **guidelines for health practitioners on how to make a more accurate and faster diagnosis of this disease**. The NIDIAG project developed the guidelines that can be used by health care professionals to make more accurate diagnosis, do it quicker and prescribe a correct drug for the treatment.

The EU funded various projects to develop specific products that could be used to avoid or treat infections (drug formulations, vaccines and other products). For example, one project

called NanoTi developed a new titanium implant that is able to resist bacterial infections without the addition of any antibacterial compounds. The incidence of infections related to dental implants is between 2-5% and can sometimes reach 15%. The new implant can help to decrease this number and at the same time reduce the need for anti-infective drugs. Many other FP7 projects worked on the development of similar products, vaccines or drugs. **Their outputs will contribute to providing better targeted treatments and lowering the overall numbers of infections.**

Antimicrobial resistance is a complex area, requiring research in animals and humans as well as across an array of bacteria, viruses, fungi and protozoa. Also, research across a range of disciplines is needed including molecular and pharmacological studies, epidemiology and clinical trials. In this case study, we analysed a small fraction of all FP7 projects related to antimicrobial resistance. Projects were conducted under different FP7 programmes such as Health, ICT, NMP, KBBE and IMI. **This fraction of FP7 projects illustrates and represents the diversity and broad scope of topics addressed by European funding.** The majority of the interviewees agreed that with national research project such broad scope and scale could not be achieved.

F.2. European added value case study 2: Large-Scale Data gathering, omics research and biobanks which contribute to personalised medicine approaches

F.2.1. Overall context

(d) Definition and expected impact of the area

'Personalised medicine' is not a precise term and no single definition has been agreed upon. Many other terms, such as genomic medicine, stratified medicine and precision medicine are frequently used synonymously with personalised medicine. For this analysis the definition of the European Commission, which was revised by the Horizon 2020 Advisory Group for Societal Challenge 1 'Health, demographic change and Wellbeing' were used[58]: "*personalised medicine refers to a medical model using characterisation of individuals' phenotypes and genotypes (e.g. molecular profiling, medical imaging, lifestyle data) for tailoring the right therapeutic strategy for the right person at the right time, and/or to determine the predisposition to disease and/or to deliver timely and targeted prevention*".

Large-scale molecular data are fundamental for the understanding of the molecular basis of diseases. The high-throughput omics technologies as well as the resulting data are the prerequisites for personalised medicine. Research into molecular understanding of diseases also requires large-scale biobanking securing the availability and accessibility of high-quality biological samples collected in a standardised manner. Access is needed to large-scale population as well as to patient cohorts that are coupled with a large quantity of omics, clinical, lifestyle and imaging information. Selected projects in this analysis belong to categories of basic research and translational research and also include so-called enablers for personalised medicine which generated large data and sample sets and developed or improved generic technologies.

According to the Advisory Group for Societal Challenge 1research should aim to establish or support a 'pipeline' needed to implement personalised medicine:

[58] Advice for 2016/2017 of the Horizon 2020 Advisory Group for Societal Challenge 1 'Health, demographic change and Wellbeing'

- **Better understanding of diseases and their co-morbidities** as well as resilience to disease at the systems and mechanistic levels. Formulating hypotheses for biomarkers or targeted interventions aimed at disease prevention or therapy.

- **Development of new tools** for utilising/extracting/sharing new knowledge in the most informative and efficient manner (e.g. molecular profiling, biotechnology, diagnostics, ICT tools) in the most appropriate personalised setting (e.g. health care system, at home), as well as **accelerating and facilitating regulatory approval paths** for new medical products for personalised medicine.

- **Piloting the personalised medicine concept in real life settings** (e.g. genetic/phenotypic screening programmes, responding to the paradigm shift in clinical trials which move away from unselected patient populations towards more individualised approaches in molecularly defined subgroups), demonstrating the health benefit and cost-effectiveness.

- **Sharing the data generated** in new and existing studies, while ensuring confidentiality and data security, and feeding this information towards the new discoveries. Empowerment of individuals to manage their data, understanding of diseases and their co-morbidities as well as resilience to disease.

The key challenges ahead and future research needs are the adaption of research tools for clinical use, standards for data and sample collection, novel statistical and modelling methods for analyses, clinical bioinformatics, translation of omics research into clinical applications, identification, qualification and clinical validation of biomarkers, adapted clinical trial methodologies, and research on the economic impact of personalised medicine. Many of these aspects were already addressed in the later stage of FP7 and have been continued in Horizon 2020. In addition, the European Medicines Agency (EMA) launched a pilot project to explore the adaptive pathways approach[59] (MAPP - Medicines Adaptive Pathways to Patients), a scientific concept of medicines development and data generation intended for medicines that address patients' unmet medical needs and improve timely access for patients to new medicines.

The Horizon 2020 Advisory Group came up with a list of key weaknesses and threats affecting the development and uptake of personalised medicine. **Insufficient interdisciplinarity** and existence of "silos" were identified as a key weakness, followed by insufficient entrepreneurship and transfer of knowledge. **Data privacy, ownership and security** were identified as key threats, as were reluctance to move from old to new ways of medicine by health professionals. In this context public/FP7 funding had its role next to others in the promotion of interdisciplinary, the creation of joined up databases, the interoperability of data and formats (overcome silos), and contribute to addressing the data privacy, ownership and security issues.

[59] http://www.ema.europa.eu/ema/index.jsp?curl=pages/regulation/general/general_content_000601.jsp

Table 15 SWOT analysis of the personalised medicine area

Strengths	Weaknesses
Comparatively strong health care system infrastructures to conduct clinical studies. Longitudinal/prospective cohort studies. Strong basic research. Rapid advances in 'omics' resulting in decreasing costs.	Insufficient interdisciplinary, existence of 'silos'. Different health care systems and regulations across EU. Insufficient entrepreneurship, making implementation of personalized medicine in real life challenging. Lack of joined up databases. Lack of training of health care and other providers.
Opportunities	**Threats**
Need for new business models Need for improved public health. Need for change to health care systems to reduce the costs.	Inadequately addressing the risks associated with personalized medicine, such as issues of data privacy/ownership and security. Resistance to change. Despite demonstrated success, public and health care professionals do not support implementation of personalized medicine.

Source: Horizon 2020 Advisory group for Health, demographic change and wellbeing

(e) Rationale for public intervention: key trends in the area, main challenges and indicators

One of the greatest societal and economic challenges of the 21st century for European societies is health and the increasing pressure on European health care systems in an ageing population. By 2025, more than 20% of Europeans will be 65 or older, with a particularly rapid increase in numbers of over-80s. According to World Bank figures, public expenditure on healthcare in the EU could jump from 8% of GDP in 2000 to 14% in 2030 and continue to grow beyond that date. As a percent of a country's GDP, the USA also spent almost 16% of their GDP on healthcare. As an example the global economic impact of the five leading non-communicable diseases (NCDs) – cardiovascular disease (CVD), chronic respiratory disease, cancer, diabetes and mental ill-health – could total US$ 47 trillion over the next 20 years, according to a study released in 2011 by the World Economic Forum. Current medical treatments based on the "average patient" and "one-size-fits-all" are in many cases not effective, but often also very harmful. The list of conditions for which there is no satisfactory treatment is increasing and, even when treatments are available, many patients either do not respond or experience unacceptable side effects. For example, a 2001 study showed that the response rates of patients to common medications from different therapeutic classes ranged from ~80% analgesics) to ~25% (oncology). Progress in developing and adopting diagnostics to identify which medicines work best for which patients, thus reducing adverse events, has been slow. In fact, between 2000 and 2011, the number of adverse events recorded by the FDA nearly tripled. According to several studies, about 5.3% of all hospital admissions are associated with adverse drug reactions (ADRs).

The increasing drug development cost with a decreasing success rate of approval is an additional burden. In oncology, as an example, average costs for clinical trials are 1.5 billion dollars per candidate. The current success rate for each candidate is between 8% and 25% with the vast majority of drugs failing to be approved at the end of long overall development time (phase I-III) of 6.5 years.

(f) Defining the scope of the European added value case study

Extensive desk research and content analysis of final and periodic reports were applied to identify FP7 Health projects that were related to personalised medicine. The final list of personalised medicine projects was narrowed down to 209 projects. In addition 17 research infrastructure projects and 34 IMI projects related to personalised medicine were identified. 40 projects belonging to the research area of "large-scale data gathering, -omics research and biobanks which contribute to personalised medicine approaches" were identified. The majority of projects from FP7 Health were funded under pillar 1, activity 1.1. HIGH-THROUGHPUT RESEARCH and pillar 2, activity 2.1.1 LARGE-SCALE DATA GATHERING (22 projects). For the analysis 30 interviews were conducted with scientists covering 21 projects.

Projects belonging to the research area of "large-scale data gathering, -omics research and biobanks which contribute to personalised medicine approaches" are transnational collaborative projects involving large consortia. European collaborative research is a key element of the European Research Framework Programmes. Cooperation in collaborative projects and the resulting exchange or shared use of knowledge, methods, infrastructures and data provide critical mass across national borders. European added value could most likely be realised within these collaborative research projects.

Table 16 Projects related to the area "Large-scale data gathering, omics research and biobanks which contribute to personalised medicine approaches" and their allocated EU contribution

Programme	Number of projects	EU contribution, EUR million
FP7 Health	30	296.767.230
FP7 Infrastructures	7	39.399.293
FP7 JTI IMI	2	47.840.380
FP7 ERC	1	2.498.658
Total	40	386.505.561

Source: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming). based on CORDA data

F.2.2. Key findings

(a) Factors/mechanisms of influence fostering European added value

Reduction of commercial and research risks

The majority of projects in the area of "large-scale data gathering, omics research and biobanks which contribute to personalised medicine approaches" were aiming at the generation of new data sets, resources, generic technologies and infrastructures which could be later used by the scientific community and were therefore more basic or clinical research projects. The

commercial risks of such projects were regarded as low. The participation of SMEs was seen as beneficial for the projects, but the main drivers were the academic groups.

The research risk was mitigated by the composition and size of the research consortia. The large European initiatives relied on project partners with a proven track record of synergistic expertise and productivity. Even in case one partner failed to deliver the required research results, the consortia were usually large enough to find a different partner which could took over the tasks. This approach helped to spread risks compared to a project conducted by one research group.

Leverage of private and public investment

EU funding leveraged other sources of support to research in their field. EU funding helped them to access other funding to expand or continue their research. The majority of interviewees reported that FP7 funding was beneficial to leverage additional funding from the EU including Horizon 2020 grants, but also from other sources. Some interviewees from larger Member States pointed out that the leverage of additional funding was not relevant for them, but they admitted that leverage of additional funding was an important driver for participants of smaller countries. The majority of newly attracted funding came from the public sector including European and national grants. The European initiatives pay back to the national level and leverage additional funds in several Member States. Without pan-European initiatives it would not have been possible to promote certain national resources and programmes. European funds were prerequisite to develop or/and improve national initiatives and roadmaps.

The ESFRI infrastructure projects received a limited seed funding by FP7 for a so-called preparatory phase. This phase already included a fundraising exercise. BBMRI, Biobanking and Biomolecular Resources Research Infrastructure, received EUR 5 million from the EU. BBMRI secured EUR 170 million by Member States.

A clear leverage effect could be seen in the Czech Republic, the Netherlands and Finland in the area of research infrastructures for mouse functional genomics, where according to the interviewees there would be no national programmes without the European funding. As an example, participation in the European initiative was the prerequisite to apply for national funds for the France Phenomin - French National Infrastructure for Mouse Phenogenomics.

The participation in successful European initiatives also helped researchers to compete for internal institutional funding. The programme-oriented funding (POF) within the German Helmholtz Association is evaluated every 5 years and the European funding is an asset to secure the basic funding of research groups.

Through the participation in large European initiatives existing networks were able to successfully apply for ERA-NET grants. Scientists are not only partner in the ERA-NET grants, but participate in Scientific Advisory Boards. They were able to shape the corresponding ERA-NET calls, because specific calls were leveraging on existing infrastructures and other project outcomes like data collections of these large European initiatives. The latest E-Rare calls demand a data-managing plan and directly refer to the use of the infrastructures developed within the RD-Connect project. In addition, the larger European initiatives influenced the structure of later European grant applications. An increase of independent biobank work packages dedicated towards sample quality and management could be observed as a clear trend. The FP7 funding is also seen as a door opener for European Structural and Investment Funds like the teaming actions disseminating best practises to countries with lower funding capacities.

Some European calls directly supported existing initiatives like the infrastructure calls aiming at optimising the use and development of the best research infrastructures existing in Europe. Several interviewees highlighted that the fact that they led or participated in a large European project helped to attract additional national grants. Numerous examples were given including MRC, BMBF, DFG, ANR, Genopole. National calls also aimed at the expansion of research programmes towards for example the low and middle income countries.

Other national calls directly referred to existing European projects and only the partners of these initiatives were eligible to apply for the national grants. This can be exemplified by the BMBF call " Improvement of German biobank sites for connection to BBMRI" where it was stated "*The development, testing and application of overarching, generic standards, products and solutions for the integration of German biobank sites with human samples and data in BBMRI will be promoted. The work of BBMRI must be taken into account in all work. It is not the objective of the funding to develop or improve local, isolated infrastructures*."

The main aims of the large-scale data gathering, omics research and biobank projects were the generation of data sets, resources and infrastructures. Interaction with industry happened mainly in precompetitive areas. Therefore, the direct leverage of private funds plays for most of the projects' participants only a minor role, but several interviewees expect to attract private funds in the near future, when projects are more advanced. On the other hand, projects' participants often claimed that initial contacts and discussion with biotech, pharma and medical technology companies were started and small-scale side projects focussing on specific aspects of the research between single project partners and industry were funded by private funds. European projects helped to attract funding from foundations like for example the Wellcome Trust (UK), Hannelore-Kohl Stiftung (Germany) and a foundation from the USA.

Pooling resources and building critical mass

Projects in the area of "large-scale data gathering, omics research and biobanks which contribute to personalised medicine approaches" are characterised by large and multidisciplinary consortia. Nearly all of the interviewed project partners and coordinators emphasised that bringing the best people in Europe together resulted in stronger collaborative networks and better scientific excellence. These networks often outlive the duration of the grants. The required knowledge and expertise for these large European initiatives were not available in single countries. Projects in this area require individuals and institutions of proven expertise and productivity for the various classes of data production, analysis and integration. Compared to national funded projects European projects could tackle the full spectrum of analyses methods in contrast to smaller and more focused projects funded nationally.

The second most important European added value aspect highlighted by the interviewees was the pooling of samples and data. The large-scale data gathering projects are illustrations of the merits of EU-induced critical mass. They had brought together large amounts of data on patients, permitting the identification of susceptibility genes and biomarkers for common diseases. Interactions of genetic variation, lifestyles and wider range and variety of environmental exposures are best studied against a background of widely different environments, something that is best leveraged between, rather than within, countries. Clinical expertise including pathologists was needed from different countries in order to get enough high quality samples. Genomic cancer projects rely on high numbers of fresh frozen samples, which are only available by pooling samples transnationally. The European large-scale data gathering projects were able to collect the worldwide largest disease cohorts. Interviewees conceded that the biggest countries have the ability to raise individual cohorts for common diseases, but even then projects were

much better of with in international perspective to analyse the full spectrum of the disease including genomics gene expression, methylation and copy number variation. Gathering all the competencies and capacities needed for such broad projects in one country would not be possible in many of the Member States. Rare diseases are prime examples of a research area that strongly benefits from coordination on a European and international scale. The funding of transnational collaborative research through FP7 Health was more efficient and enhanced the cooperation between scientists working on rare diseases in Europe and beyond and thus reducing fragmentation of research in this field. In many countries dedicated research programmes were not available. This was especially true for the smaller countries of the EU.

Large sample sizes are required to investigate the variable incidence of specific cancers across Europe. Incidence rates for renal cancer have been sharply increased with unexplained variation in different countries. The highest rates that are observed worldwide occur in Central Europe and some other European regions compared to elsewhere in the world. The underlying processes of the disease vary in different European populations. Only the analysis of a European sample collection can led to the explanation of these differences. Large sample sizes are even more important in more homogeneous disease samples in order to stratify the disease samples.

One interviewee from France underlined that the European project was instrumental in getting all clinical colleagues together at her local institute for patient recruitment. The fact that the project was a European programme was key to motivate the clinicians to include their patients into this study. Only at her side, 12 clinicians were involved in patient recruitment.

Comparative effectiveness research (CER) is designed to inform health-care decisions by providing evidence on the effectiveness, benefits, and harms of different treatment options. CER makes use of large between-centre and between-country differences in treatment and outcome. The stratification of patients by genomics, imaging technology and protein biomarkers and the observational research design is dependent on large number of patients but also on big differences in the variation of treatment. The aim is by identifying and disseminating best treatment practises and the most cost effective practise across the European Union to reduce the mortality rate to the lowest European level.

Projects in the area of “large-scale data gathering, omics research and biobanks which contribute to personalised medicine approaches” mainly pooled and shared scientific expertise and patient samples. In addition they pooled and shared research data and protocols. The pooling and sharing of infrastructures and equipment were not regarded as a major aspect for European added value, but the development of common resources and infrastructures were. Developing Europe-wide infrastructures facilitated harmonisation of protocols and integration and interoperability of data from multiple population samples. Harmonisation was recognised as a key enabling factor. Samples were collected, stored and classified according to similar procedures. Compared to national funded projects the required infrastructure could be build much faster. In one project, the coordinator was able to set-up a core lab in his department completely dedicated to omics and pain with the European FP7 funds. In several projects structures and pipelines for data collecting and analyses, data sharing and standards were established. Building of common resources helped to avoid multiplying the costs and gaining efficiency. The newly created resources and infrastructures are already used by several European but also national projects.

Another aspect of European added value relates to the missing funding opportunities in single Member States. In several of the smaller countries including the Netherlands, Belgium, Finland and the Czech Republic no dedicated national programmes and funding calls for large-scale data gathering or infrastructure projects were available. Researches in these countries were dependent

on European funds. In some cases, the European projects helped to initiate the respective national programmes. However, even researchers from some larger Member States emphasised that the scale of national funding compared to European funded projects is much smaller and did not allow the same scientific ambition.

Increased international and/or inter-sectoral mobility of researchers

International and/or inter-sectoral mobility of researchers and training were considered as an important European added value aspect by some, but not all interviewees. Often no explicit training and mobility activities were part of the research plan. Training events were often coupled to the annual project meetings or were organised as webinars. Exchange of researchers occurred on a bilateral level between academic groups in order to learn new competences and skills that were not accessible in their own institution. In addition, consortia supported the exchange of early-stage researchers between partner laboratories through the implementation of short-term travel fellowships. In IMI projects responders pointed to their short secondments from EFPIA members to academic laboratories and vice versa.

Even in projects with a dedicated mobility and training work package, these activities were often postponed, because other project tasks were considered as more important for the success of the project. In other projects these activities were a central part of the research agenda and multiple training courses in different institutions were organised by project partners. In addition, summer schools were organised, often in collaboration with other FP7 funded projects, in order to train young researchers of project beneficiaries but also scientists from outside the projects. Some of the training materials established through these projects are now used for training courses at EBI and elsewhere. Summer schools and training events were also used to reach out to smaller countries embedding additional Eastern and Southern European countries in order to strengthen the idea of the European Research Area.

In other cases the training and mobility activities were "outsourced" by obtaining addition grants like MSCA ITN projects or by the participation in dedicated training projects like IMI EMTRAIN. The landmark BMS Research infrastructures successfully applied for a Horizon 2020 training project for managers and operators of research infrastructure.

(b) Better results achieved because of European added value

Improved research excellence / capabilities

UK based researchers considered European funded large-scale data production projects in general as not successful compared to the larger, well-funded projects by the Wellcome Trust and NIH, respectively. On the other hand they admitted that several projects in the area of "large-scale data gathering, omics research and biobanks which contribute to personalised medicine approaches" were success stories of European funding. These include the BMS landmark research infrastructure initiatives and the European projects as part of larger international initiatives. The larger amount of available funding for collaborative research allow for larger and more multidisciplinary consortia where more ambitious research questions can be tackled. Compared to EU projects, national funded projects are more focused, targeted and smaller.

Scientific publications in peer-reviewed journals are good indicators for scientific excellence. It can be shown that the EU level research projects resulted in higher quality publications compared to national funded projects. Good examples are provided by European and national

projects funded as part of larger international initiatives like, IRDiRC, IHEC, ICGC and InTIBR. For example, in November 2016 a collection of 41 coordinated papers were published by scientists from across the International Human Epigenome Consortium (IHEC). A set of 24 manuscripts has been released as a package in Cell and Cell Press-associated journals, and an additional 17 papers have been published in other high-impact journals. These papers represent the most recent work of IHEC member projects from Canada, the European Union, Germany, Japan, Singapore, South Korea, and the United States. The German Epigenome Programme contributed four minor manuscripts to the collection whereas the European project contributed 26 publications in journal with highest impact factors. The scales of funding of both projects are similar in scale.

According to the interviewees, good quality consortia with complementary expertise within FP7 projects led to higher quality research results, which attracted more interest from the scientific community. Besides analysing the project results within the consortium, some projects made them immediately available to the scientific community to allow optimal usage of the generated datasets, which is in contrast to most national funded projects. An indicator is the numerous data requests these projects received by the scientific community.

The European networks not only bring together European stakeholders but help build competitiveness against other continental networks like the ones in Asia and USA. The network of a single country does not have the same power of impact. The European epigenome programme has been one of the leading consortia within IHEC which could be judged by the mutual appearance in the boards and the scientific working groups. At the end of the funding period Europe lost the leadership in this research area. Several interviewees stated they were missing a funding opportunity to secure the scientific lead and sustain the acquired expertise and project outcomes and resources. In contrast, USA and Asia increased their investment in epigenomic research. In addition to the European funding gap, there were no appropriate national funding programmes available in several countries to compensate for this.

FP7 projects also helped to create a strong position and visibility attracting interests by other groups including groups from outside Europe which allowed the researchers to collaborate and share data with other large international initiatives in the USA and Asia.

Another European initiative as part of the larger International Mouse Phenotyping Consortium (IMPC) made it as the first life science project to the G7 list of research infrastructures of global interest with global impact. The mission of IMPC is to build the first comprehensive functional catalogue of a mammalian genome, which will give new insights into gene function and human disease. This bold goal will require the support, infrastructures and cooperation of multiple countries. The IMPC is coordinating efforts to generate a knockout mouse strain for every protein-coding gene in the mouse genome (~20,000).

Economies of scale and scope

Projects in the area of "large-scale data gathering, omics research and biobanks which contribute to personalised medicine approaches" are in general expensive and beyond the scope of most national funding agencies. Pooling scientific expertise and funding allowed for larger and coordinated collaborative research and prevent fragmentation and duplication of research efforts.

Wider availability and dissemination of knowledge

Most interviewees confirmed that a majority of scientific publications were published in open access journals, but researchers differ in the handling of research data. Some projects released and disseminated the data to the wider scientific community even before they analysed them themselves. Other projects made the research data only available after the end of the project, because scientists preferred to analyse their data first or secured protection of IP has happened first. Most projects generated personal medical data which are more sensitive than other research data. Access to these data were often organised by an instrument called controlled access, where scientists have to apply for the access to the data and have to show that they are *bona fide* scientists. Others were promoting an instrument called registered access.

The European Open Science Cloud (EOSC), a virtual environment to store, share and re-use data across disciplines and borders, was known by most of the interviewees, but not all. Several responders believed that EOSC would not be the optimal instrument for health related data. Others could see the EOSC as a framework for the different cloud initiatives. Interviewees stressed that long-term data stewardships for the different data sets would be an important aspect which has to be introduced from the beginning, otherwise it would be only another online repository with no additional benefits. One scientist alerted that with the implementation of the EOSC the data analysis capacities in Europe have to be increased. The weakness in data analysis in Africa and Europe compared to the USA and some other regions would otherwise penalise European research. Several interviewees promoted the inclusion of data management plans according to the FAIR data principle (make research data findable, accessible, interoperable and reusable).

Some of the projects reached out to a broader audience in addition to researchers. One project will publish an entire commissioned issue of a Lancet journal in order to inform policy makers and funders about their research programme. Other projects coordinated the publication of a collection of scientific papers to reach the maximum public awareness.

In addition, projects organised workshops and conferences together with other initiatives including ERA-NETS to spread the project outcomes to a wider scientific community and Member State funders. Also common guideline papers were published to reach a greater acceptance. In other cases, common workshops were organised by all funded projects of one specific call in order to inform the EU, policy makers and other stakeholders about their research topic and results and to push for additional funding opportunities.

Several projects jointly organised a strategic meeting at the European Parliament in Brussels. Other projects directly visited the responsible ministries in several Member States to discuss what infrastructures are available at the national level and explain the added value of linking these infrastructures on the European level.

Projects involved specific patient organisations or the European umbrella patient organisations directly as project beneficiaries and by them reached out to patients but to the general public as well. In addition, researchers were invited by EMA to provide their statements about the utilisation of data, big data and omics, patient registries, data linkage and FAIR data principle.

Better coordination of national research policies and practices at the EU level

The coordination of national research policies and practices at the EU level was no direct aim of the projects in the area of "large-scale data gathering, omics research and biobanks which contribute to personalised medicine approaches". Nevertheless, most of these large initiatives directly or indirectly contributed to the coordination of research policies and had an impact on

the structuring effect of the European Research Area (ERA) and on national programmes in the area of health research. The members of the large collaborative networks are often key opinion leaders serving as advisers to policy makers and other stakeholders in charge of research policies that inform national funders about cutting-edge research performed by the large international initiatives. They were participating in the European Union Committee of Experts in Rare Diseases, were at the Scientific Advisory Boards of ERA-NETS, were coordinators of relevant Joint Actions, and served as chairs of Interdisciplinary Scientific Committees and International Scientific Steering Committee of large international initiatives.

In the area of traumatic brain injury the two coordinators of an FP7 project together with two other colleagues started a lobbying initiative in 2009 resulting in the launch of the International Initiative on TBI Research (InTBIR), a collaboration of funding agencies aiming to stimulate TBI research. In addition the MRC will take the model of CENTER-TBI to South Africa and India (low and middle income countries).

In the area of rare diseases FP7 researchers were in a leading position in other relevant initiatives coordinating the EUCERD Joint Action on Rare Diseases and as lead principal investigators in its successor initiative Joint Action RD-Action. These initiatives are in the science policy area of the rare disease field complementing the more research oriented projects. EUCERD aimed at aiding the European Commission with the preparation and implementation of Community activities in the field of rare diseases and were considered as the midwife of the European Reference Networks (ERN) for rare diseases, a novel EU initiative to form networks of centres of expertise and healthcare providers that support clinicians and researchers to share expertise, knowledge and resources across the EU. ERNs use communication and eHealth tools to enable the mobility of expertise across borders, rather than the movement of patients who often travel abroad, to access the care they need. The first successful ERNs were announced early 2017. Services and pipelines on data sharing and analyses generated within the FP7 project RD-CONNECT were offered to be used in the ERNs.

Another prime example was the BMS landmark research infrastructures. Without pan-European initiatives it would not have been possible to promote certain national resources and programmes. European funds were necessary to improve or even initiate national initiatives. Without the European funding there would be no national programmes on infrastructures on mouse disease models at least in several Member States according to the interviews.

In addition, the ESFRI BMS infrastructure initiatives published several common position papers on policy issues, aiming to inform national and European policy makers about the relevance of the BMS research infrastructures for building the European Research Area. As a latest example they published the position paper “Contribution from the Health related infrastructures: BBMRI, ECRIN, EATRIS, ELIXIR, EU-OPENSCREEN, INFRAFRONTIER and ISBE to Medicine Roadmap for Europe” in response to the Strategic Research and Innovation Agenda of PerMed.

The interviewees gave multiple examples where the European initiatives directly pay back to national research and research programmes. In one project the coordinator was able to set-up a national database in Italy where 12 national centres for chronic pain research were collaborating and submitted their research data for data sharing to the newly generated national database. Through the European funded project these centres, which were no partners in the FP7 project, got motivated to contribute their data to this central national database. Without the European project this would not have happened. This model database will also be replicated in several other European countries. The database and established protocols were already transferred to another country with had no expertise in this specific topic before.

(c) Long-term impacts resulting from European added value

Better addressing societal / pan-European challenges

Research and Innovation in response to the challenge of "Health, demographic change and wellbeing" is crucial to ensure better health for all European citizens. To the main research priorities of Horizon 2020 belong next to others personalised medicine and rare diseases. The projects in the area of "Large-scale data gathering, omics research and biobanks which contribute to personalised medicine approaches" all contributed to this challenge by providing insights in the underlying mechanisms of many diseases and establishing large cohorts including patient cohorts associated with clinical, omics and environmental data. These projects established or ensured a European leadership in various disciplines including epidemiology, registers, biobanks and cohorts, rare diseases, cancer and epigenetics. Medical or health research includes basic, translational and clinical research. Most of the projects of this area were basic science projects and the transfer of scientific discoveries into the clinic is a long process often outside the scope of these activities. The majority of projects in the area of "large-scale data gathering, omics research and biobanks which contribute to personalised medicine approaches" were aiming at the generation of new data sets, resources, generic technologies and infrastructures which could be later used by the scientific community for supporting future clinical trials in these areas. The gained knowledge and established and developed results, resources and infrastructures were the prerequisites for the stratification of diseases and personalised medicine. Understanding the critical mutational events underlying the development of diseases, comprehensive catalogues of mutations and the detection of new disease genes are paramount for advancing prevention, early detection and effective treatment of the diseases.

The interviewees argued that the private sector alone would not have been able to resource the projects sufficiently. No concrete case was found where a project could have been implemented using private or own funds in its entirety. Although some beneficiaries agreed that certain aspects of their projects could have been implemented with their own or private funds, the resulting outputs would have been either smaller/partial or substantially delayed. The Wellcome Trust as a charitable foundation is able to fund large-scale data gathering projects on a similar scale like the EC.

Several national strategic programmes for personalised medicine have been set up like the "Stratified Medicine in the UK" and the Personalised Medicine –Action Plan" in Germany to name only two. Some Member States initiated large-scale data gathering projects like the 100,000 genomes project by Genomics England and the UK Biobank initiative in England and the UK respectively and the planned French Genome Project with an investment of approximately EUR 700 million to build a network of sequencing and analysis centres capable of processing the equivalent of 235,000 genomes a year by 2020. In addition to the European funded ICGC and IHEC projects, several nationally funded ICGC and IHEC projects exist. But all interviewees underlined that without the EU action their projects could not have been realised. This means that the **effective critical mass of knowledge and expertise were not available within a single Member State**, that the scale of the project would not have been possible with national funding and/or that the appropriate funding programmes were missing at least in some Member States.

The beneficiaries also highlighted the critical mass of data, research subjects and infrastructures (cohorts, complementary capacities, multi-centre clinical trials and data collection) that were superior to what would have been available nationally. Responses of the interviewees point to the perception that participation brings benefits in terms of ability to **tackle more ambitious**

research objectives in European cooperation than in national funded collaborations. The European setup of research in this area had a huge impact in coordinating and managing the activities by creating, optimising and sharing resources, and avoiding duplication of efforts. These are clear indications that the FP7 large-scale data gathering projects directly contribute to the creation of the European Research Area in health research.

All interviewees were in line with the recommendation of the 2016 report of the Horizon 2020 Advisory Group for Societal Challenge 1[60] who identified as a main research gap that European research suffers from lack of sustainability of successful projects, infrastructures and projects outcomes. For better addressing the pan-European challenges the Horizon 2020 Advisory Group expressed the need for assuring sustainability of publicly funded projects including the possibility to follow up successful projects that have ended.

F.2.3. Stories of impact

Comparative effectiveness research (CER) makes use of large between-centre and between-country differences in treatment and outcome. The need for European action is dictated by these national and regional differences. These inequalities in treatment provision and outcome are not small. Up to 35,000 lives could be saved annually if traumatic brain injury mortality rates across Europe could be reduced to the lowest observed national rate. Research is expected to provide robust guidelines on best clinical and most effective practice, ensuring that every EU citizen obtains the best possible care, regardless of country or region of residence.

Several European infrastructures supported health research in general, but other platforms were specifically developed for rare diseases, which linked omics data, registries, biobanks and developed analysis pipelines. The access and the connection to these European infrastructures were already implemented in some later calls like in the E-Rare or some national calls guarantying the long-term storage and re-use of large sample and data sets. European research infrastructures served as facilities for storage, curation, annotation and distribution of samples and data for re-use in academia and for commercial purposes. New models for public-private partnerships were established.

In one of the large cancer projects, a large comprehensive catalogue of somatic mutations was generated. The results of the project are now taken further towards translation. Women with germline BRACA1/BRACA2 accounts for 1% of cases and PARP inhibitors are tested in clinical trials as medication. Based on the obtained molecular signatures patients could be stratified much better. They found additional 20% which looks like BRACA1/BRACA2 germline mutation carrier, but they do not have mutations in these genes. By changing the clinical trial strategy based on the genomic data, a therapy change of 20% of women with breast cancer can be envisaged, if successful. Several patents have been filled.

In the area of rare diseases 80 new disease genes were identified in one project and further 100 genes are in the analysis pipeline. As a result, new disease panels for stepwise diagnostics are under development. The diagnostic kits will result in the availability of targeted genetic testing. This will help physicians provide the most appropriate treatment, allow affected families to make informed family planning decisions, form better-stratified patient cohorts for interventional trials, shorten the time to diagnosis and avoid unnecessary or invasive test procedures.

[60] http://ec.europa.eu/research/health/pdf/ag_advice_report_2018-2020.pdf

F.3. European added value case study 3: Fisheries

F.3.1. Overall context

(a) Definition and expected impact of the area

Fisheries and aquaculture play an important role in European societies for their capacity to satisfy the demand of safe, nutritious and healthy food as well as for their ability to provide a large number of jobs and business opportunities.

Through the Common Fisheries Policy, the EU aims to ensure that fishing and aquaculture are environmentally, economically and socially sustainable and that they provide a source of healthy food for EU citizens. The future challenge lies on building a sustainable production system able to meet food demand and provide jobs and economic growth in a context of increasing resource scarcities and growing maritime services.

Research funded by FP7 and Horizon 2020 aims at creating the conditions for the development of new technologies, maximising synergies with activities funded at national and regional levels and avoiding duplication of research efforts. The focus of the Framework Programmes' support related to fisheries and aquaculture can be summarised in three areas.

The first area is the improvement of **resource-efficiency and management of fisheries**. This sector lacks behind in the implementation and use of technologies already developed (i.e. information technology, detection, monitoring and surveillance techniques, new materials, etc.). Adaptation to new technologies would benefit the extraction sector by improving cost-efficiency and limiting its environmental impact. At the same time, the EU needs to avoid the loss of depletion of ecosystem services and produce "more with less" to achieve the sustainability goals set in the reviewed 'Common Fisheries Policy'[61]. Projects from the Framework Programmes aimed at exploring opportunities to increase the use of innovative technologies in fisheries activities, as well as to enhance scientific knowledge to reinforce advice on fisheries management. Some of the expected impacts of FP7 on resource-efficiency and management would be:

- Improvement in energy efficiency;
- Increase in overall economic productivity;
- Improved competitiveness of fishing sector;
- Increase of private investment in innovation, notably leverage of private co-investor and/or follow-up investments;
- Reduction in damage to other marine resources and ecosystems;
- Support decision making and better ecosystem-based fisheries management.

The second area of focus is the improvement of the **technical performance of aquaculture**. Projects from the Framework Programmes seek to develop new technologies and implement

[61] The Common Fisheries Policy (CFP), January 2014. http://ec.europa.eu/fisheries/reform_en

existing ones to make the European aquaculture sector more competitive and help meet the targets set in the 'Strategic Guidelines for the sustainable development of EU aquaculture'. At the same time, projects from the FPs aim to expand and diversify aquaculture in Europe by promoting market-driven research, innovation and knowledge transfer. With this aim, FPs synergized with national research programmes and incentivised the participation of industry partners in research activities.

Examples of impacts of Framework Programmes on the competitiveness and technical performance of European aquaculture can be found in the Strategic Research Agenda from the European Aquaculture Technology and Innovation Platform. Some of these are:

- Maximise health benefits, high quality and safety of aquaculture products;
- Improve fish health, treatments and disease prevention methods;
- Ensure an environmentally sustainable and profitable industry by developing improved management systems and technology;
- Improve output and cost control at every production stage of the lifecycle;
- Implement innovations and improvements on fish genetics, reproduction in captivity and new species in aquaculture;
- Improve knowledge on fish nutritional and feeding requirements as well as safe technologies to produce cost effective feed;
- Ensure the availability and efficient use of aquaculture research infrastructures across all boundaries to benefit the industry;
- Build capacities and human capital in the European aquaculture sector.

The third area is research in **marine conditions, safety and dietary properties of seafood** and the **impact of oceans on human health**. Projects from the Framework Programmes seek to tackle challenges such as reducing sea emissions, noise and pollution. Both fisheries and aquaculture need good quality aquatic environment to ensure the production of safe and nutritious products. Projects from the FPs extensively cover areas of research related to environmental sustainability of seafood production and processing industry, seafood quality and safety and the assessment of potential public health risks caused by marine-degraded environments. This degradation might be caused by debris, chemical and microbial pollution, which cause increasing problems in oceans and seas. The economic and ecological costs of these for fishing and aquaculture industries are considerable.

European research aims to improve the observation and monitoring of marine environment. Examples of these are research on forecasting and anticipating effects of climate change and efforts to develop non-invasive systems to monitor and assess fish-stocks and biodiversity. A key focus area of Horizon 2020 Work Programme 2016-2017 programme[62] is placed on the creation of an integrated Mediterranean Sea Observing System, while the Horizon 2020 Work

[62] Horizon 2020, Work Programme 2016-2017, Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy. http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-food_en.pdf

Programme 2014-2015[63] focused efforts on tools and methodologies to model, understand and predict Atlantic marine ecosystems.

Projects in this area are expected to create European added value by supporting trans-national, pan-European research networks and synergies among national/regional and EU research programmes as well as to facilitate economies of scale and research investment efficiency by better aligning national/regional research programmes. Some of the expected impacts of FP7 on this area of focus would be:

- Providing solutions to minimise risks and transmission of fish and mollusc diseases;
- Prevention and mitigation of diseases that impede the development of the European fishing and aquaculture sectors;
- Improved productivity, economic performance and image of European fishing and aquaculture through improved biosecurity, health and welfare of marine animals;
- Improve resources management to preserve ecosystems' potential for sustainable production;
- Increased capacity to predict and measure the evolution of maritime pollution;
- Mitigate negative impacts of marine pollution on the marine environment, fisheries and maritime farms;
- Improve modelling outputs and reduce cost of data collection in support of maritime-related industrial and societal activities.

(b) Rationale for public intervention: key trends in the area, main challenges and indicators

The European Union has agreed that by 2015 where possible and by 2020 at the latest all fish stocks should be exploited at a level that will let them produce the maximum sustainable yield for the long term (MSY)[64]. This means taking the highest catches possible without affecting future productivity of the stocks. As an example of the current situation, in the Mediterranean Sea 93% of assessed fish stocks were overfished in 2015[65].

Catches are limited to levels based on scientific advice. This is done by setting total allowable catches (TACs) which are subdivided into national quotas[66]. These set limits on the amount of fish that can be caught and landed. The political and legal efforts of the EU will be in vain if all actors do not collaborate. Therefore, the EU fisheries sector has a very clear EU dimension, as choices at national or regional level directly impact the development and sustainability of the activity in neighbouring Member States.

[63] Horizon 2020, Work Programme 2014-2015, Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy. http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-food_en.pdf

[64] European Commission, Managing Fisheries. http://ec.europa.eu/fisheries/cfp/fishing_rules_en

[65] European Commission – Press release. Commission plans for 2016 fishing opportunities: North and Atlantic seas fisheries progress to sustainability, serious overfishing in Mediterranean. http://europa.eu/rapid/press-release_IP-15-5082_en.htm

[66] More information on TACs and quotas can be found in European Commission, Managing Fisheries, TACs and quotas webpage. https://ec.europa.eu/fisheries/cfp/fishing_rules/tacs_en

The EU fishing fleet is very diverse, with vessels ranging from under six metres to over 75. According to the Communication on the Reform of the Common Fisheries Policy, fleet overcapacity remains one of the main obstacles to achieve sustainable fisheries[67]. Under EU law the total capacity of the fishing fleet may not be increased and any decommissioning of vessels or reduction of fleet capacity obtained through public support must be permanent. For the last 20 years, the EU fishing fleet capacity has declined in terms of both tonnage and engine power. Despite enlargements to the EU, the number of EU vessels in 2015 was 85,154, 18,693 fewer than in 1996. Restructuring the fishing industry is estimated to raise crew wages and improve job attractiveness and working conditions in the sector. At the same time, the creation of jobs in the processing industry should partially compensate job losses in the catching sector[68].

The unintended effects of fishing on the marine environment and ecosystems have to be mitigated. Where necessary, the EU adopts measures to protect vulnerable habitats such as deep-sea corals, and to reduce unintended harm to seabirds, seals and dolphins. Illegal fishing is also a major threat to global marine resources. It depletes fish stocks, destroys marine habitats, distorts competition, puts honest fishers at an unfair disadvantage, and destroys the livelihoods of coastal communities, particularly in developing countries. It is estimated that between 11 and 26 million tonnes of fish are caught illegally a year, corresponding to at least 15% of the world's catches.

Promoting the sustainable development of aquaculture is crucial to reduce the pressure on fisheries and meet the growing global demand for fish and seafood. Europe represents the largest market for fish in the world. Currently, an average of 23.1 kg of seafood per person per year are consumed in Europe[69]. Consumption has increased over the past decades and is predicted further growth in the future. Only one out of four fish we eat in the EU comes from aquaculture today. That is not nearly enough, especially considering that seafood products farmed in the EU are as safe as can be – for animals and ecosystems as well as for us humans.

With EU landings of caught fish decreasing, fish imports have increased to around 65% of the seafood consumed in the EU. In 2015, the UE produced only 1.53% of all worldwide aquaculture production. Asian countries currently dominate aquaculture production, with China producing 61% of the whole aquaculture production volume. EU aquaculture produces around 1.25 million tonnes of fish, which represents around 4 billion Euros in value and directly employs 85.000 workers. EU aquaculture should be seen as an heterogeneous sector, with 90% of EU enterprises in the sector having under 10 employees, ranging from coastal and pond farming to a high-tech industrialised activity in particular marine fish farming. Current EU aquaculture production is mainly concentrated in 4 countries: Spain, United Kingdom, France and Greece making up 70% in volume and value of whole EU-28.[70]

Currently, the open method of coordination provides a framework for national strategy development of aquaculture and for coordinating policies between EU Member States. This voluntary process aims at giving practical answers to the challenges identified by the Member

[67] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Reform of the Common Fisheries Policy. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0417&from=EN

[68] Commission Staff Working Paper, Impact Assessment Accompanying Commission proposal for a Regulation of the European Parliament and of the Council on the Common Fisheries Policy. Referenced in http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0417&from=EN

[69] European Commission, Facts and figures on EU aquaculture production and consumption in an EU and global context. https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/2015-aquaculture-facts_en.pdf

[70] The Economic Performance of the EU Aquaculture Sector – Scientific, Technical and Economic Committee for Fisheries (STECF) https://stecf.jrc.ec.europa.eu/documents/43805/839433/2014-11_STECF+14-18+-+EU+Aquaculture+sector_JRCxxx.pdf

States and stakeholders. According to the aquaculture Strategic Guidelines[71], four priority areas should be addressed to unlock the potential of EU aquaculture:

- **Enhancing the competitiveness of EU aquaculture**. Business development and diversification can be promoted by market-driven research, innovation and knowledge transfer. To this end, the Member States should foster synergy between national research programmes and promote the participation of industry in research and innovation activities.
- **Promoting a level playing field for EU operators by exploiting their competitive advantages**. Experience in the agricultural sector confirms that there is a growing demand for sustainable, high quality food. High environmental, animal health and consumer protection standards are among the EU aquaculture's main competitive factors and should be more effectively exploited to compete on the markets. According to FAO, organic aquaculture production in Europe increased by close to 30% annually between 1998 and 2007.
- Securing sustainable development and growth of aquaculture through **coordinated spatial planning**. The lack of space often cited as a hindering factor for the expansion of EU marine aquaculture can be overcome by identifying the most suitable sites amenable for aquaculture, as the current surface and coastline occupation by aquaculture activities appears to be limited. Assessing environmental aspects in the frame of the spatial planning process can reduce the administrative burden for private developers and limit uncertainty in the licencing procedures, thus making investments more attractive.
- **Simplify administrative procedures**. Available information suggests that in several Member States authorisation procedures often take around 2-3 years to complete. Most aquaculture producers are SMEs, and they are disproportionately affected by red tape.

Interacting with fishing and aquaculture activities, marine environment and conditions across Europe are protected by the Marine Strategy Framework Directive since it was first adopted on June 2008[72]. The Directive aims to achieve Good Environmental Status (GES) of EU's seas and oceans by 2020. This is defined as the "status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive"[73]. Moreover, GES implies that: first, ecosystems are fully functioning and resilient to human-induced environmental change. Second, the decline of biodiversity caused by human activities is prevented and biodiversity is protected. Third, human activities introducing interacting with marine environment do not cause pollution effects.

Member States are required to develop a strategy for achieving Good Environmental Status and these must be kept updated and reviewed every 6 years. National marine strategies must include an initial assessment of the current environmental status of national marine waters, environmental targets with indicators and the establishment of a monitoring programme.

The table below provides a list of example indicators commonly used to measure the key trends and challenges of European fisheries, aquaculture and marine conditions sectors.

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[71] European Commission, Strategic Guidelines for the sustainable development of EU aquaculture http://ec.europa.eu/fisheries/cfp/aquaculture/official_documents/com_2013_229_en.pdf

[72] Directive 2008/56/EC of the European Parliament and of the Council. Establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0056&from=EN

[73] Article 3. Directive 2008/56/EC of the European Parliament and of the Council. Establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0056&from=EN

Table 17 Key indicators related to the areas of fisheries, aquaculture & marine conditions

Indicator	Indicator values/examples
Apparent seafood consumption	23.1 kg/year in 2012[74]
Gross amount of catches from EU fishing sector	5.1 million tonnes in 2015[75]
Gross profit of EU fishing fleet	1.3 billion Euros in 2013**Error! Bookmark not defined.**
Net profit of EU fishing fleet	506 million euros in 2013**Error! Bookmark not defined.**
EU fishing fleet capacity	83,734 vessels in 2013; Combined gross tonnage of 1.6 million tonnes in 2013; 6.5 million kilowatts of engine power in 2013[76].
Sector energy consumption in millions of litres of fuel/ energy efficiency	2, 353 million litres of fuel in 2013; 502 litres per landed tonne of fish in 2013[77].
Direct employment in the fishing sector	149,000 workers which correspond to a total of 110,000 jobs in Full Time Estimates.**Error! Bookmark not defined.**
Productivity of EU fleet	23.000 Euros per full time job.**Error! Bookmark not defined.**
Sustainability of fish stocks	Percentage of stocks overfished.
Gross production from EU aquaculture sector	1.2 million tonnes in 2014**Error! Bookmark not defined.**
Value of production from EU aquaculture sector	3.9 billion Euros in 2014**Error! Bookmark not defined.**
Direct employment in the aquaculture sector	Direct employment of 85,000 workers**Error! Bookmark not defined.**
Average yearly wage of aquaculture workers	22,100 euros in 2012**Error! Bookmark not defined.**
Aquaculture key performance indicators (KPI): growth rates, mortality and feed efficiency/feed conversion ratio	Feed conversion ratio of [1.0-1.2] for salmonids and [1.4-1.8] for omnivorous fish.[78]
Aquaculture productivity & economic performance	3,000 Euros per tonne in 2014[79]
Net investments in aquaculture sector	i.e. 64.8 million Euros in France in 2012; 223.8 million Euros in Italy in 2012[80]
Index of diversification of EU aquaculture	0.3504 for freshwater aquaculture, 0.3 for marine, 0.19 for shellfish**Error! Bookmark not defined.**

Source: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming).

[74] European Commission, Facts and figures on EU aquaculture production and consumption in an EU and global context. https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/2015-aquaculture-facts_en.pdf
[75] Eurostat
[76] Scientific, Technical and Economic Committee for Fisheries, 2015 Annual Economic Report on the EU Fishing Fleet. https://stecf.jrc.ec.europa.eu/documents/43805/1034590/2015-07_STECF+15-07+-+AER+2015_JRCxxx.pdf
[77] Based on data in Table 3.6.1 in Scientific, Technical and Economic Committee for Fisheries, The 2015 Annual Economic Report on the EU Fishing Fleet https://stecf.jrc.ec.europa.eu/documents/43805/1034590/2015-07_STECF+15-07+-+AER+2015_JRCxxx.pdf
[78] JRC Technical Reports, An approach Towards European Aquaculture Performance Indicators: Indicators for Sustainable Aquaculture in the European Union. http://publications.jrc.ec.europa.eu/repository/bitstream/JRC75891/jrc_g04_fishreg_eapi%20final.pdf
[79] Source: Eurostat
[80] JRC Scientific and Policy Reports, The Economic Performance of the EU Aquaculture Sector (STECF 14-18). https://stecf.jrc.ec.europa.eu/documents/43805/839433/2014-11_STECF+14-18+-+EU+Aquaculture+sector_JRCxxx.pdf

(c) Defining the scope of the European added value case study

FP7 contributed with almost EUR 100 million to R&D activities in the fisheries sector. Most of the funded FP7 projects in this area were supported by Food, Agriculture and Biotechnology (FP7-KBBE) and Transport (FP7-TRANSPORT), contributing with EUR 28 and 27 million respectively. Projects funded under FP7-KBBE were related to a wide range of topics such as: 1) fisheries management and sustainability; 2) transmission of scientific knowledge to stakeholders; and 3) mitigating the adverse impacts of fisheries on marine environment and ecosystems. Fisheries projects under FP7-TRANSPORT were mostly related to technological improvements of vessels such as reduction of fuel consumption and decreasing emissions. Projects funded under FP7-ENVIRONMENT, with a total contribution of EUR 20 million, also had an important role on promoting sustainable fisheries through the involvement of stakeholders on fisheries management and diminishing the impact of fishing activities on seas and oceans.

With 51 projects and a total contribution of approximately EUR 130 million, FP7-KBBE and FP7-SME had a major role in funding Aquaculture projects with around EUR 80 and 30 million respectively. These programmes covered research areas such as: the introduction of new species; the improvement of technical capabilities and productivity of the sector; achieving products with higher market value; and minimising the environmental risk of fish escapes.

Research on marine conditions received around EUR 340 million from FP7 funding. The largest part of the funding was supported under KBBE and ENVIRONMEMT programmes. Activities in KBBE tended to interact with fishing and aquaculture activities. Some examples of issues covered in this theme were monitoring toxins and pollutants in food production processes in the aquatic environment, the study of genetic differences of released farmed fish and helping consumers make fully informed choices with regards sustainability and safety of their seafood. FP7 ENVIRONMENT projects focused on topics with slightly less direct impact on fisheries and aquaculture. Examples of the areas covered are the better understanding and knowledge of ecosystems and their interaction with human activities, improving capacities to obtain and manage sea and ocean environmental data, reducing environmental risks such as algal blooms and understanding the impacts of climate change on marine ecosystems.

Table 18 Projects related to the areas of Fisheries, Aquaculture and Marine conditions and their allocated EU contribution

	Fisheries		Aquaculture		Marine Conditions	
Programme	**Number of projects**	**EU contribution, EUR million**	**Number of projects**	**EU contribution, EUR million**	**Number of projects**	**EU contribution, EUR million**
FP7-KBBE	10	31.1	21	77.7	16	77.8
FP7-TRANSPORT	9	26.5	0	0.0	2	5.6
FP7-SME	4	6.0	24	29.1	5	7.1
FP7-ENVIRONMENT	3	20.1	1	6.0	23	74.8
FP7-SiS	2	6.6	0	0.0	0	0.0
FP7-INFRA	1	5.0	1	9.2	5	24.0
FP7-REGPOT	1	0.9	3	4.3	0	0.0
FP7-ICT	0	0.0	0	0.0	3	8.7
FP7-SPACE	1	1.6	1	2.5	5	69.3
Total	30	97.8	51	128.8	60	336.6

Source: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming). based on CORDA data

F.3.2. Key findings

(a) Factors/mechanisms of influence fostering European added value

Reduction of commercial and research risks

The reduction of commercial risk was an added value in certain areas of research with potential return on investment. These areas were usually characterised by having long maturity processes of their innovation and therefore being many years away from the market. Long-term research actions could be considered too risky without public funds. According to interviews, projects of this kind would most probably have been discontinued without public intervention. Most interviewees were uncertain if national funds would have been able to cover commercial and research risks to the same extent as FP7 did.

Reduction of research risks would also be important in specific projects where fish are farmed and diseases or other biological hazards could have substantial negative impact on research outcomes. The availability of a large number of partners in FP7 and the flexibility in distributing funds across partners helped these projects diversify their risks.

Leverage of private and public investment

Interviews with beneficiaries revealed that FP7 leverage of investment in fisheries and aquaculture projects was rather limited and happened mostly from public sources of funding. Fisheries and aquaculture R&D activities are not traditionally associated with large amounts of funding from private sources. Interviews confirmed the difficulties of these research areas to attract additional private funds. Only a limited number of projects achieved further direct private investment. These projects were characterised by the development of close to market innovations. There is, however, an interesting trend of FP7 attracting considerable in-kind investments. This is especially relevant in aquaculture, where industry partners frequently committed part of their eggs/fish stocks or facilities for research purposes. The value of these in-kind investments is not easy to quantify in monetary terms, but it was relevant to kick-start many projects.

Another trend found during the interviews is that many projects used European funds to start research on specific areas. At later stages of the project, they obtained follow-up national grants to further develop narrow research issues. These sub-areas of research funded by national grants tended to be more geographically localised and more focused in scope. Follow-up national grants were especially common in certain countries where national R&D policies have traditionally allocated larger amounts of resources to support research on fisheries and aquaculture (i.e. Norway and France).

Pooling resources and building critical mass

Access to infrastructures not available in many EU countries was crucial for the development of most FP7 projects in fisheries, aquaculture and marine conditions. There are at least three reasons for this. First, many projects required infrastructures, skills or capacities that could only be found in certain 'innovation clusters' around Europe. These are projects that require very specific technical knowledge, skills or infrastructures that could not be found in any single European country. Therefore, without FP7 funds, research teams would not have been able to access key infrastructure or knowledge available somewhere else in Europe. Many projects in

fisheries and aquaculture were based on these kinds of 'vertical cooperation' where each partner was in charge of a particular task or contributed with unique facilities.

In aquaculture, it was frequent to observe private partners in hatcheries and fish farms implementing actual interventions and collecting data while universities or public research centres focused on analysing results. Therefore, research centres tended to rely not only on their own data, but also on important research data collected, in many cases, by private partners. A number of interviews confirmed that most national programmes would not include the required amount of international partners and kinds of collaborations that these projects require. Therefore, a majority of these projects involving specialised partners would not have gone ahead without European funding.

A second European added value aspect on pooling resources can be found on projects that were based on comparative research. Many FP7 projects in the areas of fisheries, aquaculture and marine conditions consisted on comparing the effects of an intervention on different species or ecosystems. These frequently required international partners in different European sea basins to cooperate in the implementation of the project. Data was usually collected in different environments (i.e. different sea basins) and analysed to compare results. In this kind of 'comparative projects' interviewees said that, without FP7 funds, projects would have gone ahead with a very substantial reduction in scope. This was mostly because they would not have been able to do these comparisons or application of research in different environments/ecosystems.

Related to this European added value aspect, interviews also showed that European fisheries and aquaculture projects offered many more possibilities to include multi- and inter-disciplinary teams than most national schemes. This made it possible to implement projects which were based on innovative combinations of approaches (i.e. integrating social sciences and pure sciences) or involvement of stakeholders. Therefore, without European funds the diversity of partners would most likely have been lower.

A third European added value aspect related to pooling resources and building critical mass is the size of certain European projects. The amount of funding of some of these projects is larger than that available from most national funding schemes. Occasionally, EU funding acted as a catalyst for projects that could not be developed only at national level. In this sense, EU funding kick-started research in one area and later attracted further national funds for complementary research activities.

Increased international and/or inter-sectoral mobility of researchers

Interviews with project beneficiaries confirmed that **international and cross sectorial mobility** was one of the main European added value aspects in fisheries, aquaculture and marine conditions projects. Practically all projects in these research areas included examples of international mobility of researchers, PhD students and/or stakeholders. International exchanges between public research institutions were very frequent. These tended to have relatively long durations (6 months to 1 year) and largely contributed to knowledge transfer and creating research networks.

International travels to visit research infrastructures (i.e. fish farms or hatcheries in case of aquaculture projects) were also common. According to interviews, even these short-term exchanges (few days to weeks) proved to support outstanding results and benefits, especially when associated to detailed planning and preparatory work, with the establishment of long-term

collaborations that are still on force, even beyond the duration of the project. Interviews highlighted the creation of knowledge and share of know-how that these visits meant for many partners. There were even cases where professionals from academia switched to the private sector and reached management positions in private research facilities. This happened in two ways. First, researchers in public research institutions moved to technical positions in partner companies. The second way was the direct creation of spin-offs from academy. Interviews confirmed that the links and networks established during FP7 projects have been crucial for these inter-sectoral exchanges of personnel and professional careers.

Some FP7 projects also included international stakeholder meetings and trips to exchange experiences. Interviews confirmed that FP7 projects made sharing information among stakeholders possible by bridging typical language barriers that would occur otherwise.

(b) Better results achieved because of European added value

Improved research excellence / capabilities

FP7 funding in the areas of fisheries, aquaculture and marine conditions had a considerable positive added value on research excellence and capabilities. According to interviewees, the European added value of FP7 on research capabilities was related to its ability to: 1) allow the cooperation among best experts on a field; 2) promote multidisciplinary teams; 3) develop new open access research infrastructures; and 4) create jobs in research institutions.

A clear added value of FP7 is its capacity to create first-class international networks with leading partners and the best experts on the field. Inside of these networks, there is frequently a high degree of multi- and interdisciplinarity that allows associates to complement each other in terms of specific skills and knowledge. This larger diversity of partners in European networks also allowed collaborations across different fields of research which were sustained once the project was finished.

In certain cases, FP7 helped develop further research infrastructures and data which are now openly available to the whole research community. A clear example is the 'Transnational Access' online platform created during the FP7 - AquaExcel project (and developed under Horizon 2020 – AquaExcel2020) [81]. This platform currently allows online applications to pursue research using aquaculture research facilities located all across Europe. It also includes an 'interactive map' that allows to visualise these and other research infrastructures in Europe and beyond. Another example are the data and models from FP7 - LifeWatch project, currently on open access and under creative commons, which allow researchers from all around the world to have an insight on marine biodiversity in European coasts [82].

In many cases, the implementation of FP7 projects also created direct research job positions and PhD vacancies in research institutions. These largely benefited from the European added value of FP7 on mobility and research networks and are expected to contribute to improve future research capabilities of European organisations.

In terms of research excellence, FP7 contributed to achieve a larger number of relevant and high impact scientific publications. This was mostly due to the improved research capacities and new

[81] Aquaexcel 2020. http://www.aquaexcel2020.eu/
[82] LifeWatch. E-Science European Infrastructure for Biodiversity and Ecosystem research http://www.lifewatch.eu/
And LifeWatch Marine VRE. http://marine.lifewatch.eu/

approaches developed during FP7 projects. Research outputs greatly benefited from the possibility of bringing together the best experts from all across Europe, the capacity of sharing research data and infrastructures and the combination of different disciplines inside of FP7 projects. Many interviewees highlighted the possibility provided by FP7 of doing research in different ecosystems (i.e. different sea basins, fish species, water environments, etc.) and with people in different branches of science (including social scientists) as key factors behind the improvement of their research outputs and excellence. The comparative and multi/interdisciplinary approaches that FP7 allowed had a very large impact on producing new methodologies, research results and high impact scientific publications.

Another important factor behind better research excellence was the prestige granted by having received FP7 funds. The competition in FP7 calls was widely known in the research community. Therefore, FP7 beneficiaries were helped by a label of 'high competitive organisations' obtained from having been selected for European funding. According to interviews, this had a positive impact on beneficiaries in terms of participation in scientific conferences and general scientific publications. However, some interviewees reported that it is unlikely that this more prestigious image of FP7 beneficiaries would have helped achieve more publications in peer-reviewed journals. Peer reviewed journals in fields linked to aquaculture, fisheries and marine conditions (i.e. genomics, biology, environmental sciences) typically have robust revision procedures that only take into account the quality of submitted research. However, according to some interviewees, there is still a lack of high quality journals that recognize the value of inter-disciplinary research, as in the case of projects which applied a typical RRI approach. This barrier might affect the interest of marine scientists to engage into inter-disciplinary studies.

The increased visibility of researchers, the data collected within projects, the network established, and projects achievements, leveraged the capability of FP7 projects participants to get involved in application to new EU/national project calls, both as a spill-over activity from consortium already established or, as single partners involved by other, earlier unknown scientists, in new consortium.

Some interviewees also revealed an European added value aspect related to the perspective of reapplying to future FP7 and Horizon 2020 calls. According to them, there is a strong incentive to publish scientific publications based on research results from FP7 projects. These publications would show evaluators the capacities and achievements of the consortium members in previous projects and would therefore increase the chances to get funding in future FP calls. This motivation to publish is not present in most national programmes as they are usually not so competitive.

Economies of scale and scope

Despite not being the main area of European added value in fisheries, aquaculture and marine conditions, some interviewees agreed that their project achieved an increase in resource efficiency due to the scale of the project. This was mostly due to sharing research infrastructures and data between international partners. Without European-wide projects there would have been a repetition of efforts on developing facilities that can already be found in other EU countries. Moreover, those projects that involved data collection or analysis in different sea basins greatly benefited from international partnerships in terms of travel costs. Without international partners these projects would have sometimes required moving across Europe key infrastructures such as research vessels.

Wider availability and dissemination of knowledge

Interviews with project beneficiaries confirmed that FP7 funding had a substantial added value in terms of wider availability and dissemination of knowledge. More specifically, FP7 projects related to fisheries, aquaculture and marine conditions would have produced many more dissemination outputs and achieved a higher involvement of stakeholders than similar national projects.

Interviewees indicated that the size of FP7 projects and the prestige of having won a competitive EU grant allowed them to reach a much larger audience. A vast majority of projects had their own webpage with full explanations of the project, highlighted news and activities and links to publications with main results. However, in most cases these websites last only until a few years after the finalization of the projects. Many interviewees noted their participation in activities such as conferences, symposiums, expositions and radio interviews among others. According to interviews, these activities also affected the visibility and interest on FP7 activities at national level, thus also influencing national research interest on topics and innovative approaches developed at European scale.

European projects, due to the fact of being larger and more prestigious, were more successful in attracting and involving stakeholders. This further increased the impact and dissemination of results. At the same time, some projects acted as a platform for stakeholders to reach and influence European policy-makers. This was especially important in the fisheries sector, where small actors usually do not have the resources to cooperate among them at an international level (i.e. because of language barriers).

An obstacle to further added value of FP projects was the lack of incentives of certain partners to disclose research results. Interviews identified that private partners in projects could sometimes release only part of their research results in order to preserve their commercial interests. Interviews showed disagreements between project partners in public institutions and those in the private sector. While the former put emphasis on publishing results, the later were sometimes slightly reluctant to share knowledge that could give advantages to their direct competitors. A point of agreement between project partners was usually reached. This consisted on publishing all important research results except those that involved a larger level of micro-managing of privately owned research facilities.

Better coordination of national research policies and practices at the EU level

FP7 funded four ERA-NET projects in the areas of fisheries, aquaculture and marine conditions that had an added value in coordinating national research policies. These were the projects MariFish (2006-2011), SEAS-ERA (2010-2014), MarineBiotech (2011-2013), and the still active COFASP (2013-2017). The total EU funding for these four actions was around 8 million euros. According to interviews, these ERA-NET projects greatly helped identifying gaps, avoiding duplication of efforts and strengthening collaboration among national programmes and agencies in the areas of fisheries, aquaculture and marine conditions. Moreover, ERA-NET actions contributed to identify strategic and future priority sub-areas of research and reduced the financial and research risks by spreading research and innovation costs.

(c) Long-term impacts resulting from European added value

Better addressing societal / pan-European challenges

EU level actions were crucial to develop a more resource-efficient Europe with sustainable production of safe, nutritious and healthy food from renewable resources. FP7 largely

contributed to optimise the sustainable contribution of fisheries and aquaculture while providing viable solutions to natural ecosystems. Interviewees mentioned that some national programmes can also address these issues, but they tend to be too specific and do not have a long term perspective of these pan-European challenges.

As explained in previous sections, the fisheries sector can not rely on fishing more because it would not be sustainable. There needs to be a change towards fishing more intelligently with a more modern and innovative fishing sector. FP7 projects have contributed to enhance scientific knowledge and innovation which is used to support decision making and more sustainable fisheries management. Moreover, some projects (e.g. Gap1, Gap2, Jakfish) also addressed the benefits of an increased stakeholders participation into research activities, fisheries management and marine governance, providing pan-European experiences, guidelines and toolbox to support approaches for a more active engagement of societal actors to tackle EU societal challenges that are relevant to managers and policy makers. At the same time, FP7 actions have played a part in producing innovations to increase fuel efficiency of vessels which can reduce emissions and noise in seas.

FP7 recognised the potential of aquaculture for growth, innovation and addressing pan-European societal challenges. Interviews confirmed that Europe is one of the leading actors behind aquaculture technological development and research. European R&D projects played a key role in achieving innovations and research outputs much faster that it would have taken without international cooperation.

A.1.1. Stories of impact

SALMOTRIP

Escaped fish can potentially cause disastrous consequences on ecosystems. These animals can impact the genetic pool of native fish populations through interbreeding, affect ecosystems through predation and competition, and transfer diseases to wild fish. In a worst-case scenario, escaped fish can expand, devastate local species and cause ecosystem collapse. Moreover, fish escapes might have had a substantial impact on the image of aquaculture. From 2007 to 2009, 255 escape events were documented in Europe. These added an estimated 9.2 million fish[83]. These events were mostly caused by technical and operational failures such as cages break, netting holes and operational accidents.

The FP7 project SALMOTRIP offered important steps to tackle negative impacts of fish escapes in aquaculture[84]. The project provided very relevant evidence of the possibility of farming and commercialising sterile salmon. In the mid future, this could generate an important innovation that could significantly improve the performance of European salmon industry and its ecological risks.

SALMOTRIP achieved the production of sterile (triploid) salmon for experimental and commercial trials and significantly strengthened the scientific understanding of biological needs of sterile (triploid) fish. Moreover, the project provided important recommendations on how to implement a full-scale production of sterile salmon and identified areas for further study before triploid salmon can be commercialised. According to interviews performed, results from this project could be potentially extended to other species in the future.

[83] Final Report from FP7 project Prevent Escape. http://cordis.europa.eu/result/rcn/56373_en.html
[84] Salmotrip. http://cordis.europa.eu/project/rcn/92644_en.html

Sterile (triploid) fish are created by forcing the egg to keep a chromosome that is normally eliminated during egg development. This is usually achieved by applying pressure to recently fertilised eggs. Before SALMOTRIP, tripoloid salmon was associated to poor economic performance due to higher mortalities and deformities. This occurred because traditional triploid egg production was often based on using substandard quality eggs. SALMOTRIP proved that with an adequate broodstock selection, triploid salmon can perform as well and even better than diploid ones. This was an important result as it constituted a significant improvement in this area of research and a potential culture change in the aquaculture sector.

FP7-SALMOTRIP was also an example of pan-European cooperation with strong trans-national collaboration involving two leading salmon breeding SMEs along with fish farming SMEs from three European countries and two UK research centres.

AQUAEXCEL

Interviewees highlighted the importance of cross-country cooperation in aquaculture. This allows researchers to compare results of research in different ecosystems (i.e. sea basins); to find very specific knowledge for cutting-edge projects; and to find particular infrastructures for experiments.

European aquaculture research experienced a certain degree of fragmentation as well as a lack of harmonization with important differences in criteria, methods and processes used for experiments.

One key FP7 project in the area of aquaculture, AQUAEXCEL[85] (2011-2015), provided a platform of top class research infrastructures and common standards and protocols for the aquaculture research community. This platform is still active under the follow-up AQUAEXCEL 2020 (2016-2020) project supported by Horizon 2020 funds. It currently integrates 39 facilities which range from production systems and fish species to research centres with specialised fields of expertise. Both projects (FP7-AQUAEXCEL and Horizon 2020-AQUAEXCEL 2020) were excellent examples of pooling resources at European level and were pointed as having very large European Added Value to aquaculture research.

The platform provides subsidised access to these facilities to selected research proposals and offers training for aquaculture researchers, technical staff and industry stakeholders. AQUAEXCEL was highly successful in this regard. It received 146 applications for research projects and funded 97 of these. The current project AQUAEXCEL 2020 has a budget of 9.7 million Euros and grants access to research teams, industry and SMEs from the EU-28 and associated research teams. Access for organisations based in third countries is limited to a maximum of 20%. AQUAEXCEL 2020 offers transnational access to infrastructures located in almost 20 different countries.

ARRAINA

ARRAINA contributed to develop sustainable alternative fish diets with reduced use of fish meal and fish oil[86]. This was achieved by studying the impact of different diets on various fish species over their full life cycle. The project carried out a large selection of tasks such as:

[85] Aquaexcel http://www.aquaexcel.eu/ and Aquaexcel 2020. http://www.aquaexcel2020.eu/
[86] Arraina http://www.arraina.eu/

- Analysing previous scientific findings on fish diet requirements;
- Studying the most efficient method to feed fish larvae and develop diets for these;
- Compiling a database to predict fish flesh fatty acid based on compared diets. This resulted in a tool that predicts the nutritional value of fish for human consumption;
- Comparing the effects of plant-based with traditional juvenile fish dietary supplements;
- Analysing the presence of contaminants (i.e. pesticides and mycotoxins) associated to non-marine based ingredients of aquaculture feed;
- Estimating waste loads and environmental impact of fish farms depending on the diet.

ARRAINA is expected to have a positive impact on fish nutrition and growth. In the mid-future, this will benefit aquaculture efficiency, competitiveness and economic performance. The project will potentially reduce environmental impacts of fish farms and will contribute towards safer fish for human consumption.

F.4. European added value case study 4: Fuel Cell & Hydrogen

F.4.1. Overall context

(a) Definition and expected impact of the area

The availability of sustainable, secure and competitive energy sources is a major factor determining today's economy's growth, jobs, stability and general well-being of European citizens. Energy is at the root of the climate change and air pollution: it accounts for 80% of all greenhouse gas (GHG) emission in the EU. Unfortunately, even today Europe's economy is still largely dependent on unsustainable carbon-based energy sources that also pose major environmental challenges. In the EU, the primary energy supply is 80% dependent on fossil fuels. Changing this trend will be extremely difficult primarily because the current infrastructure - networks and supply chains - have been optimised over decades to deliver energy from oil, coal and gas. In addition to the threat of the climate change and other environmental issues, this situation has made Europe vulnerable to energy supply fluctuations outsides its borders, which poses a major security issue for Europe.[87] It is estimated that Europe's dependence on carbon-based energy import will grow even more in the future: reliance on imports of gas is expected to increase from 57% to 84% by 2030, of oil from 82% to 93%. Finally, dependence on old sources of energy will likely to be a major challenges to Europe's future competitiveness with the EU becoming increasingly exposed to the effects of price volatility and price rises on international energy markets. [88]

All of the above challenges related to global climate change, Europe's security and competitiveness raise a need for a concerted EU-level action. Already the Europe's Energy Policy raised a strategic goal of 20% GHG reduction by 2020 (compared to 1990) and 80-95% reduction of 1990 levels by 2050 to keep the global temperature increase below 2°C. Tackling the energy-related challenges in Europe and meeting the above targets requires a transition to an

[87] Communication from the Commission, „Investing in the Development of Low Carbon Technologies" (SET-Plan), Brussels, 7.10.2009 COM(2009) 519 final.
[88] Communication from the Commission, „An energy Policy for Europe", Final, 2007.

energy and transport system built around low-carbon technologies.[89] Fuel cells and hydrogen (FCH) technologies belong to the most promising research areas, likely to contribute to the realisation of low-carbon economy in future's Europe. The main reason for this is that hydrogen is an energy carrier with the unequalled advantage of being storable in various forms and transportable in various modes. Most importantly, it can be produced from carbon-free or carbon-neutral energy sources, thereby allowing a drastic reduction of greenhouse gas emission in energy sector. Fuel cells provide the most efficient conversion device for converting hydrogen, and possibly other fuels, into electricity. In combination, fuel cells and hydrogen provide a pathway for a safe, carbon-free and decentralised energy generation with multiple applications.[90]

The importance of hydrogen as an alternative fuel is also acknowledged at the EU level. In 2008, the Fuel Cells and Hydrogen Joint Undertaking was established by a Council Regulation as a public-private partnership between the European Commission, European industry and research organisations to accelerate the development and deployment of fuel cell and hydrogen technologies. It was assumed that research, development and deployment strategies in which all the stakeholders are committed to common objective are necessary in order to achieve a significant market penetration by fuel cells and hydrogen technologies in transport and power generation.

In 2013, the Commission issued a Communication on Clean Power for Transport: A European alternative fuels strategy[91] followed by a Directive on the deployment of alternative fuels infrastructure[92]. These documents list hydrogen as one of the alternative fuels to substitute fossil oil sources in the energy supply to transport. Hydrogen is seen as having a potential to cover all transport modes (road-passenger, road-freight, rail and water) except air transport.[93] In order to improve the acceptance of these technologies related to the alternative fuels, information campaigns and large-scale demonstration projects are seen as important tools. The Strategy emphasises that based on the experience gained with the European Technology Platforms and Joint Technology Initiatives, public-private partnerships should be further developed. The Directive indicates the need to better coordinate the policy in this field and therefore requires that "*Each Member State shall adopt a national policy framework for the development of the market as regards alternative fuels in the transport sector and the deployment of the relevant infrastructure*".[94]

Expected impact

The overall long-term objective of the FP7-funded research projects in the area of fuel cells and hydrogen is to accelerate the market introduction of fuel cells and hydrogen technologies, realising their potential as an instrument in achieving a carbon-lean energy system in Europe.

[89] Georg Zachmann, Cutting Carbon, not the Economy, Bruegel Policy Contribution, Issue 2012/03 FEBRUARY 2011.
[90] Pierre-Etienne Franc et al., Fuel Cell and Hydrogen technologies in Europe 2014-2020: Financial and technology outlook on the European sector ambition 2014- 2020, 2011.
[91] EC, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Clean Power for Transport: A European alternative fuels strategy. Brussels, 24.1.2013, COM(2013) 17 final.
[92] Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of laternative fuels infrastructure. Official Journal of the European Union, 28.10.2014, L 307/1.
[93] EC, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Clean Power for Transport: A European alternative fuels strategy. Brussels, 24.1.2013, COM(2013) 17 final. P. 4.
[94] Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure. Official Journal of the European Union, 28.10.2014, L 307/1.

However, to achieve this general objective intensive research efforts are needed in several important areas, where the impacts of the EU-funded research in fuel cells and hydrogen are mostly expected[95]:

Hydrogen Production. In this area the research is expected to result in the development and implementation of cost-competitive, energy efficient and sustainable hydrogen production, storage and distribution processes that would satisfy Europe‘s long-term energy demands and help to switch to hydrogen-based economy. When considered as based on natural gas, hydrogen production is already an advanced technology. However, more intense research is needed in order to provide hydrogen from ‚CO_2-free‘ sources, such as renewables and nuclear power. The sustainable hydrogen production technologies expected to result from the research include (i) reforming (and gas purification) based on bio-fuels as well as conventional fuels; (ii) cost-efficient low-temperature electrolysers adapted for the large-scale use of carbon free electricity and (iii) biomass to hydrogen (BTH) thermal conversion.

Hydrogen storage and distribution. Major technical advances are needed in this area as the current energy density is fairly low for existing hydrogen storage technologies, being 10 – 20 % of that of gasoline or diesel. To increase the storage capacities, current research is expected to result in the development and demonstration of technology options for high volume, safe hydrogen storage such as storage in underground caverns and decentralized storage. In addition, the research should provide improved hydrogen storage based on solid and liquid materials. In terms of the hydrogen distribution, the research is expected to improve the means of hydrogen distribution and delivery by road transport (e.g. increased capacity), in order to meet the needs of large fuelling stations.

Stationary Power Generation and Combined Heat & Power. In this area, research is expected to improve the technology for fuel cell stack and balance of plant components to the level required by the stationary power generation and Combined Heat and Power (CHP) markets by bridging the gap between laboratory prototypes and pre-commercial systems. For this purpose, it will be important to achieve the principal technical and economic specifications necessary for stationary fuel cell systems to compete with existing and future energy conversion technologies. Research will deliver new or improved materials as well as reliable control and diagnostics tools both at component and system levels. It will also improve their performance, endurance, robustness, durability and cost. In addition, research will aim at making the new technologies ready for their introduction into the market: this will require test campaigns for product validation under real market conditions and preparations for the start-up of fuel cell installation, operation and maintenance services.

Transport & Refuelling Infrastructure. In this area research is expected to support the development and testing of competitive hydrogen-fuelled road vehicles and corresponding hydrogen refuelling infrastructure, and the full range of supporting elements for market deployment and increased industrial capacity. Most importantly, a variety of fuel cell hybrid vehicles, including cars and buses, hydrogen-fuelled vehicles and an appropriate number of refuelling stations, should be generated and demonstrated in fuel cells and hydrogen focused research projects. In addition, the research should demonstrate that this new type of vehicles are suitable are ready for large-scale market use, including the durability, robustness, reliability, efficiency and sustainability of both vehicles and support infrastructures. In addition, research

[95] Fuel Cells And Hydrogen Joint Undertaking (Fch Ju), Multi - Annual Implementation Plan 2008 – 2013, Adopted by the FCH JU Governing Board on 22nd November 2011.
Also: European Hydrogene & Fuel Cell Technology Platform: Strategic research Agenda, 2005.

activities also envisage the application of fuel cells and hydrogen based technologies in the area of heavy duty road transport, such as commuter trains, rail cars, city trains, trucks, aircrafts, as well as maritime applications. Finally, in terms of the refuelling infrastructures, research activities are expected to result in the development and integration of the necessary components for hydrogen refuelling stations and their associated peripheral conditioning systems. As in the case of transport, application, research should also lead to the improvement of refuelling infrastructure‘s energy efficiency, robustness, functionality, safety, as well as prepare it for large-scale introduction into the markets. Overall, research on the application of fuel cells and hydrogen technologies in the area of transport and refuelling technologies is expected to be the main instrument in reducing CO_2 emissions, alleviating dependence on oil and improve fuel economy in Europe.

Early Markets (portable applications). Although not highly relevant for reducing CO_2 emissions and developing carbon-free energy economy, early market applications are important in terms of proliferating fuel cells and creating an early industry consisting mainly of SMEs. Therefore, it is expected that research projects focusing on fuel cells and hydrogen will also contribute to the development and deployment of a range of fuel cell-based products capable of entering the market in the near term. More specifically, research will show the technology readiness of (i) portable and micro fuel cells for various applications; (ii) portable generators, back-up power and UPS-systems; (iii) specialty material handling vehicles including related hydrogen refuelling infrastructure. Most importantly, the expected impacts include not only the development of these technologies, but also preparation for their wide-scale market introduction by reducing the production costs, achieving the market economies.

(b) Rationale for public intervention: key trends in the area, main challenges and indicators

Although fuel cells and hydrogen provide probably one of the most promising pathways to a carbon-free economy in Europe, markets alone cannot encourage the development and deployment of competitive technologies.[96] The scale and scope of the financial resources and technical capacities necessary for the development and deployment of fuel cells and hydrogen technologies across the spectrum of applications goes beyond the capacity of single companies or public research institutions. Several key barriers require a concerted EU-level action that would unite and coordinate the efforts of industry and research community:

- In order to introduce new technologies into a consumer market, a **close collaboration between public and private entities** is necessary. This collaboration will help to bridge the gap between the research/prototype demonstration stage and the full-scale commercial introduction of fuel cells and hydrogen technologies[97]. The Joint Undertaking in the area of fuel cells and hydrogen supported by the European Commission helps to ensure the leading role of industry in defining priorities and timeliness of the work;

- As in the case of many new technologies, a threat of market failure poses a real threat for the deployment of fuel cells and hydrogen technologies in European economies. During the transition period, the initial investment cost and risks are too great for private companies and mass-market volumes are too distant, as is return on investment. This means public intervention is needed to **share costs and risks with the private sector** and to bridge the gap

[96] Georg Zachmann et al., The great transformation: decarbonising Europe’s energy and transport systems, Bruegel 2012.
[97] European Hydrogen and Fuel Cells Technology Platform, Deployment Strategy, August 2005.

to the market. A critical mass of public investment in R&D and infrastructure should help to create the conditions for the emergence of a competitive consumer market[98];

- **Mobilisation and pooling of resources and expertise:** strong involvement of the EU in supporting the research in fuel cells and hydrogen helps to mobilise a critical mass of financial resources and expertise necessary for complex and expensive tasks involved, as well as to leverage the funds from private and national/regional entities. Moreover, a better coordination of the European, national and private resources should increase the efficiency and economic value of the research.

A European public-private partnership – Fuel Cells and Hydrogen Joint Undertaking – was established in order to address all of the above needs. High-level objectives and targets have been identified following a thorough assessment performed primarily by working groups comprising representatives of the Industry and Research Groupings and in consultation with the Commission (see Table below). The targets represent qualitative and quantitative objectives against which the progress of the Fuel Cells and Hydrogen Joint Undertaking is to be assessed in four application areas: transportation and refuelling infrastructure; hydrogen production; stationary power generation and combined heat and power; early markets. These targets and indicators summarised below are of different types and concern the price of the fuel cells and hydrogen technologies (e.g. it is aimed that the hydrogen delivered to retail stations should cost around 5-9 EUR per kilogram by 2020), quantity (e.g. by 2020 it is expected to have 20 000 fuel cell cars) and capacity (e.g. the target for distributed production of hydrogen by water electrolysis for 2015 was 1.5 tonnes per day).

Table 19. List of key indicators related to the area of this European added value case study

Indicator			**Volume & cost**	
Application Area	Market application		2015 mid-term MAIP targets	2020 long-term MAWP targets
AA1 – Transportation & Refuelling	Cars: Vehicle PEM-FC System		>5,000 / <50k€ 100€/kW	50,000 /<30k€ for C-segment 50€/kW
	Busses: Vehicle PEM-FC System		500 / <1M€ <3,500€/kW	200 / <650k€ <400€/kW
	Hydrogen refueling stations		<300 / 0.6 - 2.5 M€ (depending on size of filling station)	/ 0.8 - 2.1M€ (depending on size of filling station) no target for nr of HRSs in MAWP
	APU's	for truck applications (5kW)	1,000€	<3000 €/kW for 3 kW
		for aircraft applications (20-120kW)	flight validation supply	<3000 €/kW for 3 kW
		for maritime applications (50-500 kW)	some tens / 3000-4000 €/kW	<3000 €/kW for 3 kW
AA2 – Production	Hydrogen delivered to retail station		5 €/kg	5-9 €/kg
	Distributed production of		1.5 t/d cap. | 68% eff. | 2.8 M€/(t/d)	No capacity and no efficiency

[98] Pierre-Etienne Franc et al., Fuel Cell and Hydrogen technologies in Europe 2014-2020: Financial and technology outlook on the European sector ambition 2014- 2020, 2011; Also http://www.fch.europa.eu/page/who-we-are

Indicator		Volume & cost	
	hydrogen by water electrolysis		targets in MAWP | 2 M€/(t/d) for electrolysers (irrespective of whether distributed or centralised H2 production
	Distributed production by reforming of biogas SMR (incl. purification)	1.5 t/d cap. | 64% eff. | 3.8 M€/(t/d)	No capacity target in MAWP| 70% eff. | 3.1 M€/(t/d)
	Total installed production capacity from renewables	-	No target in MAWP
	Centralized production of hydrogen by water electrolysis	-	No target in MAWP specifically for centralised or distributed electrolysers
	Centralized underground storage of hydrogen	-	No target in MAWP Target of 0.45 M€/t for gas storage
	Distributed storage of gaseous hydrogen	5 t cap. | 0.45 M€/t	No target in MAWP
	Storage of hydrogen in solid materials	5 t cap. | 1.5 M€/t	No target in MAWP
	Total installed storage capacity of H2 produced from grid	-	No target in MAWP
	High capacity compressed H2 trailer	1.3 t cap. | 0,55 M€/t	No capacity target in MAWP. | 0.55 M€/t
AA3 – Stationary	Micro-CHP (residential), natural gas based	1,000 units / 10,000 € per system (1kWe + household heat) Assuming supported deployment from 2013+	No deployment targets in MAWP /12000€/kW
	Industrial/commercial, H2 based	>5 MW / 3,000 €/kW Assuming supported deployment from 2013+	No deployment target in MAWP / 2000-3000 €/kW without limitation to H2 feed
	Industrial/commercial, natural gas based	>5 MW / 4,000 €/kW Assuming supported deployment from 2013+	No distinction in MAWP whether H2 or natural gas
AA4 - Early markets	Heavy duty material handling vehicles	>1,500 units | <1,500€/kW fuel cell system Anticipating supported deployment from 2013+	No deployment targets in MAWP | <1,200€/kW fuel cell system
	Back-up power systems	9.000 units | <1.500€/kW fuel cell system	No specific targets in MAWP
	Small micro fuel cells	>30,000 units | <6,000€/kW fuel cell system	No specific targets in MAWP

Source: Source: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming based on Fuel Cells and Hydrogen Joint Undertaking (FCH JU), Multi - Annual Implementation Plan 2008 – 2013, Adopted by the FCH JU Governing Board on 22nd November 2011; FCH2 JU, Multi-Annual Work Plan 2014 – 2020, Adopted by the FCH2 JU Governing Board on 30th June 2014.

(c) Defining the scope of the European added value case study

With 155 projects and EUR 450 million EC contribution, the largest and the most important programme supporting research in fuel cells and hydrogen was the FP7 Fuel Cells and Hydrogen Joint Undertaking. The relevant research, however, was conducted under other FP7 specific programmes, including FP7-Energy, FP7-NMP and others.

The distribution of FP7 funding for fuel cells and hydrogen research across different programmes shows the current state-of-play and the general policy objectives in this area. Around 72% of all FP7 projects in fuel cells and hydrogen and 71% of all funding was distributed through the Fuel Cells and Hydrogen Joint Undertaking, thereby implying that fuel cells and hydrogen research in Europe has reached advanced stages and the major efforts are made to bring the technology closer to the market and translate it into specific products. Although to a considerably smaller extent, FP7-ENERGY was the second most popular programme for the fuel cells and hydrogen related research, thereby showing that fuel cells and hydrogen is one the most promising research area in terms of advancing alternative sources of energy.

Table 20 Projects related to the area of fuel cells and hydrogen and their allocated EU contribution

Programme	Number of projects	EU contribution, EUR million
FP7-ENERGY	20	73.3
FP7-ENVIRONMENT	4	11.8
FP7-NMP	16	58.3
FP7-Infrastructures	1	8
FP7-KBBE	1	4.5
FP7-REGPOT	4	4.9
FP7-REGIONS	1	2.7
FP7-SME	10	13.5
FP7-TRANSPORT	3	7.8
FP7-JTI	155	450
Total	215	634.8

Source: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming based on CORDA data

F.4.2. Key findings

(a) Factors/mechanisms of influence fostering European added value

Reduction of commercial and research risks

Interviews confirmed that the sharing of risks was indeed an added value of implementing a project at the EU level. First, the substantial investments from **EC provided the certainty and trust in the future returns of research**, which is crucial to attract investment from private companies. The interviewees indicated that the "Commission brand" helped private companies consolidate the funds necessary for project realisation, especially in terms of negotiating and securing bank loans. This was particularly important for SMEs, which have limited resources and therefore are very sensitive to potential risks. Similarly, a number of beneficiaries confirmed that by pooling together a number of different organisations FP7 projects helped to share the potential financial risks related to the withdrawal of one or several partners:

In addition to reducing the financial risks, the quality of the consortia in terms of the complementary expertise helped to reduce the potential research risks. Certain tasks and

activities were shared among the organisations and researchers who were the best fit for their implementation. A larger number of partners involved in the project implementation also allowed to reduce the risks in case some other partners quit or failed to deliver the required outputs. However, some interviewees noted that the sharing of research and financial risks is a characteristic of any large project involving a number of different partners and that this is not an exclusive advantage of European projects alone.

Leverage of private and public investment

Interviews with the participants of the projects and other stakeholders supported the claim that **FP7 funds helped to leverage additional research funding both from private and public sources**. A leverage effect can materialise at two stages: leverage of private and public investments for the implementation of the specific project and leverage after the project implementation in attracting funding for further research.

Interview respondents were quite reserved in claiming that the fact that it was an FP7 project made it more attractive for project partners to invest their own financial resources into the project. The decision to get involved in the implementation of a EU level project and to invest their money is much more complex and cannot be explained by one sole reason. However, quite a few respondents noted that the changed co-financing requirements under Horizon 2020 increased the attractiveness of EU level projects.

However, according to official information, for the closed projects as of 31 December 2015 the leverage effect of the Fuel Cells and Hydrogen Joint Undertaking was EUR 1.2 /EUR 1, meaning that each EUR 1 spent by the EC for Fuel Cells and Hydrogen Joint Undertaking research projects attracted EUR 1.2 into the project from private industries and research partners.[99] Moreover, according to the representatives of the Fuel Cells and Hydrogen Joint Undertaking, before the coordinated European efforts in this field, only Germany was making major investment in fuel cells and hydrogen research. Although the national/regional funding for fuel cells and hydrogen research differs across Europe, the trend is that funding for this research area is quite limited: there are almost no dedicated programmes for fuel cells and hydrogen research at the national/regional level. Most of the national funding comes from the general R&D research programmes, but due to the financial crisis these funds were also reduced, especially in Southern Europe.[100] Coordinators and participants of these projects have noticed a positive trend that after the establishment of the Fuel Cells and Hydrogen Joint Undertaking, a number of other European countries started to pay more attention to this research area and invest in order to bring these technologies closer to the market.

Almost all respondents agreed that the EU funding received and the implementation of EU level projects helped their organisations to **stand-out in the national context and therefore to indirectly attract further funds for their research**. The fact that an institution participated in a European project provides quite a good outreach in terms of image and marketing, which in return results in better exposure to industry and helps to leverage additional funding. Participation in EU level projects also allowed SMEs to establish contacts with other big companies prominent in the field and as a consequence to establish cooperation for continuing their research and to sign new contracts for their further research.

Pooling resources and building critical mass

[99] Report to the European Parliament On The Socio-Economic Impact Of The FCH JU Activities, 21st January 2016.
[100] Based on the information provided by the interview respondents

Access to large infrastructures is particularly important for the success of fuel cells and hydrogen research, which requires the use of complex measurement, testing and other tools. The majority of interviewed project coordinators and participants confirmed that the **implementation of their project at the EU-level helped to access and share one or another type of research equipment crucial to the project's success**, including large-scale computational equipment, pressure vessel testing facilities etc. Without the European collaborative projects, especially smaller countries would not have the opportunity to access and use these infrastructures because they are not available in their own countries. In some cases only a few countries in Europe have the equipment for these specific types of computation or testing, and project beneficiaries even coming from large countries like Germany or Italy would not be able to perform their research without the access to these infrastructures or the support from institutions who have them.

Even if such infrastructures are available at the national level, the **respondents still emphasised the advantages of being able to choose from the best partners from across the EU with the highest quality and fit of the infrastructure for the specific project needs**. Very often project partners shared technical tasks within the consortium depending on the relative capacities and expertise of each partner to implement a specific task. In many cases, EU-level cooperation and sharing of infrastructure continued even after the end of the project, thereby contributing to the establishment of long lasting collaborations.

The evidence also confirms that FP7 projects in fuel cells and hydrogen allowed gathering larger consortia that, as a consequence, had considerable added value in terms of pooling **complementary expertise and skills** available in different countries and organisations. One project, for instance, brought together the leading European research institutes and companies to use their specific expertise in specific components of fuel cells stack in order to put this expertise together and come up with a European stack platform, which can address any applications in cars, busses or residential applications. According to the project coordinator, many of the project partner organisations were willing to participate only if they were supported by the Fuel Cells and Hydrogen Joint Undertaking. Otherwise, without the EU-level platform and support, it would not be possible to realise these kinds of projects in the real world. According to the representative of the Fuel Cells and Hydrogen Joint Undertaking, almost all of the 200 projects in this programme have a similar story of the European added value created behind it. Similarly, in another case, developing a strong expertise in deploying hydrogen refuelling stations in one of the partner countries (the UK) and project success could have been achieved only by sharing the expertise with partners from other countries.

A number of interviews with project coordinators confirmed that **without the EC financial support the projects could not be realised** either because they required sharing of certain infrastructures, access to international expertise in fuel cells and hydrogen research or the funding itself was quite limited at the national/regional level. This was the case even for research organisations from large countries with a highly developed RTD landscape.

Some of the organisations with the necessary skills and expertise could have also been found at the national level, though, **the diversity and motivation of the partners** would be considerably lower.

Similarly, several beneficiaries also confirmed that their projects **could have been realised even without the EU funds, although at a much lower scale and scope**. It was estimated that without the EC contribution and relying only on private industry and national public funds, the FP7 project HyFIVE would have deployed only around 70 fuel cell cars, instead of the actual 185. Without the EC contribution, the research projects would have also been slower in the sense

that it would have taken more time to implement the project activities. In some other cases project coordinators also indicated that without the FP7 funds their project would have started at least 1-2 years later than it actually did. The main reason for this is that the EC funds reduced the financial and research risks related to the project results: some of the organisations involved would have waited for a longer period until it was better proven that it is possible to achieve the research results with the research and technological means available.

Finally, in some projects the European dimension **helped some beneficiaries to access the research data** crucial for the project success. For instance, in the project HyFIVE the participating car manufacturers and fuel cell infrastructure developers acquired from the partnering research institutes access to crucial research data which revealed the technically strong and weak sides of their products. As it is very difficult for private companies to implement their own research data collection, they would not have had the access to these data without the FP7 funds.

Increased international and/or inter-sectoral mobility of researchers:

Interviews with the coordinators and participants of the projects suggested that **international/cross-sectorial mobility** of the researchers and staff was quite limited in FP7 fuel cells and hydrogen projects. In those cases where mobility actually took place, it was usually between academia and public research institutions. The involvement of industry partners in the mobility activities during the implementation of these projects was limited.

Despite the limited mobility in fuel cells and hydrogen projects, beneficiaries noted that in order to develop the necessary skills and expertise, it is crucial for young researchers working in the field of fuel cells and hydrogen to be internationally mobile: only by working in an international environment could they develop a broad perspective in relation to experimenting techniques and other skills. Mobility was identified as a crucial prerequisite in developing human research capacities in the fuel cells and hydrogen area because the research facilities in this field are still scarce and distributed across different European countries: training of top-class researchers able to work with the newest research equipment thereby requires mobility. Although the evidence of mobility in fuel cells and hydrogen projects is limited, there were several examples of MSCA Innovative Training Networks (ITN) projects specifically focusing on training young researchers working in the area of hydrogen storage: in one of these projects 10 PhDs and in another – 12 PhDs were trained.

(b) Better results achieved because of European added value

Improved research excellence / capabilities

Interviews with project beneficiaries confirmed that FP7 support had considerable added value in terms of improved excellence and research capabilities in the area of fuel cells and hydrogen research. First, the case study findings indicate that the **European scale of research funding helps to ensure the high quality of research proposals selected**. A number of project coordinators confirmed that the evaluation procedure of FP7 projects (especially those under the Fuel Cells and Hydrogen Joint Undertaking) are very competitive since the staff involved in the proposal evaluation have high expertise and experience in this area. In addition, the interviewees indicated that the FP7/Horizon 2020 project proposals in fuel cells and hydrogen tend to be of higher quality since they attract the top experts in relevant research areas. This is particularly important for fuel cells and hydrogen because the pool of top experts and organisations deeply involved in fuel cells and hydrogen in Europe is not large, and none of the single countries have

enough expertise covering all of the application areas. The representatives of the Fuel Cells and Hydrogen Joint Undertaking confirmed that overall the proposals quality of the research projects under the Joint Undertaking is very good and has been steadily increasing over the last years: the proposal are now much more competitive than they were before. According to one member of the Fuel Cells and Hydrogen Joint Undertaking, an American expert that they were consulting recognised that the quality of the EU proposals was much higher than those usually developed in the USA.

Some project coordinators noted that in comparison to national level projects, the **funding selection procedures in FP7/Horizon 2020 are much more objective, transparent and clear**. In contrast, the criteria under which projects are selected under national funding schemes are not always as transparent and are often influenced by lobbying. The level of excellence within FP7 fuel cells and hydrogen projects was also increased due to the **efficient coordination during the project implementation**: project coordinators from the Fuel Cells and Hydrogen Joint Undertaking side usually have a high technical knowledge and can even advise and criticise technical aspects of the research approach. This also facilitates and improves the project's reporting phase because the involvement of highly-qualified project coordinators allows to include more technical details into the report.

Second, a number of FP7 projects focusing on fuel cells and hydrogen research resulted **in a common development of advanced applications and scientific breakthroughs** that could have hardly been realised by a single institution or Member State. For instance, one project developed a completely new model to measure the heat and mass balances in solid fuel cells, while taking into account the 3D mechanical design of the system. This model was later shared among all of the project partners, and the staff was trained on how to use it. According to the project coordinator, this was made possible only due to the combination of the expertise and knowledge of different countries and organisations involved. Similarly, in one of the major projects 54 new generation fuel cell buses were deployed across different European cities. New generation buses included a number of improvements, including hybridisation of the fuel cell drivetrain, with the integration of batteries/super capacitors allowing the bus to buffer peak loads, boost acceleration and allow energy recovery from braking. In addition, the new hybrid systems allowed smaller and cheaper fuel cell systems, offering extended lifetimes and better fuel efficiency, leading to the use of fewer storage tanks while maintaining the range.

In other projects, the **research led to the improvement of the efficiency of multiple fuel cells and hydrogen technologies in one country**. In one of such instances, meetings between partners from different countries and organisations allowed British partners to learn and apply in their national context the superior technologies already developed by partners abroad, as well as to solve the existing technical problems and shortcomings, including the deployment of hydrogen stations, fixing problems of the compressor or pump in the refuelling stations and increasing the accuracy of metering in hydrogen refuelling stations. In some cases the technological improvements were related to the improvements of user experience in the already developed fuel cells and hydrogen applications: one of the projects, for instance, helped the German partners to improve the vehicle charging card technology for users, which was more advanced in partner countries.

Third, although publications in peer-reviewed academic journals are the usual outcomes of collaborative projects at both national and at the EU level, the evidence shows that the **EU-level research projects resulted in higher quality publications**. According to the respondents, good quality consortia with complementary expertise within FP7 projects led to higher quality research results, which, in its turn, attracted more interest from the scientific community. This

allowed the project beneficiaries to publish their research results in more prestigious journals with a higher impact factor. The exception to this general trend was the demonstration and applied research projects with high technology readiness levels or pre-normative research, as well as the studies commissioned by the Fuel Cells and Hydrogen Joint Undertaking in which the academic publications are not very usual due to their specificity.

Table 21. Number of publications and patents produced in Fuel Cells and Hydrogen Joint Undertaking projects

	2013	2014
Number of projects with publications in peer-reviewed journals	9	21
Number of publications in peer-reviewed journals	70	115
Number of projects generating one or more patent applications	4	6
Number of patent applications	12	14

Source: Fuel Cells and Hydrogen Joint Undertaking Annual Activity Report 2014

Fourth, the interview results indicate that the network and communication activities between researchers and organisations involved in fuel cells and hydrogen projects resulted in significant **learning effects for all sides**. This learning experience, increased knowledge and updated skills mainly resulted from the large scope and interdisciplinary nature of the research activities undertaken. Beneficiaries from different countries shared their experience, thereby contributing to the growing understanding and expertise in each of the researchers involved. This was particularly the case during the early project stages (when, for instance, the partners from different countries met to discuss the results of the calculations, thermodynamic measurements and testing), as well as the phase when various prototypes and demonstration modules had to be assembled and the technologies developed by different partners integrated. A number of beneficiaries acknowledged that they learnt new competences and skills that were not accessible in their institution or even country.

Finally, the representatives of the Fuel Cells and Hydrogen Joint Undertaking confirmed that tremendous progress was made in all of the five Fuel Cells and Hydrogen Joint Undertaking application areas: whereas some of the long-term indicators for 2020 might not be achieved, it was estimated that **around 90% of the targets will be achieved**. Moreover, during the period between FP7 and Horizon 2020 significant progress has been made in terms of the Technology Readiness Levels (TRL) in Fuel Cells and Hydrogen Joint Undertaking projects: whereas at the beginning of the initiative, the first projects mainly focused on fundamental research, by 2014-2016 the majority of projects supported under the Fuel Cells and Hydrogen Joint Undertaking corresponded to the *proof-of-concept* and even higher TRLs.

Economies of scale and scope

The main economies of scale and scope in FP7 projects resulted from pooling together the research infrastructure possessed by project partners. One of the main strengths of the Fuel Cells and Hydrogen Joint Undertaking was that it gathered into one pool all the major European industries (more than 100 enterprises as of 2016) and research players (more than 60 institutions) in this field. All the major European research institutes working in fuel cells and hydrogen research (ENEA, CEA, SINTEF, JRC and others) are members of the Joint Undertaking and support the research with opening-up their infrastructures and other facilities. Thanks to the FP7 fuel cells and hydrogen projects, beneficiaries from smaller countries, like Denmark, the Netherlands or Belgium, had access to large and complex infrastructures that could only be

provided by large research centres. This opportunity helps to **save up large amounts of funding, which would otherwise had to be spent on building similar infrastructures** across different Member States.

Some of the business partners indicated that the **EU contribution is the sole means to achieve the economies of scale necessary for the market introduction of fuel cells and hydrogen technologies**. The main reason for this is that market introduction of fuel cells and hydrogen products, in addition to technological advance, also and foremost requires the increase in sales volumes. Currently single hand-crafted models of fuel cells and hydrogen applications have to compete with the series of traditional products produced at a mass scale. However, in practice it is possible to compete only if sufficient quantity of applications are produced and sold on the market. Private industries usually start at very low sales volumes and there is very little chance that they could alone reach the necessary sales volumes and start competing at price. In order to speed up the market application of fuel cells and hydrogen technologies, volume effects must be created in the value chain and the price must be reduced so that the industries could compete with the traditional systems. Interviews with beneficiaries indicate that the FP7 support already contributed in this area, though, public funding should be boosted in order to accelerate further market application of fuel cells and hydrogen technologies in Europe.

The available evidence shows that coordination activities by the Fuel Cells and Hydrogen Joint Undertaking already contributed to the achievement of the economies of scale in fuel cells and hydrogen products. Five procurement clusters of bus operators and cities from different European regions/countries were established under the lead of the Joint Undertaking, in order to agree on a common bus specification and enable joint procurement of fuel cell buses. By 2016, all five clusters reached an agreement to procure 600 new fuel-cell buses, thereby creating economies of scale and reducing the unit price. Successful application for funding has already been made which will support the deployment of the first 142 buses. It is estimated that this large-scale joint procurement alone will reduce fuel cell bus capital costs by 25% versus the current state-of-the-art (i.e. from today's EUR 850,000 per 12 m bus to below EUR 650,000). It will also double the size of Europe's fuel cell bus fleet - from 90 by the end of 2016 to more than 220.[101]

Wider availability and dissemination of knowledge

The available evidence shows that **FP7 projects focusing on fuel cells and hydrogen research had considerable knowledge dissemination effects through the organisation of and participation in conferences and workshops, as well as the preparation of reports and papers**. Some larger projects (CHIC, HYTEC and MobyPost) included wider-ranging dissemination and awareness-raising activities, such as launch events, test-drive opportunities, school visits, participation in fairs or local festivals, a shuttle service at public events and substantial press presence.[102] Especially the demonstration projects involved a high scope of dissemination activities. e.g. during the H2moves Scandinavia project public ride and drive events of hydrogen vehicles were organised. Similarly, the hydrogen road tour took place in 2012, during which nine different cities in Europe were visited (in the United Kingdom, Northern Italy, Germany and Denmark). Some of the projects were also tackling broader audiences in addition to researchers and other stakeholders directly involved in fuel cells and hydrogen research. For instance during the RELHY project an article was published in a more

[101] Element Energy et al.: Strategies for joint procurement of fuel cell buses [July 2016] http://www.fch.europa.eu/sites/default/files/Strategies%20for%2joint%20procurement%20of%20FC%20buses_0pdf
[102] FCH Joint Undertaking: Programme Review Report 2015.

general technological-political EU journal called *International Innovation*, which is accessible to a wider audience. In some cases, project outputs included studies on the factors determining the acceptance of the new technology: the CHIC project, for instance, conducted a study on influencing factors for fuel cell bus acceptance. The study included 185 face-to-face, one-hour interviews in five European regions.

The representatives of the **Fuel Cells and Hydrogen Joint Undertaking maintain a constant contact with key EU and national policy makers and inform them about the state of play and future prospects of fuel cells and hydrogen research**. The events organised by the Fuel Cells and Hydrogen Joint Undertaking were a good platform for SMEs to promote and introduce themselves to the big players prominent in the field. The interviews also show that coordination activities by the Joint Undertaking also provided synergies between the dissemination activities under different projects: meetings organised by the Joint Undertaking allowed the project coordinators to get acquainted with each other's work and to organise common dissemination activities such as workshops and conferences. Some of the projects focusing on pre-normative research disseminated information about the knowledge produced in their work, in order to change the industrial standards, as this is the only way to bring knowledge closer to the market. The main instruments used for this purpose were the publications, presentations and workshops dedicated to key European industrial and research stakeholders in this field.

Even though the EU research funding programmes aim at making knowledge more widely available, e.g. through open access to publications and data, some of the beneficiaries noticed that many companies tend to protect the knowledge developed during fuel cells and hydrogen research and not to share it publicly in order to protect their commercial interests. This trend was identified as a potential source of tensions between the companies cautious of sharing any research results with a potential commercial value and academia/public research institutes, which are strongly interested in producing high-quality publications.

Better coordination of national research policies and practices at the EU level

The European added value in the area of EU-level coordination of fuel cells and hydrogen research was very clear and specific since more than 70% of the EU funding in this area was distributed through the Fuel Cells and Hydrogen Joint Undertaking– a large public-private partnership, which helps to coordinate research in accordance to the interests and needs of different stakeholders involved. A number of interviews confirmed significant added value of this coordination at different levels. First, the presence of such a public-private partnership **ensured a strong involvement of industry** and its role in leading research activities, which is crucial to push technologies into the market. This is mainly achieved through the involvement of both academic and industry partners in drafting common implementation plans and strategies, which set the research agenda and priorities while taking into account the industry interests and needs.

Some beneficiaries, however, noticed that because of the industry's strong role in the Fuel Cells and Hydrogen Joint Undertaking, there is too much focus on demonstration projects at the expense of fundamental research. In the future this might jeopardize the progress in the area of fuel cells and hydrogen research. According to some opinions, the European research funds should instead concentrate on fundamental research, since it is more sensitive to sharing of top expertise and infrastructures, whereas demonstration projects could be supported at national or even regional level with high support from private industries. Divergent opinions of the respondents clearly shows the importance (and difficulty) of finding the optimal balance between supporting low and high technology readiness levels activities.

Second, hydrogen technology has a number of different application areas and makes links to other technologies (solar, wind energy, transport, medicine etc.). Because there are so many fuel cells and hydrogen application areas and because they are so interlinked, it was necessary to establish one formal European-wide coordination platform and strategy, which helps to **set priorities and ensures the pooling and rational distribution of resources for research**. A single European research coordination platform is necessary because an overall success in fuel cells and hydrogen research can only be achieved if research in different application areas is implemented simultaneously and is being jointly coordinated. For example, in order to have a clean hydrogen-based transport system, it is necessary to have clean (CO_2 emission-free) hydrogen production, as well as efficient and safe hydrogen storage and transportation technology. Similarly, in order to have a system of harvesting the unused electric energy in a form of hydrogen, it must be possible to apply it in the transport system: the two application areas are therefore closely interdependent. According to one of the interviewees, the Fuel Cells and Hydrogen Joint Undertaking provides this European-wide framework for coordination and priority-setting, which is essential for long-term success in this area.

Every year the Fuel Cells and Hydrogen Joint Undertaking reviews the progress achieved against target indicators in five different application areas. This helps to maintain progress across all of the areas, since it helps to trace which areas of research are lagging behind and need further stimulation. After identifying these areas the Joint Undertaking launches a new call in the area/topic that needs acceleration. This approach allows **efficient distribution of resources and prevents the duplication of funding for those areas where substantial progress has been already achieved**. However, one respondent stated that the Joint Undertaking should me more directive in deciding what kind of topics should be financed and better strategic prioritisation should take place on what research projects should be continued and where the funding flows should be directed.

Third, some of the FP7 projects had considerable **impact on national policy regulations and even the general outlook of policy makers towards fuel cells and hydrogen technologies**. For instance, the agreement between two project partners in FP7 HyFIVE project (ITM Power and Shell) influenced the UK's regulations and facilitated collocating the hydrogen and petrol on the same refuelling forecourts. The implementation of EU-level projects helped to showcase the importance of this research area and therefore contributed to allocating higher national/regional financing. Similarly, some of the private companies indicated that the presence of the Fuel Cells and Hydrogen Joint Undertaking demonstrates the political support at the highest level, as well as the need of fuel cells and hydrogen technology for the society at large. This support encourages businesses to invest in this research area even when the financial returns of this investment are not immediate and the payback time is quite in the future.

(c) Long-term impacts resulting from European added value

Better addressing societal / pan-European challenges

Horizon 2020 addresses major concerns shared by citizens in Europe and elsewhere by tackling seven main societal challenges.[103] All of the interviewees agreed that their **research in the area of fuel cells and hydrogen is particularly relevant and contributing to solving three of these seven societal challenges**:

[103] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/societal-challenges

- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, environment, resource efficiency and raw materials.

A number of **interviewees confirmed that the EU research funding has already contributed a lot in solving the above societal challenges**, mainly by helping to demonstrate the applicability of hydrogen as a transport fuel across Europe and building necessary infrastructure (e.g. hydrogen refuelling stations). One of the largest projects under the FP7 Fuel Cells and Hydrogen Joint Undertaking, for instance, gathered good practices and demonstrated to other cities in Europe how effectively the deployment of fuel cell buses can address CO_2 emissions and climate change issues. It was shown that the deployment of 12 meter fuel cell bus using the hydrogen mix (combination of hydrogen from renewable and conventional sources) reduces the global warming potential impact by 43% compared with a corresponding state-of-the-art diesel bus, whereas fuel cell bus using 100% green hydrogen fuel reduces the global warming potential impact by 85%[104].

Overall, in terms of CO_2 emissions, **fuel cells are currently the most efficient way of addressing climate change**: studies conducted under the Fuel Cells and Hydrogen Joint Undertaking estimated that even the natural gas based fuel cell technology can reduce the CO_2 emissions by up to 80%. The technology combining fuel cells with hydrogen produces a 0% CO_2 emissions. Due to the increased efficiency and reduced consumptions of energy, the introduction of fuel cells and hydrogen technology could save around EUR 1,000 of energy bills per year for an average European family. In addition, the shift towards a fuel cells and hydrogen based energy and transport system would significantly increase Europe's energetic security and stability by reducing its dependence on energy imports: hydrogen can be produced locally in a number of different ways, depending on the original feedstock. For instance, hydrogen can be produced through electrolysis, which is a completely zero-emission based production method. A number of interviewees recognized that the future transformation of energy and transport sector will probably be based on a mix of electricity and hydrogen based applications, rather than hydrogen alone.

The interviewees also agreed that **it is indispensable to implement the shift towards a fuel cells and hydrogen based energy and transport system at the European, rather than national or regional levels**. Due to their importance, the coordinated and concerted actions at the EU level are needed in order to avoid any contradictions among the national policies. The main reason for this is that the EU energy and transport infrastructure is so interlinked that it would be impossible to have a fuel cells and hydrogen based system in one country and a completely different system in another.

In addition, because of the natural-geographic factors, every European country has different advantages and capabilities to produce hydrogen: some countries or regions (for instance, southern European countries) have the potential to produce hydrogen from solar energy, others from hydro energy (for instance, Scandinavian countries), whereas others have none of these natural advantages. As a consequence, in order to achieve a zero-emission based system in

[104] Source: Clean Hydrogen in European Cities (CHIC) 2010-2016 project, Fuel cell electric buses: a proven zero-emission solution. Key facts, results, recommendations. 2016.

Europe countries have to cooperate and share the resources necessary for the introduction of fuel cells and hydrogen technologies.

F.4.3. Stories of impact

The FP7 H2SusBuild project (Development of a clean and energy self-sustained building in the vision of integrating hydrogen economy with renewable energy sources), implemented from 2008 to 2012, aimed at developing a self-sustainable and zero-CO_2-emission hybrid energy system, in which the storage of hydrogen provides the energy supply for heating, cooling and electricity of buildings in case of energy shortage. The new system allows converting the excess of renewable energy produced from photovoltaic solar panels and wind power generators into hydrogen to be used as energy storage medium. The project resulted in the development and installation of this full-scale system in a medium-sized (525 m2) office building located in Greece. At the time H2SusBuild project demonstrated the first and the most advanced technology in this area,.

The FP7 **SOFCOM proof-of-concept project** (SOFC CCHP with poly-fuel: operation and maintenance), implemented from 2011 to 2015, was the world's first demonstration of an innovative system where fuel cells were used to generate electricity and water that is clean enough to be drunk by consuming organic waste that is collected from wastewater treatment plants. Project partners built two demonstrations of biogenous-fed solid oxide fuel cell (SOFC) systems in order to test the proof of concept. The first was in Turin, Italy and featured a fuel cell system fed with biogas produced from an industrial water treatment plant. The second system was based in Helsinki, Finland and comprised a fuel cell stack fed with another type of renewable fuel – syngas produced from biomass gasification. The system developed for electricity production from renewable energy sources ensured negative CO_2 emissions. This project is expected to have a positive impact on society and the environment through the sustainable management of energy and its related effects on the global climate. The follow-up project (DEMOSOFC), financed under Horizon 2020, started in 2015 and aims at scaling up the technology. This will result in the installation of a 174 kW electric biogas-fuelled SOFC system that will also be the biggest size plant in the EU so far.

Even though the functional readiness of the fuel cell technology in automotive application is very advanced, durability, efficiency, power density and cost of the fuel cell stack need further advancements and in some cases substantial improvements. The **Auto-Stack Core project** (Automotive Fuel Cell Stack Cluster Initiative for Europe II), implemented from 2013 to 2017, therefore aims to develop the best-of-its-class automotive stack technology with superior power density and performance. The newly developed stack technology will be beyond of what is currently known for the global market in respect to power density and volume of the stack. The project's current progress shows that the targets will be reached as planned and automotive stack production in Europe will start from 2018/19.

The aim of the **HyLIFT-EUROPE project** (Large scale demonstration of fuel cell powered material handling vehicles), implemented from 2013 to 2017, is to demonstrate more than 200 fuel cell materials handling vehicles and associated refuelling infrastructure at 5-20 sites across Europe, making it one of the first and the largest European demonstrations of hydrogen fuel cell materials handling vehicles. By 2016, a fleet of 46 vehicles was already in operation in one of the project partner's logistics facility in France and contracts for more vehicles were already signed. In addition, Carrefour Group, the second-largest retailer in the world, plans to purchase more than 150 fuel cell forklifts, which will be deployed at Carrefour's brand new distribution centre located in Vendin-lès-Béthune, France. It is expected that the demonstration of the fuel-

cell vehicles at large industrial companies will ensure maximum exposure of the project results, whereas the project's best practice guide to be shared with potential future vehicle-users will help streamlining the procedures for future deployments of fuel cell materials handling vehicles.

Several large-scale FP7 projects included some of the **most significant breakthroughs in developing fuel cells and hydrogen transport infrastructure in Europe**. In HyFIVE the project consortium uniting the researchers and some of the largest car manufacturers in the world (including Daimler, BMW, HONDA, Hyundai and Toyota) are deploying 185 fuel cell electric vehicles (FCEVs) and 6 new hydrogen refuelling stations across three geographical clusters in Europe. Similarly, the FP7 CHIC project deployed a fleet of 54 fuel cell electric buses and 6 hydrogen refuelling stations across 8 European countries. In addition, the project consortium achieved a number of technical improvements significantly facilitating the commercialization and wider applications of fuel cells and hydrogen technologies in transport in the future: these include short refuelling times at hydrogen refuelling stations, high fuel consumption efficiency, reduction of CO_2 by up to 85% and other. It is estimated that these project will significantly contribute to removing the remaining barriers to wide-scale application of fuel cells and hydrogen in European transport system, thereby making a major step in cutting greenhouse gas emissions and increasing the share of renewable energy sources in the Union's energy mix.

F.5. European added value case study 5: Food Waste

F.5.1. Overall context

(a) Definition and expected impact of the area

Food waste is an important ethical, economic and environmental issue. Recent studies show that between one-third and half of the world's food production is wasted at different stages of production and throughout the supply chain, starting at the farm (e.g. vegetables/fruits that do not meet quality requirements thrown away) and ending at consumer level waste[105]. By conservative estimates, about 1.3 billion tonnes of food produced for human consumption is lost globally every year. In the EU alone about 88 million tonnes of food are wasted every year, worth an estimated EUR 143 billion (Stenmarck A. et al, 2016). Surprisingly, developing and developed countries experience similar levels of food waste – about 40%. The largest food losses in the developing world occur at the harvesting and processing stages, whereas in the developed world most of the food is wasted at retail and consumer levels. The European Commission is committed to preventing and reducing food waste in order to transition towards a resource efficient and more environmentally friendly Europe.

Food waste causes negative environmental (e.g. energy, climate change, water, availability of resources), economic (e.g. resource efficiency, price volatility, increasing costs, consumption, waste management, commodity markets) and social (e.g. health, equality) consequences. Moreover, a significant amount of food, especially in developed countries, is wasted at the consumption stage. To tackle these issues and meet the Sustainable Development Goals (SDGs), the European Commissions has introduced a new Circular Economy Package[106], which

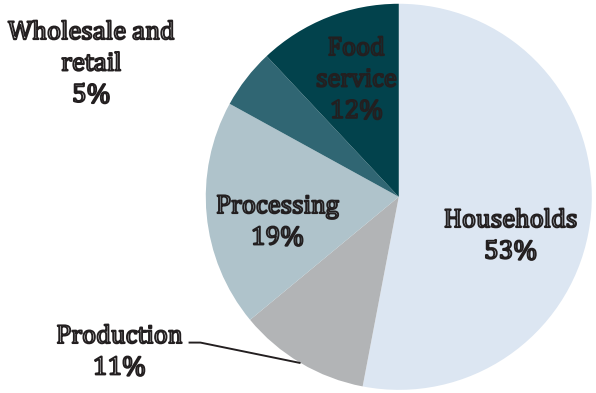
[105]Jenny Gustavsson, Christel Cederberg, Ulf Sonesson, Robert van Otterdijk & Alexandre Meybeck (2011). "Global Food Losses and Food Waste: Extent, Causes and Prevention", Rome: Food and Agriculture Organisation of the United Nations; Åsa Stenmarck, Carl Jensen, Tom Quested, Graham Moates (2016). "Estimates of European food waste levels". FUSIONS EU project.

[106]More on Sustainable Development Goals: https://sustainabledevelopment.un.org/topics. More on the EU Action Plan for the Circular Economy: http://ec.europa.eu/priorities/jobs-growth-investment/circular-economy/docs/communication-action-plan-for-circular-economy_en.pdf

stimulates Europe's transition towards a circular economy that boosts global competitiveness, fosters sustainable growth and generates new jobs. Food waste prevention is an integral part of the package and aims to halve the per capita food waste at the retail and consumer level by 2030, as well as significantly reduce food losses along the food production and supply chains.

Food waste distribution among different food production and supply stages is presented in the chart below.

Figure 1 Split of EU-28 food waste in 2012 by sector



Source: Stenmarck A. et al, 2016

Ensuring global food security, good environmental governance and prevention of food losses is of vital importance. Food waste, in addition to a loss of resources used in production such as land, water, energy and inputs, produces negative externalities as a result of the production - such as CO2 emissions - and represent a loss of economic value of the food produced. Thus, actions geared towards food waste prevention and reduction play a big role in combating hunger and climate change. Becoming more efficient in food production and more responsible at the consumption level will have positive economic and environmental impacts.

United Nations (UN) members agreed to frame their agendas and policies following the SDGs, which aim to end poverty, protect the planet and ensure prosperity for all. Since food waste reduction is an essential part of the agreement, the UN carried out a study on food waste, detailing the main causes and proposed prevention mechanisms to combat food loss throughout the food production and supply chains (Gustavsson J. et al, 2011). The main goal of the EU is to reduce food waste without compromising food safety (the EU food safety policy – to protect both human and animal health). Thus, in addition to the UN's propositions on achieving food waste SDG targets, the Commission is in the process of pursuing several actions aimed to reduce food losses[107]:

- Elaborate a common EU methodology to measure food waste consistently across the Member States and stakeholders (unified quantification of food waste levels);

- Create a new platform (**EU Platform on Food Losses and Food Waste**[108]) involving both Member States and actors within the food chain (the goal is to define measures

[107] More on EU actions against food waste:
http://ec.europa.eu/food/safety/food_waste/eu_actions/index_en.htm
[108] http://ec.europa.eu/food/safety/food_waste/eu_actions/eu-platform/index_en.htm

needed to achieve the food waste SDG, facilitate inter-sector co-operation, and share best practices and results achieved);

- Take measures to clarify EU legislation related to waste, food and feed and facilitate food donation and the use of former foodstuffs and by-products from the food chain for feed production, without compromising food and feed safety;

- Examine ways to improve the use of date marking by actors in the food chain and its understanding by consumers, in particular "best before" labelling.

The EU Member States are committed to meeting the SDGs, and if prevention mechanisms are implemented successfully, expect:

- A 50% reduction in the per capita food waste at the retail and consumer level by 2030;

- A significant reduction of food losses across entire food production and supply chains.

In order to achieve these targets, all actors in the food chain have to play a role in preventing and reducing food waste, from those who produce and process foods (farmers, food manufacturers and processors) to those who make foods available for consumption (hospitality sector, retailers) and consumers themselves.

(b) Rationale for public intervention: key trends in the area, main challenges and indicators

As discussed above, food waste has a negative impact on a wide range of issues in particular ethical, economic and environmental. Food losses occur, to various degrees, at all stages of production and the supply chain. Studies argue that public intervention is necessary in preventing and reducing food waste for a number of reasons:

- Government agencies and public institutions are better positioned than non-profits to inform and raise awareness about the benefits of reducing food wastage (saving money by reducing over-purchasing and disposal costs, positive environmental impacts) via public education, public campaigns, etc. For example, in 2008, the University of Texas at Austin initiated a programme to raise awareness among students about food waste that produced impressive results – a 48% reduction in wasted food[109];

- Investments in infrastructure, transportation, food processing and storage require enormous resources, and the private sector would not be able to do it alone, especially in developing countries (Gustavsson J. et al, 2011);

- Data collection – the European Union will create a unified methodology and then Member States will calculate food waste based on the proposed methodology. A common methodology will allow different countries to better understand levels of food waste, and

[109] EPA (2016). "Reducing Wasted Food & Packaging: a Guide for Food Services and Restaurants"; European Commission, http://ec.europa.eu/food/safety/food_waste/eu_actions/index_en.htm

therefore, encourage them to take action if necessary (Gustavsson J. et al, 2011; Stenmarck A. et al, 2016; European Commission's commitment[110]);

- Governments can create policies that promote prevention and reduction of food waste, and punish food waste (e.g. recent French legislation, which forbids food waste for supermarkets[111]).

Therefore, public intervention not only raises public awareness, but makes a difference in food wastage – through creative legislature that significantly reduces food waste. The main food recovery strategies food waste projects pursue (from the most environmentally friendly to the least):

- Reduction (seeking supply demand balance, better processing and storage practices, increasing consumer awareness)
- Reuse (feed hungry people, feed animals)
- Recycle/Recover (Industrial uses, recover food waste to energy, composting)
- Landfill/incineration (Last resort option for food waste management)

(c) Defining the scope of the European added value case study

Food waste is a complex and new area of research, requiring collaboration between top experts, sharing of infrastructure and heavy investments. A multidisciplinary approach is needed to tackle the food waste challenge effectively. In the case study, a big fraction of all FP7 projects related to food waste were analysed. Projects were implemented under different FP7 programmes including Energy, Environment, KBBE, NMP, Regions, Science in Society, SME and ICT. Projects analysed represent the diversity and broad scope of topics addressed by the FP7.

Overall, approximately 40 European projects tried to determine or solve problems related to food wastage. Most of the observed projects associated with food waste either produced new technologies (e.g. robotic flexible food handling, innovative packaging) or provided services (databases, policies, various innovative tools). Most projects, 23 in total, were implemented under the FP7 KBBE programme. The EU contribution for these projects topped EUR 82 million. An additional 17 projects related to food waste were identified in other parts of FP7, including notably Research for the Benefit of SMEs (7 projects), Environment (3 projects). The full list of projects that worked on food waste prevention and reduction are presented in the table below.

Table 22 Key projects related to the area of Food waste

Programme	Number of projects	EU contribution, EUR million
FP7 Energy	1	3.48
FP7 Environment	3	9.62

[110] More information on the EC proposed actions against the food waste: http://ec.europa.eu/food/safety/food_waste/eu_actions/index_en.htm

[111] More information: https://www.theguardian.com/world/2016/feb/04/french-law-forbids-food-waste-by-supermarkets

FP7 KBBE	23	82.06
FP7 NMP	1	7.208
FP7 Regions	1	0.88
FP7 Science in Society	1	0.40
FP7 SME	7	8.62
ICT	3	19.27
Total	**40**	**131.53**

Source: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming , based on CORDA data

F.5.2. Key findings

(a) Factors/mechanisms of influence fostering European added value

Reduction of commercial/research risk

Interviewed coordinators and project members confirmed **that European level projects enabled sharing and reduction of commercial and research risks**. Respondents named three main factors that helped reduce commercial and research risks: (1) **substantial financial support from the European Commission**, (2) **the Commission's reputation and the prestige of FP7 projects** and (3) **the high quality of consortia in terms of expertise and commitment**. In the area of food waste, both reduction of commercial and research risks are important factors in pursuing EU projects. According to the participants, the effect of added value in this area is much more expressed and clear in European than in national projects.

Most of the respondents supported a claim that research risks were reduced (for all types of projects). Significant funding from the European Commission provided recipients with necessary cash flows and allowed stable implementation of the projects.

In addition, the trust and certainty in the future returns of research that came with the Commission's "brand" facilitated access to funds essential for project realisation (for example, negotiating and securing bank loans). Finally, organisations and researchers shared certain tasks and activities that were best fit for their implementation, or in some cases, other partner organisations took over tasks when assigned researchers or organisations failed to successfully complete them. Similarly, beneficiaries supported the claim that by pooling together a number of different organisations, FP7 projects helped to share potential financial risks related to the withdrawal of one or several partners.

The European level intervention reduced commercial risks for projects that produced technologies and prototypes. Respondents from such projects confirmed that in many cases they could not attract equivalent funding from private sources to develop prototypes and innovative technologies.

According to the beneficiaries EU projects provided them with additional funding to implement technologies and worked as a leverage effect to attract funding before and after the implementation of the project. As a result, participants significantly reduced commercial risks.

Leverage of private and public investment

Interviews with project participants and other stakeholders revealed that **FP7 funds helped to leverage additional research funding from both private and public sources**. The vast majority of respondents agree that the **leverage effect from European projects is higher than from national Programmes**. Moreover, with the exception of large European countries, such as France and Germany, as well as Scandinavian countries, there are almost no equivalent national/regional programmes in the area of food waste**. Given limited national/regional funding, European funds are essential in supporting food waste research**.

It was observed that **FP7 funds had two types (before-and-after the project) of leverage effects, which materialised at different stages of the project**. First, the prestige of FP7 funding allows coordinators to form highly competent and motivated research teams. The international profile of the consortia and potential European funding attracts industrial partners, both nationally and internationally, and investments into the project as a result. Second, winning of grants and the successful implementation of EU projects at the European level not only make research teams more visible in international arena, but also send positive signals to potential investors. **The European funding aspect and the prestige of winning Framework Programmes' grants helped participating institutions to stand-out in the national context** and therefore to indirectly attract funds for research. Research teams that participated in European projects became more visible in the industry, strengthened their image and demonstrated their portfolios to a wider, international audience. These factors, in particular, international reputation, image and better exposure to the industry, helped participants to leverage additional funding. For SMEs, EU-level projects guaranteed contacts (and in some cases contracts) with other companies, such as innovative SMEs and leading industrial corporations prominent in the field.

Among above mentioned reasons for increased funding from other sources, participants cited specific skills and experiences they acquired that helped them attract additional financing for their projects: management skills, conflict-management (between partners), studying of the new areas of research via collaboration with the different and complementary partners/experts, learning the rules and evaluation schemes of EU projects.

According to most of the respondents, participation in a European project increased funding from national programmes, charities and non-governmental organisations, and the industry, not only for the particular project, but also for projects that followed. In some cases, project participants gained significant amounts of additional funding for their current and future research.

Pooling resources and building critical mass

A key added value for project participants in the area of food waste, according to the project participants, was the pooling resources and building critical mass. **European level projects opened opportunities for cooperation with international partners that possess necessary and unique skills and knowledge, data sources, laboratories and other infrastructures.**

Most of the interviewed project participants supported the claim that **the implementation of their project at the EU-level helped to access and share region-specific knowledge and data, equipment, testing facilities etc. crucial for the projects' success**. European collaborative projects were extremely important for participants from smaller countries, who would not have had opportunities to access and use the knowledge and infrastructures unavailable in their own countries. European level projects allowed respondents to choose the best, most experienced

partners from across the EU (and beyond) and to access infrastructure and data needed to successfully implement the project.

Food waste research is a relatively new area with little funding at national level. The current patterns of multidisciplinary approach in food waste research and the adoption of innovations from other industries than food require various types of skills, equipment and data sources. Thus, European level funding, and especially the international aspect that comes with it, becomes superior to other forms of funding.

Some respondents suggested, that these additional benefits of European projects, networking and learning from each other in particular, offset the co-funding requirement - which is not required by national programmes in their countries - and makes EU funding more desirable than funding from national sources.

Virtually all interviewed coordinators and project participants (with the exception of very few participants from Germany, France and the United Kingdom who could have implemented the project at full or nearly full scale and scope) confirmed that without European funding the projects could not be implemented, either because they required sharing of certain infrastructures, access to international expertise in food waste research or the funding itself was quite limited at the national/regional levels. Only a few respondents substantiated that their projects could have been implemented without EU funds, but at a much lower scale and scope.

International expertise and infrastructure encouraged the sharing of tasks between partners. Many respondents emphasised that EU-level cooperation and sharing of infrastructure established strong networks, exposed to new markets and encouraged learning from each other. These connections continued even after the end of the project, thereby contributing to the establishment of long lasting partnerships. These partnerships allowed research teams to grow, ensured effective cooperation and helped attract additional funding from other than European sources.

Increased international and/or inter-sectoral mobility of researchers

Interviewed coordinators and project participants emphasised several aspects of increased international and/or inter-sectoral mobility of researchers that bring added value in the area of food waste research. However, the European aspect is not an exclusive advantage over national programmes in this case. Although international mobility is higher for European projects, inter-sectoral cooperation is common among national projects as well.

According to the participants **mobility occurred between universities, research institutions, large corporations and SMEs** in some cases. All levels of specialists participated in this mobility – from PhD students to experts and academia. As some participants from SMEs and big companies acknowledged, industry partners were less likely to send their staff to other institutions, because they have assigned tasks and responsibilities beyond the project.

For those who participated in international or inter-sectoral mobilities, this was **a good learning experience:** gaining knowledge in the field of food waste research, learning new competences and skills.

Most participants agree that young researchers and PhD students benefited the most from these exchanges – they developed new crucial research skills, broadened their perspectives by working

in an international environment, defended PhD theses on this topic and some even received job offers from the institutions with whom they interned.

(b) Better results achieved because of European added value

Improved research capabilities / excellence (also involves access to skills, data, infrastructures and research capacities)

The European aspect of FP7/Horizon 2020 enabled project participants to build strong international research teams, attract top experts, innovative SMEs and leading industrial partners. Interviewed beneficiaries confirmed that **European projects brought higher added value in terms of research excellence and capabilities than projects funded only under national programmes**.

According to a significant share of project participants, there are a number of reasons that make EU-level programmes stand out in terms of research excellence. The selection mechanism of Framework Programmes ensures a high quality of research proposals selected. The large scale of the projects encourages top experts in the field to participate. The international nature of these projects allows consortia to form the most capable teams with expertise from different countries and access necessary infrastructure and databases. A large number of interviewed project participants emphasised efficient coordination and sharing of tasks as an important aspect in ensuring successful project implementation. All these factors lead to improved research capabilities and excellence.

In addition, some of the project participants noted that the funding selection procedures in European Framework Programmes are more objective and transparent compared to national level programmes. This finding contrasts the often perceived "bureaucracy" of EU research programmes.

Economies of scale and scope

A number of respondents stressed that EU funding, together with international cooperation ability to pool resources and increased visibility across Europe, are necessary for the wider European level adoption of food waste research and technologies. In general, respondents agreed that **European level food waste projects achieve economies of scale and scope much more often than projects funded under national research programmes**.

From the interviews with project participants it appears that **economies of scale and scope are most prevalent in those food waste projects that focus on development of databases, software tools and methodologies**. European aspect allows project participants to bring project outcomes accessible and applicable across Europe at relatively low cost. In many cases national level project could not be widely applied due to lack of experts, experience from other countries and infrastructure.

The main factors that contribute to the effectiveness of EU projects, according to the participants, are:

- Outcomes of similar projects at national level can often only be applied at tackling food waste in the country where research is performed. Slightly larger project budget, access to top experts and infrastructure make results applicable more widely;

- Comparable national projects are implemented slower due to a lack of experts, infrastructure and funding opportunities;

- Limited access to institutes and infrastructure nationally makes national projects less efficient and more complicated.

Increased access to European infrastructures and top experts as well as guaranteed EU funding allowed focusing on research activities, saved time and resources. **Instead of working at national level, researchers aimed to make the outputs of the project applicable across Europe**. The European dimension and larger scale reduced unit cost of outputs.

Wider availability and dissemination of knowledge

Virtually all respondents agreed that **a larger number of dissemination activities is an important added value of European projects, which make them superior to national level programmes.** In addition, international recognition and reputation that comes with the EU brand enable project participants to attract top experts and cooperate with European and international partners. As a result such projects produce high quality research, publish in top peer-reviewed journals and attract attention from non-European countries (e.g. the USA). In addition, most of the interviewed participants viewed positively the Commission's efforts to promote open access and data sharing, and believed that it helps to draw attention from academia and the public. These aspects make the outcomes of European projects more visible internationally compared to national programmes.

Interviewed coordinators and project participants supported the claim that **European projects lead to and open opportunities for considerable dissemination activities that would not be available at national level**. For project participants, these dissemination activities included publications in peer-reviewed journals, patents and other protection of intellectual property rights, tests at laboratory scale and participation in conferences, seminars and workshops. In general, according to interviewees, FP7 funding had a clear effect on improving access to research outputs. Project participants support European efforts to promote open access and stressed the importance of open access to publications and data. According to them, making knowledge more widely available helps them reach wider audiences and advance research. However, speaking about the open access as such, some of the respondents were wary of and pessimistic about the impact it produces – publishing in open access journals, which are often lower ranked, is costly and not always an effective way of reaching wider audiences.

Better coordination of national research policies and practices:

Most of the researchers separated national and European projects as serving different purposes. **European projects are larger scale projects and usually make bigger impact than national programmes.** Moreover, a large number of European countries do not have national funding dedicated to food waste research. Interviews revealed that only Germany, France, the Netherlands and some Scandinavian countries have comparable programmes with sufficient funding. In other countries food waste research usually fits under broader categories in national programmes, but competition for grants is very high and the funding is relatively small.

According to the participants, in a perfect scenario, both European and national programmes in food waste research would complement each other. Currently, however, in many European countries there is a lack of national programmes that could complement EU programmes.

Despite the EU's efforts many respondents mentioned the still existing research bottlenecks at national level.

(c) Long-term impacts resulting from European added value

Addressing societal/ pan-European challenges

Researchers believe that European collaborative projects address food waste research, specifically food waste reduction, prevention and valorisation, make bigger impact at a shorter time period than national projects. **Pan-European projects have bigger impacts, because these projects are more visible across Europe, enable collaboration with top experts and allow consortia share region-specific knowledge and data, equipment and testing facilities.** However, participants agree that national level projects complement European projects.

It is difficult to distinguish the main trends of food waste projects, since they **cover a wide range of topics and aim to solve various problems related to food waste reduction, prevention and valorisation**. Analysed food waste projects built tools (software, apps, and databases) that promote healthier lifestyle, sustainable food consumption, encourage food waste reduction and promote waste valorisation. Also, EU-level projects developed technologies that reduce food waste at both food processing and consumer levels. In addition, food waste projects proposed new policies and directives to policymakers that could help prevent or significantly reduce food wastage. Overall, there is a wide pallet of issues these projects dealt with at different stages of production and throughout the supply chain.

From the interviews with project respondents, two main advantages of EU-level projects compared to national programmes emerged. First, **European projects save time**, especially when commercialising the products, according to most of the participants. Respondents estimate that European level allows project outcomes to reach the market 3-5 years and in some cases up to 10 years faster than national projects. Second, **European projects in the area of Food Waste reach much larger population than national projects**. According to the respondents, EU-level brings a connection to the European market, and as a result, such projects make an impact on several hundreds of thousands of people at European level. According to the participants, some of the European projects have a potential to reach up to 100 million people (e.g. the NanoBarrier project) across Europe. Under the national programme such level of impact would not have been possible. EU-level project outputs reach the market quicker and have a positive impact on a larger customer base compare to national projects.

Virtually all interviewed participants agreed that their **research in the area of food waste achieved broader impact with European level projects than they would have achieved at national level programme.** All food waste projects tackle the following societal challenge directly: 'Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy'. A large portion of European projects related to Food waste, although indirectly, also contribute to solving challenges, such as:

- Health, demographic change and wellbeing (e.g. the ECsafeSEAFOOD project, which helps consumers detect contaminants in seafood and get dietary recommendations, whereas for processing facilities and aquaculture proposes innovative solutions how to reduce contaminants and toxins in the environment and in seafood);

- Secure, clean and efficient energy (e.g. the Muse-tech project introduced innovative energy-efficient sensors that could be used in food production and the FRISBEE that

provided new refrigeration tools and concepts for energy optimisation along the cold chain in Europe);

- Climate action, environment, resource efficiency and raw materials (e.g. the PicknPack, NOSHAN and Susfood projects that aimed to ensure efficient food processing, packaging processes and introduce innovative solutions to re-use the food waste; The Veg-I-Trade project sought to assess the impact of anticipated climate change and globalisation on the safety issues concerning fresh produce and derived food products).

Most of the participants agreed that European research on food waste is on the right track. **The EC funding is sufficient, and these EU-level programmes connect top experts in their fields all across Europe.** Together they make break-through discoveries. Although respondents emphasize the effectiveness of European projects, they realise the importance of national programmes too. However, they are not equipped to produce as significant impacts especially in the technological food waste projects that require heavy investments, top experts (usually available in different countries), infrastructure and leverage to attract additional private sources of funding (the prestige of European level project increases visibility and reputation, and trust from potential private investors as a result). France, Germany and Scandinavian Countries are few exceptions that have strong national programmes in the areas of food security and food waste. For other participants, European projects allow producing high quality research, an opportunity they would not be able to realize at national level.

To tackle societal challenges European leadership is necessary. When large investments are needed but the industry is not getting involved because of the risks involved, European programmes can play a significant role. **EU funding allows science to produce high quality research, attract top experts, encourage sharing of infrastructure and as a result help tackling societal challenges**. Key sources of European added value are the leverage effect of EU projects that helped attract additional funding from other public and private sources, as well as the international aspect – project participants reached wider audiences, i.e. European scientific community and European consumer base. National programmes are not enough, although they are important in complementing EU research**. Compared to other continents Europe is leading in the food waste research.**

F.5.3. Stories of impact

Several areas and projects were identified that are examples of successful initiatives of FP7 funding in the area of food waste. These successful projects tackle the food waste challenge at three levels: reduction, prevention and valorisation. The majority of projects focused on building new software tools, databases, methodologies and technologies as well as proposed new policies and directives. Projects covered various stages of the food industry value chain. The results of these initiatives are expected to contribute to reducing food losses across the entire food production and supply chains, re-using existing food waste (e.g. feed production) and achieving the European Commission targets to reduce per capita food waste by 50% at the retail and consumer level by 2030.

One category of projects – databases and software tools – aimed at raising awareness of food waste issue, developing tools that improve health of consumers and increase effectiveness of food processing, optimizing food distribution, and pushing for new policies regarding food waste among other impacts. Notable examples of such projects are ECsafeSEAFOOD, Hightech Europe, FoodIntegrity and FOODMETRES. One key project ECsafeSEAFOOD assessed food safety issues related to contaminants present in seafood and evaluated their impact on public

health. Based on their findings project members developed an online tool for different stakeholders and guidelines, a result of which, consumers can assess nutrition and contaminants of their seafood consumption as well as get dietary recommendations. By using project outcomes food processing facilities will be able to ensure the quality of food, measure contaminants and process the food more effectively, and as a result, reduce food waste. One small part of the project is expected to have a significant impact on the public health and food waste. Although the success of the ECsafeSeafood project depends on the capacity of private businesses to integrate the outcomes of the project in their daily activities, project participants estimate that several hundreds of thousands of people at European level will benefit from the results of this project.

Technological food waste projects increased effectiveness in food processing and production, reduced energy use, and introduced sustainable eco-friendly solutions to packaging. One of the success stories in this category, the NanoBarrier project searched for innovative and safe multifunctional packaging solutions. The project developed a renewable sustainable nanotechnology-based platform. The characteristics of packaging developed throughout the project include better oxygen barrier and sensor features (PH, temperature), which not only increase the shelf life of the product, but also allow real-time monitoring of food freshness and quality (any changes in the quality are detected by sensors). The nanosensors make it possible to provide information of the condition of food, packaging and environment (e.g. freshness, whether packaging is damaged or product is kept in required conditions). According to the interviewed members of the project, the application of intelligent packaging solutions is an emerging market that will see an accelerated growth in the coming years. Since project participants estimate a potential reach of 100 million consumers across Europe, the project outcomes are very likely to significantly reduce food waste.

The food industry lags behind other industries in terms of automation and use of technologies in food production. One of the success stories in this area, PicknPack, a technological food waste project aimed to revolutionise food production and packaging processes. The concept developed throughout the project offers a flexible solution for food industry that helps cope with variability of food products (types and sizes of products). The project achieved progress in three areas of food production: food quality inspection (a sensing module assesses the quality of products before and after the packaging), food handling (a robotic solution separates the product from a harvest bin/transport system and places it in the right position in a package) and adaptive packaging (accommodates various types of packaging with flexibility in terms of package shape, size, product environment, sealing and printing). According to the participants of the project, intelligent solutions developed throughout the project will lead to maximum performance in quality, reducing change over time, reducing time for reprogramming, adaption to operators, reducing waste of food and packaging material and stock. Moreover, flexible food picking, processing and packaging, allow early and self-learning quality assessment of food and more accurate prediction of the shelf life. The project was technologically challenging, but according to the participants the process was rewarding – some of the project outcomes are already commercialised. Project outcomes provide the industry with the benefits of automation: reduction in costs, greater hygiene and more efficient use of resources.

Another project that aimed to modernise the food industry, the Hightech Europe project, is a network of excellence. The project focused on the introduction of already existing modern technologies to the food industry and making the industry more efficient by connecting relevant companies from all over Europe. With the help of this tool, European companies shared their knowledge with each other and as a result adopted new technologies. For example, the food industry in Spain has adopted technological solutions for food handling using experience from

other industries than food. After a publication in the project‘s website, these solutions were adopted by food companies from other European countries (Scandinavia in particular). As a result, more efficient food handling allowed European countries to reduce food waste in the food processing stage. Project participants believe that the Hightech Europe project will help the European food industry to embrace new technologies from other industries towards more efficient use of resources and reduced food waste.

Projects concerned about food waste valorisation, for example the NOSHAN project, investigated the processes and technologies that could be used to convert food waste to feed production. The low energy consumption and positive environmental impact are features that make the NOSHAN project stand out. In addition, project participants made knowledge available through open access to the wider audience. By processing the food waste and converting it into animal feed, the project not only tackled the societal challenge of food security, but also other challenges, such as climate action, environment, resource efficiency and raw materials.

Other successful food waste projects, such as FoodIntegrity were concerned about the EU brand and food quality. Modeextreme, aimed to improve yield monitoring and forecasting systems, and as a result to help European Agriculture to face extreme weather events by simulations and analysis of plant responses to weather extremes (heat waves, cold shocks, droughts, frost). The project also developed softwares that could be used by the general public. The Food Metres project aimed to improve the sustainability of the urban food production chain. The project‘s goal was circular economy. It assessed the demand and supply of different types of food, which is expected to lead to better strategic planning by local governments and businesses, and as a result to reduction in food wastage and increased food security. These projects although very different in nature all helped to reduce food waste at different food supply and production stages.

F.6. European added value case study 6: Climate Change evidence

F.6.1. Overall context

(a) Definition and expected impact of the area

Small changes in the average temperature of the planet can translate to large and potentially dangerous shifts in climate and weather. Land and ocean surface data shows a warming of 0,85 °C over the period 1880 to 2012[112] (for more indicators see table 32 below). Rising global temperatures have been accompanied by changes in weather and climate. Many places have seen changes in rainfall, resulting in more floods, droughts, or intense rain, as well as more frequent and severe heat waves. The planet's oceans and glaciers have also experienced some big changes – oceans are warming and becoming more acidic, ice caps are melting, and sea levels are rising. As these and other changes become more pronounced in the coming decades, they will likely present challenges to the environment and society.

Therefore, climate change is a global problem to be addressed by combining global efforts. This case study concerns less environment policy and climate change in general, but more a specific part which relates to **providing scientific evidence/data/knowledge for policymakers and society on environmental and climate change issues**. The case study deals with this type of projects financed under European Union FP7 programmes and, largely, with FP7 Environment.

[112] IPCC Climate change 2014 synthesis report, p. 8;

Many adaptation and mitigation options can help address climate change, but no single option is sufficient by itself. Effective implementation depends on policies and cooperation at all scales and can be enhanced through integrated responses that link mitigation and adaptation with other societal objectives. Adaptation and mitigation responses are underpinned by common enabling factors. These include effective institutions and governance, innovation and investments and environmentally sound technologies and infrastructure, sustainable livelihoods and behavioural and lifestyle choices[113].

The ex-post evaluation of FP7 Environment documented the European added value of environmental research projects from different perspectives including capacity building and development of a critical mass, as well as harmonising databases, procedures, measurements, models, etc. However, it was noted that the added value of a project heavily depended on the uptake of research results, including the adoption of harmonised measurement procedures or tools, or the integration of recommendations into relevant policies.

Some intervention areas of FP7-Environment are exemplary of European added value, because research is to be coordinated at European and/or international level. This is clearly the case of Earth Observation. The FP7- Environment programme played an active role in implementing the **Global Earth Observation System of Systems (GEOSS)** while the European Commission is one of the four co-chairs of the Group on Earth Observation (GEO). GEO is an intergovernmental organisation of 89 governments and around 80 international organisations, which develop together projects and coordinate their strategies on earth observation. GEOSS is critical to tackle global challenges such as a climate change, energy and food security, or health.

FP7-Environment also played a key role in the development and aggregation of **climate change models, with a strong impact at the International Panel on Climate Change** (IPCC). FP7-Environment was unique because of its coordination role. FP7-Environment allowed an international co-development of climate change models, creating a process of mutual learning and an efficient knowledge creation. With its funding activities in the field, the Commission contributed to **the creation of international standards that avoid fragmentation of research** and funding. Something similar happened in other areas, like greenhouse gases (GHG) measurement or carbon in the sea, where the EU is leader thanks to its coordination and standardisation role.

Interest of the EU and society, with a view to preserving and improving human life and lifestyle, were addressed through the design of strategically oriented research programmes in the different fields within the theme. The FP7-Environment work programme was specifically designed to support the refinement of the EU's environmental policies, thus further contributing to the development of said policies in a research-informed manner. The FP7-Environment calls for proposals were also designed to provide **impetus to enhance the coordination of European research efforts, both trans-boundary and trans-disciplinary**.

The majority of projects funded via FP7-Environment were collaborative research projects involving large consortia (some over 30 partners) and large-scale EU funding investment (several over EUR 10 million)[114]. Areas of action of FP7-Enviroment include[115]:

- Climate change, pollution and risks;

[113] IPCC Climate change 2014 synthesis report, p. 62;
[114] Ibidem, p. 18;
[115] FP7 Cooperation Work Programme 2010: Environment (including climate change), p. 2;

- Sustainable management of resources;
- Environmental technologies;
- Earth observation and assessment tools for sustainable development.

The Council Decision 2006/971/EC[116] underlined the **European added-value of cooperation in the field of environment research**, and defined the main orientations or functions of future actions as:

- Coordination and integration of research outputs: developing common methodologies, databases, large-scale observations and forecasting systems;
- Policy support to the EU and Member states;
- Contribution to global and EU commitments;
- Technology development: supporting innovative environmental technologies for a more sustainable use of resources, contributing to the improvement of the competitive position of European enterprises.

From the review of 90 projects in the framework of the FP7 Environment ex-post evaluation, it was evident that activities funded through FP7-Environment contributed strongly to addressing increasingly global-scale environmental challenges**, supporting the improvement of the policy making process** through the provision and improvement of scientific evidence for policy assessment. Examples of such contribution include[117]:

- Strong contribution to the EU's Climate Action and Renewable Energy Package, the Floods Directive, the Droughts and Water Scarcity Communication, the Communication and Action Plan on Disaster Prevention and Early Warning, the Environmental and Health Action Plan, the Environmental Technologies Action Plan, etc.
- Strong contribution to international initiatives, including International Panel on Climate Change (IPCC), Global Earth Observation System of Systems (GEOSS), the Biological Diversity Convention (BDC).

The relevant programmes may not be directly linked with the decision-making as their main policy role was more in creating knowledge that would subsequently be used through intermediaries, such as the Joint Research Centre, the European Environment Agency, think-tanks and consultancies. However, some major provision and improvement of scientific evidence for policy making could be observed.

Table 23. Key indicators related to the area of this European added value case study

Indicator	Indicator values/examples

[116] Council Decision 2006/971/EC of 2006 concerning the specific programme 'Cooperation' implementing the FP7 of the European Community for research, technological development and demonstration activities;
[117] Ex-post evaluation of FP-7 Cooperation Programme Theme: Environment (including Climate Change), p. 57;

Indicator	Indicator values/examples
Atmosphere and ocean warming	Land and ocean surface data shows a warming of 0,85 °C over the period 1880 to 2012[118];
Ice mass loss	The annual mean Arctic sea ice decreased over the period 1979 to 2012. The rate of decrease was very likely in the range 3.5 to 4.1 percent per decade[119].
Sea level rise	Over the period 1901-2010 global mean sea level rose by 0.19 m[120];
Natural and anthropogenic radiative forcing	Concentrations of carbon dioxide, methane and nitrous oxide have all shown large increases since 1750 (40%, 150%and 20% respectively)[121].

Source: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming , based on IPCC Climate change 2014 synthesis report

(b) Defining the scope of the European added value case study

The majority of climate change projects were funded under FP7-Environment. However, a considerable part was also funded by other FP7 programmes, such as FP7-Infrastructures, FP7-ICT and FP7-Social Sciences and Humanities.

According to the Work Programme on Environment 2010[122], in **FP7 Environment** the emphasis was put on the prediction of climate, ecological, earth and ocean system changes, on tools and technologies for monitoring, prevention and mitigation of environmental pressures and risks. Examples of FP7-Environment projects related to the area of climate change are I-REDD, EUROCHAR and GEOWOW[123]. FP7 Environment was primarily designed to support and coordinate cooperation in environmental and climate change research. Innovation and technological development was a secondary objective of FP7-Environment, until the global economic crisis[124]. The re-orientation of research towards innovation and impact became a major tool in addressing the financial crisis and tackle societal challenges. Thus, the global economic crisis of 2007 required that the FP7 focus adapted and evolved within a changing global context.

FP7 Infrastructures refer to facilities, resources and related services used by the scientific community to conduct top-level research in their respective fields. Examples of FP7 Infrastructures projects related to the area of climate change are ICOS, IAGOS-ERI and INCREASE.

Within **FP7 ICT** the research funding is focused on seven key research challenges to ensure Europe becomes a world leader in ICT. Three challenges aim at industrial leadership in key ICT sectors, while four are driven by socio-economic targets. Examples of FP7 ICT projects related to the area of climate change are AEOLUS, E-AGRI and TELEIOS.

[118] IPCC Climate change 2014 synthesis report, p. 8;
[119] Ibidem, page 10;
[120] Ibidem;
[121] Ibidem, page 12;
[122] Work Programme 2010 on Environment (including climate change), 2009;
[123] Please find examples of climate change projects in www.cordis.europa.eu;
[124] Ex-post evaluation of FP-7 Cooperation Programme Theme: Environment, p. 3;

FP7 Social Sciences and Humanities contribute to an in-depth, shared understanding of the complex and interrelated socio-economic challenges facing Europe and the rest of the world. Examples of FP7 Social Sciences and Humanities projects related to the area of climate change are CREATING and TRANSIT.

Table 24 Key projects related to the area of Climate change

Programme	Number of projects	EU contribution, EUR million
FP7 Environment	60	259
FP7 Infrastructures	30	145
FP7 ICT	27	21
FP7 Social Sciences and Humanities	10	75
Total	**127**	**500**

Source: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming based on CORDA data

F.6.2. Key findings

Thirty interviews with coordinators of different climate change projects have been carried out (including FP7 Environment, FP7 Infrastructures, FP7 ICT and FP7 Social Sciences and Humanities) in the framework of this case study. The key findings from these interviews are are structured according to different categories of European Added Value. All interviews were semi-structured and performed by telephone.

(a) Factors/mechanisms of influence fostering European added value

Reduction of commercial and research risks

As climate change research projects usually have a considerable number of partners, they allowed **sharing of project risks among them**. In case one partner was unavailable, another one could undertake its tasks to achieve the planned result of a project. Moreover, the large budgets of projects allow shifting resources among activities and adapting to new circumstances and thus addressing unanticipated risks.

In a considerable number of climate change projects, SMEs and other private companies were engaged to carry on certain tasks, like maintenance of equipment, delivery of software, supercomputing services, etc. However, because the climate change projects usually had many partners and considerable budgets, **researchers belonging to large networks and having long track records of relevant research were better placed to enter such projects**. Smaller research teams and young researchers experienced certain difficulties to be invited to participate in such projects.

Leverage of private and public investment

EU funds helped to attract additional funds (national/ regional/ from other EU funding bodies/ private funding) to the same research area or other stages of the same research. This was confirmed by almost all interview respondents. Moreover, interviewees indicated that the amount of resources they received from the Framework Programme would be hardly possible to assemble through national and/or regional financing.

In some instances the EU funding covered only a certain part of research costs; the remaining part was covered by national governments (i.e. in the DACCIWA project the national governments of France, Germany and the UK made available their research aircraft for data collection on climate change in West Africa). One more example is the PREFACE project that utilised the ship time of German, French, and Norwegian vessels.

Moreover, in some of the projects national financing made up quite a considerable share. For example, in the ICOS project the Framework Programme funded only the preparatory phase of the project. Thus, the running of operational systems, the acquisition of equipment (such as atmospheric stations, ecosystems stations, or ships that continuously measure the transfer of greenhouse gases in the surface of earth and in the atmosphere) were financed by national governments.

A successful commercial application in the private sector usually helps to attract private funding to a particular research area. Moreover, in some instances private companies showed interest in climate change research because they wanted to know their own impact on climate change and be more socially responsible (i.e. different aircraft companies in the IAGOS-ERI).

As research projects financed by the Framework Programme usually last a couple of years, a successful project often helps to secure a follow-up project. The majority of project coordinators mentioned that they have successfully applied or intended to apply for a follow-up within Horizon 2020 and other sources of EU financing.

Pooling resources and building critical mass

EU funds made it possible to acquire **research equipment (in some instances sophisticated/expensive equipment) that could be shared by project partners and even by researchers outside the project.** This was also supported by the majority of the interviewees. For example in the MESOAQUA project the equipment was unique in the world and can be run in the open ocean. Other countries (Japan, the USA) have tried to design similar equipment, but they failed. Researchers from all over the world could come and work with this equipment. To analyse the results of the data obtained, the best groups of scientists in the world were invited.

In some projects **supercomputing, sophisticated sensors or similar equipment** were used (i.e. in the IS-ENES). In some instances (for example in the SEMANCO project) the equipment and different software products used by the researchers were developed by private companies. The software license was usually paid for with the project's funding.

In some instances the research equipment used in the projects created **the possibility to take samples inside and outside the EU was essential for the success of a project**. The climate change research area is rather unique in the sense that it is often very important to take regular samples across many countries (in different meteorological and climatic regions) in order to produce reliable climate models and to predict future climate change. For example, the IAGOS-ERI project achieved that the necessary equipment was placed on airplanes for conducting atmospheric observations on a global scale. The JERICO project offered a pan-European approach for European coastal marine observatory network. The PREFACE project has helped to extend and maintain the ocean observing system in the Tropical Atlantic.

In a majority of climate change projects **large sets of data were produced**, which were shared not only by project partners, but also for a wider scientific community and even the general public. Moreover, in some instances **sophisticated ICT tools were used**. For example, the main

purpose of the SEMANCO project was to develop an ICT platform to support the decision making of different stakeholders, who are involved in energy related urban planning, particularly in urban areas.

Increased international mobility of researchers

EU funds contributed to the enhancement of researchers' skills through international/cross-sectorial mobility, networking activities, workshops and other similar events. This was confirmed by almost all interview respondents. Networking activities, workshops and other similar events organised by different projects were very important in enhancing capacities of researchers and in exchanging their knowledge.

As research projects usually had a considerable number of partners, quite many mobility instances could be observed among them. However, a considerable share of projects attracted researchers outside of the project. It was quite a usual case in many projects for a PhD or postdoctoral student outside of the project to use the project infrastructure to collect data for his/her dissertation or other research activity. Moreover, a considerable share of mobility took place for taking different samples in different EU and non-EU countries. In some cases, it was necessary to take samples in as many countries as possible to build reliable climate models.

(b) Better results achieved because of European added value

Improved research excellence/capabilities

EU funded climate change research **allowed the EU to be at the forefront of this research area and/or ahead of other countries**. This statement was supported by the majority of interviewees. The EU was well placed to reach scientific excellence in this research area, as efforts of different EU Member States could be pooled. This has been a significant value added of the climate change projects and allowed joining forces and even being ahead of such countries as the USA, China, Canada and others.

Moreover, **in many instances EU funded climate change projects were carried out outside the EU**: in different African countries (i.e. building research capacity of local researchers in the CREATING), Southeast Asia (i.e. fighting deforestation in the I-REDD) or Middle East (i.e. building climate data depository in the DARECLIMED), as climate change is a global challenge where global efforts are necessary. Frequently the countries being the most affected by climate change are the least well placed to understand the issues. Therefore, they need help to develop appropriate adaptation plans and to implement them. Some of the projects were only partially related to climate change. For example, the SEMANCO project developed an innovative platform to assess energy performance in buildings of urban areas, the TRANSIT project focused on social innovations.

Climate change science is usually basic research and it is quite difficult to use its findings for commercial application. Nevertheless, in some instances such applications were discovered (i.e. in agricultural or tourism sectors). For example, the ACTRIS project had strong collaboration with the private sector, in particular with SMEs. The cooperation took place because the project participants had to offer expertise that the private sector needed. This cooperation evolved into developing prototypes together. Private companies also came to the project sites to test their instruments. In some cases they produced a prototype and the project tested it.

EU funded climate change science projects **produced a considerable number of publications, which might be openly accessed by the public/other researchers**. Climate change projects usually produced publications not only in prominent scientific journals, but different kinds of reports and newsletters for wider public were also delivered. Different conferences, symposiums and seminars were also organised for dissemination of project findings and results. Interaction with policy bodies and ministries outside the EU is also a very important means of dissemination (i.e. PREFACE interacted with the Ministry for Fisheries in several African countries and communicated with sub regional fishery commissions).

The EU funding **facilitated engaging in interdisciplinary research** in the area of climate change, which enabled comparing different approaches. For example, in the I-REDD project geographers, biologists, economists received a possibility of working together to find necessary solutions. With national funding, it would not have been possible to have a project of this scale.

Economies of scale and scope

The majority of EU funded climate change science projects were large-scale projects with a considerable number of partners and work packages. As the deliverables of such projects were quite many and diverse, this could entail some economies of scope.

Economies of scale are not very much relevant to the research area of climate change. However, in a considerable share of climate change projects a large number of samples were taken in different EU and non-EU countries, which allowed researchers to improve their skills and to do the job better after a certain amount of samples. For example, in the ACTRIS project it was important to have the equipment located in different meteorological and climatic regions and researchers moved from one location to the other and studied different processes that are related to different climatic areas.

Moreover, advanced equipment purchased in a considerable number of projects, allowed the sample collection job to be easier and cheaper to handle. For example, in the ACTRIS and MESOAQUA projects some of the research stations or experimental installations were equipped with very advanced instrumentation.

Wider availability and dissemination of knowledge

In a majority of climate change projects **large sets of data were produced, which were usually made available not only for project partners, but also for a wider scientific community**. For example, in the case of the ACTRIS some private services were based on its data. The data could be used for agriculture, tourism and other applications with economic impact. For example, during the volcano eruption in Iceland in 2010, the aircraft industry was interested in receiving information about real level of risk for flying in specific areas. According to the International Air Transport Association, the total loss for the airline industry was around EUR 1.3 billion due to the volcano eruption. The atmospheric data helped to somehow alleviate this loss. In many cases special portals were created for the data. Alternatively, the data was placed in already existing data portals.

Better coordination of national research policies and practices at the EU level

Climate change research usually needs to be carried out in different EU and even non-EU countries (i.e. for atmosphere/sea/ocean data collection in different countries). Therefore, **efforts of different countries may be easily combined and national research policies coordinated.**

In this regard the EU has an advantage against other large economies (i.e. USA and Canada), which enables pooling its resources to solve pan-European challenges.

In many instances the EU funded research in the area of climate change started/initiated research and then national/regional authorities decided to get involved, thus contributing to the achievement of the projects' objectives of fighting climate change.

A few interviewees indicated that **much more coordination is necessary between European and national funding in terms of different evaluations, methodologies**, etc. in order to avoid unnecessary overlaps and duplications. This would allow a more efficient use of project resources. In some instances, access to different research infrastructures should be more coordinated as well to achieve a better use.

(c) Long-term impacts resulting from European added value

Better addressing societal pan-European challenges

One of the strengths of EU funding lies in the possibility **to join efforts of different EU Member States to tackle wider societal challenges**, such as climate change; secure, clean and efficient energy; smart green and integrated transport; food security. For example, the ACTRIS data can be used for improvement of weather forecasts and serve as solid input data for future climate scenarios. This allows also dealing with natural and anthropogenic disasters like eruptions of volcanos, forest fires, and nuclear accidents. Climate modelling is very important in this regard, as it is essential to understand how the climate will evolve and to be prepared for extreme events and to mitigate them.

When available data or models do not permit forecasting effects of climate shift on ecosystems, full ecosystem-scale empirical studies, such as done in the MESOAQUA, delivered critical data from many sites from the Mediterranean to the Arctic. Data from the MESOAQUA thus significantly contributed to increase our present understanding of future risks. It is critical to conduct such investigations over a wide and representative range of climate zones, and over extended time to gain adequate understanding of these complex systems. Thus, such coordinated transnational studies are only possible through strong international funding schemes, such as from the Framework Programmes.

As addressing wider societal challenges does not pay off immediately and requires continuous efforts, it is quite difficult to gather necessary resources to tackle them. Moreover, certain climate change projects undertake such tasks as fighting climate change in West Africa (such as the DACCIWA and PREFACE projects), which are expensive to be undertaken by a Member State alone. In this regard the Framework Programmes are well placed to deal with pan-European challenges.

In some instances FP7 climate change projects **contributed to the development and implementation of EC directives and action plans in the area of climate change**. For example, the HYDROLAB project strongly supported the development and implementation of the European Floods Directive firstly adopted in 2007. The European Floods Directive stipulated how to act facing the danger of flooding in different EU Member States. Another similar example is the SEMANCO project, which contributed to the implementation of the Energy Performance Directive.

F.6.3. Stories of impact

Climate change research played an active role in implementing the Global Earth Observation System of Systems (GEOSS). The EOS conducted long-term **global observations of the land surface, biosphere, atmosphere and oceans of the Earth, by producing large quantities of data**, which is critical to tackle global challenges such as a climate change, energy and food security or health. Some of the research stations were equipped with very advanced equipment and infrastructure and employed researchers from different countries and sectors. Projects of this kind engaged in research on air quality by placing sensors on commercial aircraft (i.e. IAGOS-ERI), in water related research (i.e. HYDRALAB IV) by focusing on marine ecology and in full scale ecosystems regional experiments in a global manner (i.e. MESOAQUA).

MESOAQUA critically contributed to the international joint activity that generated a comprehensive data set which allowed to study the complex responses of pelagic communities to climate change, in a way that was not previously possible. In particular, the project increased our understanding of how the lower part of the pelagic food web works, how it responds to climate change, pollution and environmental toxins, **and what role it plays in producing food for larger species of fish**. **Thus, the project strongly contributed to tackling food security issue on a global scale.** During four years MESOAQUA offered to more than 150 European and not-European marine scientists access to research facilities where they were leading or contributing to a total of 23 different cooperative international experiments, thereby advancing studies of aquatic ecosystems from the Arctic to the Mediterranean.

The data obtained from the HYDRALAB IV project tests **is crucial to reduction of the cost of energy from wave energy systems.** Commercial exploitation of wave energy will require installation of large numbers of Wave Energy Converters (WECs), arranged in an array (or a farm or park). Given their geographical distribution and the wealth of resources available in Europe, tidal and **wave energy is poised to provide the most significant contribution to the European energy system[125].** To illustrate this, as much as 45 % of wave energy developers are located in the EU. Moreover, the majority of ocean energy infrastructure, such as ocean energy test centres, is also hosted in the EU[126].

Climate change research played a key role in the development and aggregation of climate change models, which are essential to understand **how the climate will evolve and to be prepared for extreme weather events and to mitigate them**. For example, floods are a serious problem in the EU and world-wide. In May-June 2016, flooding killed 20 people in different EU Member States (in Germany, France, Belgium and Romania). HYDRALAB IV research findings allowed the **quantitative assessment of flood risk reduction by salt marshes under extreme conditions** and thus provided input into the future engineering of such biophysical buffers in the face of global environmental change. The project also improved ice load measurements, which improved the understanding of loading on structures and icebreakers. Moreover, **GEOWOW provided solutions that contributed to further improvements in high impact weather forecasting.** In particular, GEOWOW provided a get around the 2-day delay in the data accessibility and helped weather forecasters to improve warnings of hazardous weather, and so avoid some of the associated impacts, especially in developing countries.

[125] 2014 JRC Ocean energy status report, page 14;
[126] Ibidem;

The ACTRIS project was an essential pillar of the EU ground-based observing system that provides the long-term observations information required to **understand current variability of the atmospheric aerosol components and better predict their impact on climate and air quality in a changing climate**. ACTRIS aimed at integrating European ground-based stations equipped with advanced atmospheric probing instrumentation for aerosols, clouds, and short-lived gas-phase species. ACTRIS supported and complemented aircraft and satellite observations and had an important role in the validation, integration, full exploitation of remote sensing data. The strategic focus of ACTRIS was to ensure the long-term continuation of advanced measurements on aerosols, clouds and reactive gases in Europe in a coordinated and cost-efficient way.

Climate change research is unique because of its strong coordination role*,* as it allows an **international co-development** of climate change models, creating a process of mutual learning and an efficient knowledge creation. In many instances EU funded research initiated climate change research and then national/regional authorities topped up the efforts with additional financial resources, thus **creating synergies and added value**. In some of the projects national financing made up quite a considerable share. For example, in the ICOS project the Framework Programme funded only the preparatory phase of the project. Thus, the running of operational systems, acquisition of equipment (such as atmospheric stations, ecosystems stations, or ships that continuously measure the transfer of greenhouse gases in the surface of earth and in the atmosphere) were financed by national governments, thereby strongly complementing the EU funding and creating additional value.

EU-funded climate change research is very valuable, as the obtained data can be used for multiple purposes in different sectors ranging from climate change, energy to food security and health. Therefore, good accessibility to this data is crucial. The GEOSS portal provides scientists, policymakers and citizens with improved discovery and access to cross-discipline Earth observation data and services that meet their individual needs (i.e. GEOWOW project). Via the GEOSS portal users may discover and access different earth observation resources which have been registered. It connects data providers with users by having implemented different apps and interfaces in a way that users can easily find data without being expert in different protocols used by data providers.

EU climate change research is unique of its global character. A considerable share of EU climate change projects were carried out in non-EU countries: in different African countries (i.e. building research capacity of local researchers in the CREATING), Southeast Asia (i.e. fighting deforestation in the I-REDD) or the Middle East (i.e. building climate data depository in the DARECLIMED). This was an important contribution in fighting climate change, because **the countries most affected by climate change are often the least well placed to understand the issues and provide financing.**

F.7. European added value case study 7: Contributions to the Digital Single Market through innovative online public services in an inclusive and reflective society

F.7.1. Overall context

(a) Definition and expected impact of the area

This case study focuses on the research supported by FP7 in the area of innovative online public services and the contribution (the European added value) it has made to the Digital Single Market as well as to building a more inclusive and reflective European society. The subject of

this case study draws its rationale from one of the societal challenges that Horizon 2020 programme aims to address, namely *Societal Challenge 6 (SC6): Europe in a changing world - inclusive, innovative and reflective societies*. Among other research areas falling under this Societal Challenge, Horizon 2020 will finance research on how Information and Communication Technologies (ICT) could contribute to the inclusiveness, innovativeness and reflectivity of the European societies. As clarified by the Societal Challenge 6 Work Programmes 2014-2015 and 2016-2017, issues researched in this area can be quite diverse, ranging from eGovernance (the way governments are using ICT for providing public services) and eParticipation (providing citizens with a way to engage in policy-making with the help of ICT) to the digitisation of resources with societal relevance (e.g. digitising historical books and other resources, 3D modelling for accessing EU cultural assets).

This case study aims to assess the European added value and impacts of the research on innovative online public services funded under the predecessor FP7 programme. In broad terms, projects analysed fall into one of the following research topics:

- **eGovernment/ eGovernance** – the use of ICT to improve the activities of public sector organisations. The following sub-topics will be covered under this research area;
    - **Improving government process**. Initiatives within this domain are concerned particularly with improving the internal workings of the public sector;
    - **Connecting citizens and government**. Such initiatives deal particularly with the relationship between the government and the citizens: either as voters/stakeholders from whom the public sector should derive its legitimacy, or as customers who consume public services;
    - **Building external interactions (eSociety)**. This area covers initiatives aimed at developing citizens-to-citizens interactions (building communities), as well as creating links between citizens and other organisations (NGOs, businesses).
- **Digitisation and digital preservation of culturally relevant resources**. Research in this area aims to analyse, among other things, (1) how cultural and historical resources can be digitised and preserved, (2) how these resources can be made accessible to citizens as well as researchers, and (3) how cultural digital resources can be innovatively re-used to offer economic opportunities to the cultural and creative industries.

The Digital Agenda for Europe[127] adopted in 2010 indicated eGovernment services as a cost-effective route towards better public services for every citizen and business, as well as towards a participatory, open and transparent government. eGovernment services can reduce costs and save time for public administrations, citizens and businesses. They can also help mitigate the risks of climate change, natural and man-made hazards, for example by sharing of environmental data and environment-related information.

The main impact expected from research funded in the area of **eGovernment** is to contribute to developing **new and improved processes, products, services and methods of delivery** in the public sector. Using ICT to innovate in the public services provision is also expected to make the

[127] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions A Digital Agenda for Europe: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52010DC0245

public administrations more effective and efficient (e.g. through better responding to society's needs) as well as to **improve the quality of services** they provide.

The Digital Agenda for Europe has also indicated the need[128] to digitise Europe's cultural heritage and make it available to this and future generations as well as to create a legal framework to facilitate the digitisation and dissemination of cultural works in Europe.

In the area of **digitisation and digital preservation**, the key expected impacts of the EU-funded research are:[129]

- Improving access to and use of digitised cultural material that is in the public domain;
- Improving conditions for the digitisation and online accessibility of digitised material;
- Reinforcing strategies and legislation for the long-term preservation of digital material;
- Making the necessary arrangements for the deposit of material created in digital format in order to guarantee its long-term preservation.

(b) Rationale for public intervention: key trends in the area, main challenges and indicators

There is an unquestionable rationale for the public intervention in the area of innovative online public services. The output of research in this area itself is first and foremost used by the public institutions. Even in such cases when research leads to marketable innovations (e.g. applications, websites) developed by the private sector organisations, they usually have a social purpose and therefore contribute to the objectives of public institutions. Furthermore, research funded by the FP7 in the area of digitisation and digital preservation often has not only national, but also EU-level rationale, since it is related to protecting the European cultural and historical heritage.

Research in the area of eGovernment mostly responded to a challenge on how to make public administrations in Europe more effective and efficient in providing public services. A recent study on eGovernment services in Europe[130] showed that there remain many issues to be addressed in this area: for example, in many cases users of public services in different countries are still asked to fill forms with information already available to the administration. Only 57% of the public services are available to trans-national businesses and only 41% to other EU citizens across the border. As many as 73% of the public services websites do not have a mobile-friendly version. These are just a few indicators underlining the importance of funding research (and especially EU-level research) in this area.

The orientation paper published in 2013 as a result of the public consultation on directions for EU-level research on ICT-driven public sector innovation[131] listed a number of measures how research supported at the EU level is expected to foster ICT-driven public sector innovations.

[128] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions A Digital Agenda for Europe: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52010DC0245

[129] Commission's Recommendation on the digitisation and online accessibility of cultural material and digital preservation: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:283:0039:0045:EN:PDF

[130] Capgemini, IDC, Sogeti, and Politecnico di Milano, "Future-proofing eGovernment for the Digital Single Market: An assessment of digital public service delivery in Europe." Background report, June 2015.

[131] Orientation paper: research and innovation at EU level under Horizon 2020 in support of ICT-driven public sector innovation, 10 May 2013, p. 2.

These measures were summarised into two categories related to (1) the key drivers and trends in the eGovernance area and (1) the basic technology tools and other enablers.

Regarding key eGovernance drivers and trends, it was recommended that researchers in the ICT area to focus on:

- Promoting **open data, open services and open participation** through developing frameworks and models linking many parts and levels of the public sector as well as linking the public sector to other appropriate actors outside government;

- Promoting **approaches focusing on the user/client**: user empowerment, co-creation, service personalisation, simplicity and needs fulfilment. To achieve this, the researchers were invited to learn from the best in the private sector and to ensure that that all users are served by employing appropriate channels and that their privacy and integrity are protected. This also includes supporting the development of local and location-based services, based on open data and mobile devices using GPS and web-based services (e.g. smart city approaches);

- Fostering **participation and engagement of citizens/users**. Researchers are expected to focus more on enabling widespread collaboration in service strategy development, making design decisions, managing public assets and other work process arrangements.

- Undertaking **bottom-up societal experimentations on a small scale** where failure is small and thus survivable, while success can be supported and up-scaled.

The following key aspects to be addressed by EU-funded research were highlighted in the area of basic technology tools and other enablers:

- There is a need to **adopt and develop new types of infrastructures and processes** (both hardware and software) as well as to use and adjust the technological elements already developed elsewhere. Among other things, research should focus on building infrastructures needed to support 'big processes' (such as decentralised innovative operations, big data analysis) and the use/development of reference models and standards for ICT. Regarding infrastructure, the following trends should be especially noted:

    - Increasing the focus on web 2.0, social media, gamification, mobile solutions and Bring Your Own Device (BYOD;

    - Developing and deploying privacy-enhancing-technologies which ensure data protection, cyber security, identity management and authentication;

    - Deploying advanced cloud solutions, semantic interoperability, web 3.0 approaches and the Internet of Things.

- EU-funded research must use and focus on obtaining **good quality data** available in machine readable linked datasets which can be easily searched and merged. In addition, future research is expected to focus on ways how to enhance standards for data quality, structuring, linking and searching, as well as on the development of standard tool modules for compilation, analysis and visualisation of data. Safeguards for ensuring the provenance, integrity, auditability, authenticity and transparency of data should also be taken into account.

- EU funded research is expected to investigate **ICT-based policy modelling and making** by developing common public sector toolboxes for data analytics to address complex societal problems, investigating the potential of policy simulation, massive multiplayer policy gaming and model-based decision-support systems.

- Researchers should also assess how the most recent ICT can contribute to **measuring and monitoring government performance** in particular through providing new measurement tools and methods;

- EU-funded research is also expected to look at how ICT can be used to **empower public sector staff** as well as how the public sector employees can be assisted in acquiring necessary skills to use the ICTs.

However, researchers and practitioners in the area should also note certain concerns that changing and adapting the roles of government based on the ICT-driven innovation might bring[132]:

- Loss of control and blurred accountability of services (by whom to whom?);

- Service quality standards are more difficult to determine and maintain with many designers and suppliers;

- Privacy and data security;

- Danger of data and content misuse;

- Information and data overload.

The rationale for the EU to invest in digitising cultural resources was already underlined in the Commission's Communication "i2010: Digital libraries" published in 2005.[133] The key objective of the initiative was to make Europe's cultural and scientific record accessible for all and to create a virtual European library. The initiative indicated three main strands of action to be followed that are still valid:

- **Digitisation of resources** for their wider use in the information society;

- **Preservation and storage of digital resources** to ensure that future generations can access the digital material and to prevent precious content being lost;

- **Fostering online accessibility of digital resources** to maximise the benefits that citizens, researchers and companies can draw from the information.

[132] Orientation paper: research and innovation at EU level under Horizon 2020 in support of ICT-driven public sector innovation, 10 May 2013, p. 3.
[133] Communication from the Commission of 30 September 2005 to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – i2010: digital libraries, COM(2005) 465 final: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52005DC0465&from=EN

The Digital Agenda for Europe indicated[134] that the fragmentation and complexity in the current licensing system hinders the digitisation of a large part of Europe's recent cultural heritage. Rights clearance must be improved, and Europeana – the EU public digital library – should be strengthened. Increased public funding is needed to finance large-scale digitisation, alongside initiatives with private partners provided that they allow a general accessibility of Europe's common cultural heritage online. Europe's cultural heritage should also be made better accessible to all Europeans by advancing and using modern translation technologies.

The table below provides a list of quantitative indicators most commonly employed to measure the impacts of innovative online public services.

[134] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions A Digital Agenda for Europe: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52010DC0245

Table 25 Key indicators related to the area of innovative online public services

Indicator	More detailed description	Indicator values/examples
E-GOVERNMENT		
UN E–Government Development Index (EGDI)	The EGDI is based on a comprehensive survey of the online presence of all 193 United Nations Member States, which assesses national websites and how e-government policies and strategies are applied in general and in specific sectors for delivery of essential services. The assessment rates the e-government performance of countries relative to one another as opposed to being an absolute measurement. The results are tabulated and combined with a set of indicators embodying a country's capacity to participate in the information society, without which e-government development efforts are of limited immediate use. EGDI is a weighted average of normalised scores on the three most important dimensions of e-government, namely: • Scope and quality of online services (Online Service Index, OSI); • Status of the development of telecommunication infrastructure (Telecommunication Infrastructure Index, TII); • Inherent human capital (Human Capital Index, HCI).	The indicator takes values from 0 to 1. Where 1 indicates the maximum development level of E-Government. For example: • The UK: EGDI was 0.9193 in 2016; • Germany: EGDI was 0.8210 in 2016.
UN Telecommunication Infrastructure Index (TII)	The TII is an arithmetic average composite of five indicators: • Estimated internet users per 100 inhabitants; • Number of main fixed telephone lines per 100 inhabitants; • Number of mobile subscribers per 100 inhabitants; • Number of wireless broadband subscriptions per 100 inhabitants; • Number of fixed broadband subscriptions per 100 inhabitants.	The indicator takes values from 0 to 1. Where 1 indicates the maximum development level telecommunication infrastructure. For example: • San Marino: TII was 0.61276 in 2016; • Serbia: TII was 0.54344 in 2016.
UN Online Service Index (OSI)	The OSI assesses each country's national websites in the native language, including the national portal, e-services portal and e-participation portal, as well as the websites of the related ministries of education, labour, social services, health, finance and environment as applicable. The assessment includes the accessibility and usability of online tools provided by the national institution website.	The indicator takes values from 0 to 1. For example: • San Marino: OSI was 0.23913 in 2016; • Serbia: OSI was 0.81884 in 2016.
Individuals using the internet for interaction with public authorities (Eurostat)	Individuals using the internet for interaction with public authorities within the last 9 months before the survey: % of individuals aged 16 to 74.	Netherlands: 61 % of individuals were using the internet for interaction with public authorities in 2009. Austria: 49 % of individuals were

Indicator	More detailed description	Indicator values/examples
		using the internet for interaction with public authorities in 2009. Note: Indicator covers period from 2008 – 2015.
Individuals using the internet for taking part in online consultations or voting (Eurostat)	Individuals using the internet for taking part in online consultations or voting within the last 3 months before the survey: % of individuals aged 16 to 74.	Denmark: 12 % of individuals were using the internet for taking part in online consultations or voting in 2011. Ireland: 4 % of individuals were using the internet for taking part in online consultations or voting in 2011. Note: Indicator covers period from 2011-2015.
DIGITISATION AND DIGITAL PRESERVATION		
Institutions with digital collections per country (Enumerate)	Actual number of institutions (incl. national libraries, museums, archives, etc.) possessing digitised material.	Sweden has around 107 national institutions with digital collections; Spain has more than 146 national institutions with digital collections.
Presence of a written digitisation strategy per country (Enumerate)	Actual number of institutions (incl. national libraries, museums, archives, etc.) possessing written digitisation strategy.	Sweden has around 39 national institutions with written digitisation strategy; Spain has more than 60 national institutions with possessing written digitisation strategy.
Existence of embedded policies related to the sustainability of digital collections (Enumerate)	This indicator is a measure of the internal/managerial support for activities related to the preservation of an institution's digital collections.	-
Online access to digital heritage (Enumerate)	Percentage of metadata that is available online for general use.	There is ~46% of digitised material which could be accessed through online platform in Spain; There is ~45% of digitised material which could be accessed through online platform in Sweden.

Source: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming).

(c) Defining the scope of the European added value case study

The FP7 ICT programme (FP7 ICT)was the single largest and most important FP7 programme part supporting research in the area of innovative online public services. As many as 62 projects were funded by FP7 ICT in this area with around EUR 169 million of EU contribution. A few relevant projects were also funded by other FP7 programme parts, which are listed in the order of significance in the table below.

Table 26 Projects related to the area of innovative online public services and their allocated EU contribution

Programme	Number of projects	EU contribution, EUR million
FP7 ICT	62	169.14
FP7 Environment	5	26.02
FP7 Infrastructures	2	4.95
FP7 Research for the benefit of SMEs	2	2.32
FP7 Social sciences and humanities	2	5.10
FP7 Regions of knowledge	1	2.60
FP7 Transport	1	2.82
Total	**75**	**212.95**

Source: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming based on CORDA data

F.7.2. Key findings

(a) Factors/mechanisms of influence fostering European added value

Reduction of commercial and research risks

When it comes to the research risks, such as addressing an innovative research topic that is uncertain to lead to relevant results, most of the interviewees had a general feeling that the EU funding provided a major contribution to mitigate such risks. Although the participants of the FP7-funded projects could not provide many specific examples, one of the area where risk-reducing effect of the EU funding was rather clear was research on digital preservation of the European cultural resources. The main argument for this was that national or private funders would not be interested in this issue with specific European relevance. Therefore FP7 funding for research in this area was of key importance to make it happen.

The interviewees also mentioned that FP7 funding ensured a certain level of trust that research will go on without interruption at least for a few years, which made mainly the private actors become more interested in participating in such projects. This way businesses could be ensured that for a certain amount of time they will have a reduced risk to analyse the specific and sometimes riskier-than-usual topics.

In addition to this, the interview programme indicated the potential of FP7 to contribute to reducing commercial risks: there were a number of business participants in the research area of innovative online public services (especially companies developing potentially marketable applications), who claimed that participation in FP7 allowed them to look at specific innovative issues, which later resulted in commercialisation through the development of a mobile application or some specific process/part of the application necessary for the operationalisation. However, interviewees from businesses said that in many cases it takes a lot of time (4-6 years) to commercialise research outputs, which means that the EU funding often helps to avoid risks only for some time and later on these risks still have to be taken by companies.

For example, in the case of the project Instant Mobility it took around 6 years - adding both the time were FP7 support was received (2011-2013) and the time where research was funded by the company itself (2010-2011 and 2013-2016) - to arrive at a situation where customers were ready to buy the application to improve the multimodal mobility systems.

Leverage of private and public investment

Interviews with participants of EU-funded projects did not allow to come to a straightforward conclusion on whether funding from FP7 tends to attract additional private or public investment in the area of innovative online public services. Although there are a number of specific examples when (1) the fact that an organisation was applying to FP7 helped to find public or private co-funding for a specific project or (2) additional funding was leveraged as a result of the project success, interviewees were reluctant to claim that this is a general trend in the research area focusing on innovative online public services.

However, evidence from interviews showed that a significant share of participants of EU-funded research projects have successfully **attracted additional follow-up funding from FP7 and Horizon 2020** to continue their research and development of technologies in follow-up projects.

The analysis also revealed that **there are significant differences among EU countries in terms of funding opportunities available at the national level** in the area of innovative online public services. A consensus among the interviewees emerged that, on average, the smaller a Member State is, the less national opportunities it has. A similar statement can be made related to the economic development level of a country. Therefore EU research funding opportunities would be especially important for smaller and less economically advanced countries. The funding from FP7 has certainly helped such EU Member States to catch up or to get closer to the leading Member States both in terms of research capacities and level of excellence. On the other hand, many of the interviewees mentioned Germany, the UK, France and the Netherlands as those countries where it would be possible to find similar funding opportunities in the absence of the EU framework programmes.

The case study also showed that some large private organisations (including, for example, Google) are very active in the area of digitisation of cultural resources (especially, books). Some of the interviewees mentioned that they have cooperated with Google, who was providing co-funding in digitisation projects. Interviewees also noted that, however, it is very difficult to attract any private funding for digital preservation (in contrast to digitisation) projects, since it is much more difficult to translate research on digital preservation of cultural resources into marketable products. Therefore public funding is necessary in this area.

Pooling of resources and building critical mass

When it comes to pooling of resources, **the key concern of the participants in research projects implemented in the area of innovative online public services was receiving good and sufficiently large datasets**. Many interviewees mentioned that collaborating with partners in different countries helped them gather richer data as well as different types of data. Examples in this area are provided by five projects under the FP7-funded initiative called "Citizens' Observatories", which aimed at developing novel technologies and applications in the domain of Earth observation. These projects have exploited the capabilities offered by portable devices (smartphones, tablets, etc.), to enable an effective participation by citizens in environmental data collection. For example, under one of the projects – COBWEB – the visitors of four Biosphere

Reserves (Dyfi in Wales; Wadden Sea and Hallig Islands in Germany; Gorge of Samaria and Mt Olympus in Greece) were involved to collect environmental data using their mobile devices.

The mere **size of the European research projects was also mentioned as an advantage**. There was a consensus among the interviewed participants that large projects such as the ones funded in FP7 are very rare at the national level. Most interviewees were of the opinion that their projects would not have taken place at all without European funding. According to the projects participants, they would still research the same issues even without receiving funding from FP7, however, the objectives of their research and most likely the results would have changed significantly.

FP7-funded projects have frequently involved a large number of partners from different countries and different disciplines, thus **enabling the consortia to expand their research depth and scale**. For some of the digitisation projects focusing on preservation of the European cultural resources, cooperation between partners in different countries and large-scale funding was absolutely necessary due to the specific European-level relevance of their research. In addition, many interviewees mentioned that their partners sometimes possessed additional skills, which were lacking in their own organisations, for example, on the application of specific research methods or use of specific softwares.

Interviews revealed that **pooling infrastructure was not a vitally important issue in the area of innovative online public services**. The necessary softwares and hardwares (mostly computers) were usually relatively cheap and available in all partner organisations.

Increased international and/or inter-sectoral mobility of researchers

The interview programme did not indicate any relevant instances of international or inter-sectoral mobility. In most of the analysed projects, partners were working specifically on their own work packages while exchanging the insights from their research in the regularly organised meetings or online calls with their partners. In some cases, researchers from one partner moved to the premises of other international partners for no more than 1-2 weeks in order to do research, which is specifically related to their own work packages.

The case study did not indicate any instances of inter-sectoral mobility. Nevertheless, taking into account the fact that many of the analysed projects involved both academic and business partners, the involved researchers did get exposed to some extent to operations/research in a different sector (academia to business and vice versa).

As mentioned by some interviewees from the private sector, businesses are often not willing to send their researchers to work or do internship in other research institutions, e.g. academia. This is related to the unwillingness of private companies to use their human resources in a way, which is not directly related to the key business operations and is not directly leading to revenue/profit.

(b) Better results achieved because of European added value

Improved research excellence / capabilities

One of the main ways through which FP7 funding contributed to improving research capabilities of organisations doing analysis in the area of innovative online public services, was by **helping to build new research partnerships/ consortia or to sustain those that already existed**. The interview programme has indicated that the impact of FP7 on building new international research teams and networks was especially significant. Many interviewees reported that they have found

new partners. when applying to FP7 funding. Furthermore, most of them said that they have continued cooperating with the newly established partners even after the EU funding has ended. In a number of cases the research consortia that were established as a result of FP7 funding succeeded in securing further funding from FP7 or Horizon 2020. This evidence suggests a clear and very significant impact of EU research funding on building lasting research consortia.

In addition to this, **there is a clear impact not only on the cooperation as such, but also on inter-sectoral collaboration**. The interview programme indicated a number of instances where FP7 funding led to long-term cooperation between academia or public research institutes and businesses.

FP7-induced long-term cooperation also **helped smaller actors to up-scale, enter and establish themselves in specific research areas or even markets** through cooperating with larger organisations in the area. This is relevant both for academic and business sectors. First, the case study indicated instances where SMEs established themselves in specific markets by cooperating in FP7 projects with larger and very well-established companies. A similar trend was indicated in academia. Through participating in FP7, less established universities, especially from the new EU Member States, have successfully built links with the best universities in Europe and the world.

FP7 also had a significant effect on the size of the research teams – this was indicated by many interviewees. However, it is not entirely clear to what extent this effect was direct (i.e. hiring researchers from the project funding) compared to the leverage effect (hiring additional researchers as a result of project results, which would not be funded from FP7 funding). The collected evidence shows only that the new researchers were certainly hired from the project funding. The analysis done for the case study even indicated a number of research institutes, where the employees are mainly remunerated through funding from the Framework Programme. This means that such teams would likely disappear if the EU funding was to end. Interviewees did not mention any specific examples where the employment of new researchers would have been the result of the success of a project and the attraction of funding from other sources than EU.

The interview programme also revealed that in the area of research on online services **there is some tension between the development of excellent research** (measured in the number of scientific articles published in top journals) **and the development of specific ICT applications**. For example, the POSEIDON project has developed an application for users with Down's syndrome, which supports daily planning of activities such as shopping, money handling, traveling and similar. Although FP7 was a programme focusing in particular on support for research activities, the researchers in the area of ICT saw the development of very concrete innovative tools and applications as no less important. Some interviewees even indicated that they would like the Commission to focus less on the quality of research itself and more on the applicability of the developed tools. A number of interviewees also noted that follow-up funding for making the developed innovations operational or marketable would be welcome.

The interview programme indicated a **low effect (if any) of FP7 funding on training/improving the skills of researchers**. Interviewees reported that training for the researchers working in the projects was not usually provided as part of the project funding. Nevertheless, other training opportunities were offered for researchers in the organisations, both academia and businesses, as part of usual operations of the involved participants.

Economies of scale and scope

There was little evidence demonstrating the impact of EU research funding on economies of scale and scope. An example coming closest to such effect was research in the area of digitisation of cultural resources. A number of interviewees in this area indicated that without the EU funding and involvement of partners from different countries it would have been impossible to digitise as many resources at the national level in separate countries as the FP7 funding allowed to at the European level. Access to different types of data available in different countries (e.g. historical fonts, paintings) also allowed improving the digital recognition tools so that the digitisation of each specific cultural unit is relatively easier and also cheaper. This shows that cooperation in digitisation projects at the European level allowed to improve the efficiency of the relevant ICT tools and therefore to save resources.

Wider availability and dissemination of knowledge

According to interviewees, FP7 funding had a clear effect on improving access to research outputs. However, this is mostly the result of projects where the European Commission required that all data and research outputs should be published in open source repositories. When it was not directly required, participating organisations were less willing to do this on their own. A number of interviewees from businesses indicated that a requirement to publish data or the developed prototypes in openly accessible websites has harmed commercialisation opportunities related to the potentially marketable outputs developed.

Interviewees also agreed that, compared to the nationally-funded projects, **research done under the EU-funded projects is generally much better communicated** to the practitioners in the area as well as to the wider public, since the Commission often directly asks to allocate a certain amount of resources for communication (which is not always the case in nationally-funded projects or even less so in projects funded with own resources). A number of conferences and other communication events were organised as part of projects funded by the EU in the area of innovative online public services.

Finally, a clear result of the FP7 funding is a **better international visibility of research results**. Not only it is the case that FP7 projects allow research organisations to cooperate with EU and international partners, but they also attract more attention from third countries and especially the USA.

Some of the EU-funded projects also led to the establishment of competence centres or similar institutions, which, among other things, seek to share knowledge about specific research topics with the scientific community. Examples of such centres are PrestoCentre (a result of the project PrestoPRIME) and the Impact Centre of Competence (project IMPACT). However, interviewees noted that in many cases it is difficult to keep the websites of these competence centres up-to-date without additional funding from the EU.

Better coordination of national research policies and practices at the EU level

A clear positive effect that the EU funding had on the coordination of national research policies and practices in the area of innovative online public services was through establishing research standards in this area, for example through building centres of excellence/competence. An example of this phenomenon is the Impact Centre of Competence established as a result of the FP7 project "Improving Access to Text (IMPACT)." The centre was a direct planned outcome of the project. It provides tools, services and facilities to further advance the state-of-the-art in the field of document imaging, language technology and the processing of historical text. It is one of many examples how FP7 projects contributed to establishing research standards in the ICT area.

As already mentioned above, a similar centre of competences – PrestoCentre – resulted from another project called PrestoPRIME. The PrestoCentre is a membership-driven organisation that brings together a global community of stakeholders in audio-visual digitisation and digital preservation to share, work and learn. PrestoCentre works with experts, researchers, advocates, businesses, public services, educational organisations and professional associations to enhance the audiovisual sector's ability to provide long-term access to cultural heritage.

There was also a consensus among the interviewees that EU-funded projects tend to be of more interdisciplinary nature than those funded at the national level. Many of the interviewed participants claimed that they have felt a certain push from the Commission to involve partners representing a wide variety of disciplines, not only ICT, which was certainly beneficial especially in the area of eGovernment.

(c) Long-term impacts resulting from European added value

Better addressing societal / pan-European challenges:

Research funded by FP7 in the area of digitisation and digital preservation had a clear positive impact on making European historical and cultural resources better accessible to the general public, the researchers (e.g. historians) and to audio-visual industries.

FP7 funding in the area of innovative online public services also had a structuring effect in the area of environmental monitoring and especially in involving citizens as important sources of information about the environment they are interacting with. Five FP7 funded projects (CITI-SENSE; OmniScientis; Citclops; COBWEB and WeSenseIt) developed and implemented a highly innovative approach of "Citizen Observatories", involving citizens in information capturing, evaluation and communication, mostly in the area of environmental research. A number of novel technologies and applications were developed in the domain of Earth Observation as a result of FP7 funding. These projects contributed to finding new ways how to exploit portable devices (smartphones, tablets, etc.) and enable effective participation by citizens in environmental monitoring based on broad stakeholder and user involvement in support of both community and policy priorities. This approach was later taken up in 2015 with a specific topic in Horizon 2020 called "Growing a Low Carbon, Resource Efficient Economy with a Sustainable Supply of Raw Materials" aiming at strengthening environmental monitoring capabilities by using Citizen Observatories.

EU research funding in the area of innovative online public services has also contributed to a better inclusion of disadvantaged persons into the European society. Such projects as Prosperity4All and POSEIDON can be mentioned as examples and good practices in the field. The Prosperity4All project, which is still ongoing, is a response towards a societal challenge that over 2 billion people worldwide have different types, degrees, or combinations of disability, literacy, digital literacy or aging related barriers that impede or prevent the use of ICT. The researchers involved in the project believe that the EU cannot afford (socially, politically and economically) having this large percentage of society offline in the time when access to ICT is required for most education, employment, and commerce, and is increasingly required for travel, health, safety, daily living and participation in society. By building on the success of another EU-funded project Cloud4All (2011-2015), which has developed preference management tools for people with special needs to auto-configure their computers, tablets and smartphones, making them easier to use, the Prosperity4All project further develops the infrastructure and ecosystem

that is necessary for a sustainable Global Public Inclusive Infrastructure (GPII)[135] – a software and service enhancement to our broadband infrastructure. The two mentioned projects have attracted more than EUR 25 million (of which, more than EUR 15 million from FP7) to improve the accessibility of people with disabilities to Internet and key related technologies.

Another good practice project in the same area, "Personalized Smart Environments to increase Inclusion of people with Down's syndrome (POSEIDON)," researched on the ways to use ICT to help people with Down's syndrome to achieve a greater level of independence in their lives, a greater autonomy at home, at work, education and leisure, as well as to improve their opportunities for socialising. The project resulted in a number of prototypes for apps to support the daily lives of people with Down syndrome and their carers. The developed apps support independence in different areas of living such as daily plans, travel, shopping and money handling.[136]

F.7.3. Stories of impact

The EU-funded **Citizens' Observatories initiative**, covering five FP7-supported projects (Citclops, CITI-SENSE, COBWEB, Omniscientis and WeSenseIt) has a clear potential to foster a major break-through in the way that personal portable devices (smartphones, tablets or micro-sensors) are used to enable an effective participation by citizens in **environmental monitoring**. The goal of the above-mentioned five projects was to develop novel technologies and applications in the domain of Earth Observation, which is defined as the gathering of information about the planet Earth's physical, chemical and biological systems via remote sensing technologies supplemented by earth surveying techniques, encompassing the collection, analysis and presentation of data. Earth Observation is usually carried out through complicated technologies available for the governmental agencies or private corporations. The Citizens' Observatories initiative succeeded in fostering active participation of lay citizens in environmental monitoring and policy making through using their personal portable devices. In addition to this, the five projects enabled sharing of data and information through advanced data management strategies based on open e-collaboration, addressing questions of privacy, data standards, quality and reliability.

For example, **WeSenseIt project**[137] (2012-2016) enabled citizens to become active stakeholders in information capturing, evaluation and communication for the water environment including flood risk. The project brought together the expertise of 14 European partners across academic institutions, research centres and industry. The project has already delivered new smartphone crowdsourcing apps, innovative low cost rain gauges, and autonomous soil-moisture sensors. It encouraged citizen communities to upload, share, discuss and rate data and information on their water environment with a focus on minimising the effects of pluvial flooding and poor water quality. The developed technology was tested in three case studies: Doncaster, UK; Delftland, the Netherlands; and Vicenza, Italy.

[135] Global Public Investment Infrastructure, http://gpii.net/index.html
[136] For examples of the developed apps, visit: http://www.poseidon-project.org/product/
[137] Project website: http://www.wesenseit.com/