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COVER NOTE

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Subject:	COMMISSION STAFF WORKING DOCUMENT IN-DEPTH INTERIM EVALUATION of HORIZON 2020

Delegations will find attached document SWD(2017) 220 final - PART 3/4.

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PART 3/4

COMMISSION STAFF WORKING DOCUMENT

IN-DEPTH INTERIM EVALUATION of HORIZON 2020

{SWD(2017) 221 final}
{SWD(2017) 222 final}

7. HOW EFFICIENT HAS HORIZON 2020 BEEN SO FAR?

This question aims to consider the relation between the inputs of the programme (i.e. resources, budget, selection processes) and the outputs and impacts achieved by the programme. Since this is a mid-term review of the programme, the assessment mainly refers to the efficiency of the programme management (e.g. grant management, proposal evaluation) and implementation processes (e.g. selection and participation patterns). This makes it possible to shed light on whether the way in which the programme is managed is likely to influence positively or negatively the outputs that will be generated.

Expectations from Horizon 2020 in terms of efficiency

Compared to FP7 Horizon 2020 is expected to make EU research and innovation funding simpler to access, not only for established players, but also for newcomers. Administrative costs for applicants and participants are expected to reduce drastically, which is expected to significantly improve accessibility, in particular for SMEs, and increase levels of support from all types of stakeholders. Per euro disbursed, implementation costs are expected to be lower under Horizon 2020 than under FP7 because of far-reaching integration, simplification and harmonisation (common rules benefitting stakeholders but also lowering the Commission implementation cost), and externalisation. Combined with the increased benefits expected from Horizon 2020 compared to FP7 this is expected to result in an increased efficiency.

The analysis looks closely into the administrative cost as well as aspects of the simplification of the programme for the programme beneficiaries (i.e. cost of writing proposals) as well as the Commission services (i.e. cost of administrating and running the programme). In addition, it assesses the use of new management processes by looking at the efficiency of the externalisation to the Executive agencies, one of the key management decisions taken to decrease the administrative cost of the programme. To understand to which extent programme management processes might influence the types of projects selected and the motivations for applying, the assessment also looks into the efficiency of the current application as well as the proposal evaluation processes. Finally an analysis of the funding distribution is performed in order to identify possible deviations from expectations based on the objectives set.

Summary box: Key findings on the efficiency of Horizon 2020

- ✓ Based on macro-economic projections, Horizon 2020 is as cost-effective as FP7 and comparable to the expected cost-effectiveness of public spending in research.
- ✓ Compared to FP7, Horizon 2020's efficiency is positively influenced by the extensive externalisation of programme implementation to new management modes including Executive Agencies.
- ✓ Simplification reduced administrative burden for participants and led to large decreases in the time to grant.
- ✓ Current administrative expenditure is below the target and is particularly low for the executive agencies.
- ✓ The new funding model is attractive for stakeholders and did not led to a significant change in funding rates compared to FP7.
- ✓ Horizon 2020 suffers from underfunding resulting in large-scale oversubscription, much larger than under FP7, which constitutes a waste of resources for applicants and a loss of high quality research for Europe.
- ✓ The proposal evaluation process is generally highly regarded but some aspects such as the feedback to applicants could be improved.
- ✓ Despite the low success rates, and cost of proposal writing, the costs on stakeholders seem to be proportionate given the (expected) benefits of participation, which go beyond the financial contribution received.
- ✓ The balance in project size did not change significantly compared to FP7 and does not have a negative impact on newcomers in the programme.
- ✓ Horizon 2020 funding reaches a wide range of stakeholders, including SMEs and a high number of newcomers. However, a large share of funding is still concentrated to a few players.
- ✓ Horizon 2020 is open to world and has a broad international outreach but funding of participants from third countries has decreased compared to FP7.
- ✓ Horizon 2020 promotes intensive collaboration between different types of organisations, scientific disciplines and sectors.

7.1. Overview of budgetary allocations

During the first three years of the programme 38% (EUR 29.0 billion) of the total Horizon 2020 budget was committed to all activities including the administrative expenditure, calls and other activities (e.g. PPPs, events, studies). **Grants remain the most prominent type of support from the programme: 69% of the programme commitments (EUR 19.9 billion) were allocated to grants[1].** EUR 7.5 billion (36.8%) was allocated in Pillar 1: Excellent Science, EUR 4.5 billion (22.3%) to Pillar 2: Industrial Leadership, EUR 7.4 billion (36.0%) to Pillar 3: Societal Challenges and EUR 944.1 million (4.9%) to additional priorities[2].

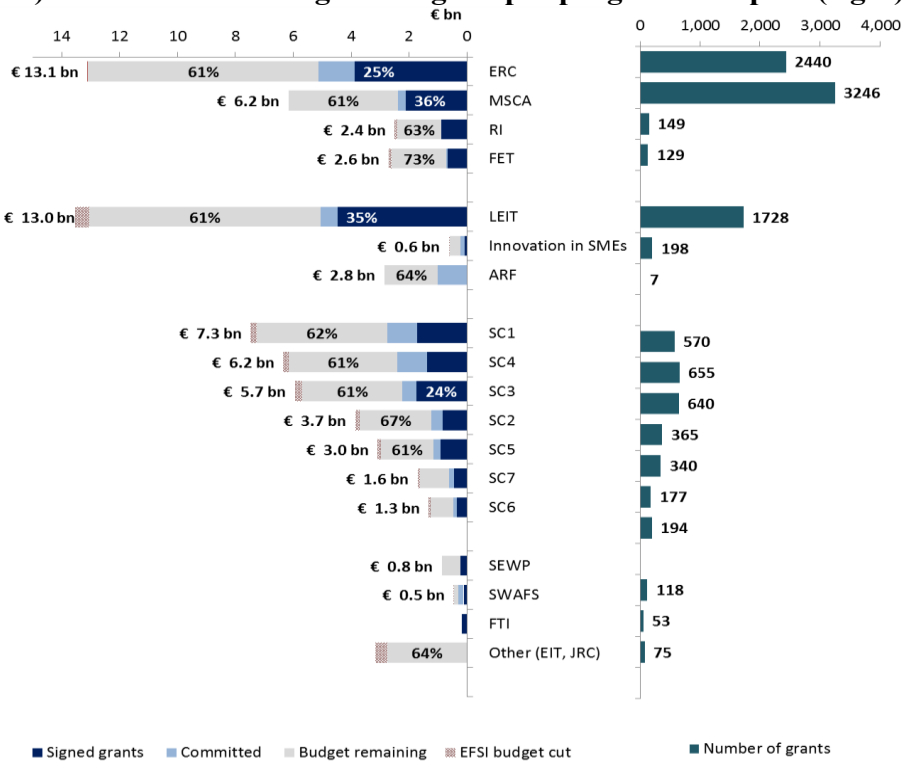
Horizon 2020 grants are implemented through 12 different types of actions[3]. Four types of actions received 86% of the overall funding and 72% of the total number of grants: Research and innovation actions (RIA, 39.3% of the funding, 15.1% of allocated grants); ERC actions (19.0% of the funding, 21.9% of the allocated grants); Innovation actions (17.2% of the funding, 6.2% of the allocated grants); and the MSCA grants (10.3% of the funding and 28.4% of the allocated grants) (see Figure 5 in Section 5.1).

In the second year of the programme implementation, the overall Horizon 2020 budget was cut by 2.9% (EUR 2.2. billion) to contribute to the creation of the European Fund for Strategic Investments (EFSI) and provide support via financial instruments. Financial instruments such

[1] Based on CORDA data excluding grants under Euratom, cut-off date by 1/1/2017 and Regulation (EU) No 1017/2015
[2] For further information regarding the budget allocation see Section 5- Implementation State of Play.
[3] Implementation data for other non-grant based instruments is currently not tracked in a comparable way.

as loans and guarantees are currently provided, among others, within the Access to Risk Finance (ARF) and Societal Challenge 1-Health and Societal Challenge 3-Energy part of the programme. These activities are being implemented by the European Investment Bank (EIB) and the European Investment Fund (EIF).

Figure 1 Horizon 2020 budget, mid-term rate of commitments (all) and implementation of grants (left) and the number of grants signed per programme's part (right)



Source: EC DG RTD analysis based on CORDA, cut-off date by 1/1/2017, Regulation (EU) No 1291/2013, Regulation (EU) 2015/1017 and budget data. Note: Total budget figures relate to revised Horizon 2020 budget after the ESFI cut. Committed budget to all activities (grants as well as other activities such as conferences, events, studies, PPPs, Art.185, prizes).

7.2. How efficient are the programme management structures?

7.2.1. New Management Modes

New Management Modes (NMMs) are a new way to manage Horizon 2020 implementation activities with the use of external bodies (e.g. Executive Agencies, Joint Undertakings) with the aim to increase the efficiency and effectiveness of the programme.[4] The Commission services are expected to focus on core institutional tasks, such as policy-making, implementation and monitoring of the application of EU law, and strategic management, whereas the NMMs aim to deliver effective and efficient implementation of the programme.

Horizon 2020 grant management has been delegated to four Executive Agencies[5]. Already in FP7 two Executive Agencies (REA and ERCEA) implemented almost 30% of budget. However, in the first three years of Horizon 2020 almost 60% of the budget is implemented by the four executive Agencies (REA, EASME, ERCEA and INEA).

[4] European Commission
[5] The division of labour between the Commission and the Executive Agencies is defined and documented in Delegation Acts.

The governance structures of the Executive Agencies are designed to ensure proper supervision by the Commission and transparency. Special attention is paid to ensuring the effectiveness and efficiency of the feedback loop feeding project results from the Executive Agencies back to the Commission for policy purposes. Also, single set of rules for participation and dissemination in Horizon 2020 across all actors implementing the programme were established under Horizon 2020.

Based on the Cost Benefit Analysis[6] the "Communication to the Commission on the delegation of the management of the 2014-2020 programmes to Executive Agencies"[7] prior to the launch of Horizon 2020 noted, that delegation of programme management tasks to External Agencies is a fully relevant solution to improve cost-effectiveness due to:

- **Higher specialisation**: As a result of their experience and specialisation in specifically defined tasks, the agencies guarantee a high quality of programme management and better service delivery in terms of faster contracting, faster approval procedures for technical and financial reports and quicker payments.

- **Creation of synergies between closely related portfolios:** Giving the agencies coherent programme portfolios was expected to create synergies between closely related policy domains and foster knowledge spill-over.

- **Existing communication and outreach channels of the agencies**, which overtime developed to keep them close to beneficiaries were expected to provide increased level of direct exchanges with beneficiaries through "info days", kick-off meetings for larger and multi-annual projects, and monitoring visits.

- **Continuous simplification of processes and procedures** (e.g. simplified forms of grants, proportionate controls and electronic application forms) were expected to result in higher productivity.

- **Lower cost:** A lower number of full-time equivalents (FTEs) required to manage the programmes due to specialisation and recruitment of a larger share of contract agents compared to Commission officials.

The analysis estimated the administrative savings compared to the "in-house" scenario to EUR 43.1 million and EUR 44.6 million in case of REA and ERCEA respectively. In the case of Horizon 2020 a key assumption allowing for such savings in addition to the factors outline above, was a larger size of Horizon 2020 grants in comparison to FP7[8].

Recent external evaluations of REA and ERCEA[9] demonstrated that Executive Agencies improve cost-effectiveness of the grant management and that both agencies exceed even the positive estimates made in the Cost-Benefit Analysis. In the 3 years covered by the evaluation report REA and ERCEA managed to save EUR 53.4 million (REA) and EUR 46.5 million (ERCEA) compared to the fully "in-house" implementation mode. The additional savings

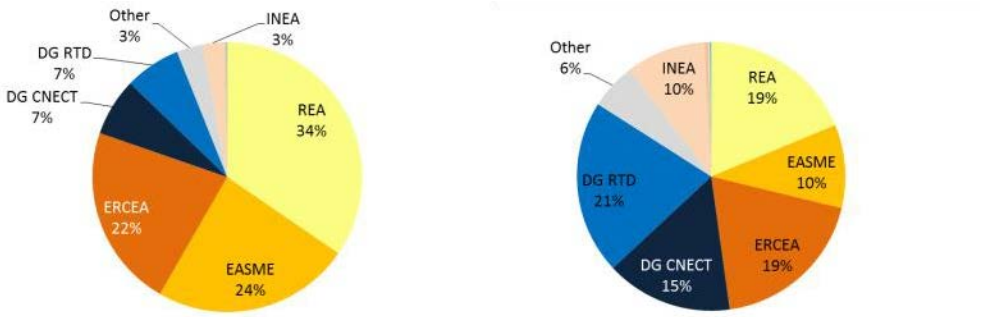
[6] DG GROW 2013 Cost Benefit Analysis (CBA). The report is referred extensively in SEC(2013) 493 final Accessed at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52013SC0493(01)
[7] Ibid.
[8] REA http://intranet-rea.rea.cec.eu.int/sites/rea/about/governance/Documents/Establishment%20Act.pdf and http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D0779&from=EN
[9] Public Policy and Management Institute, Evaluation of the operation of REA (2012-2015), 2016 and Evaluation of the operation of ERCEA, 2016

achieved in both agencies are due to lower than estimated staff costs and lower cost of overheads[10]. At the same time the evaluation concluded that ERCEA and REA reached very high levels of satisfaction with their performance among their beneficiaries and independent experts: 82% in case of REA and 93% in case of ERCEA.

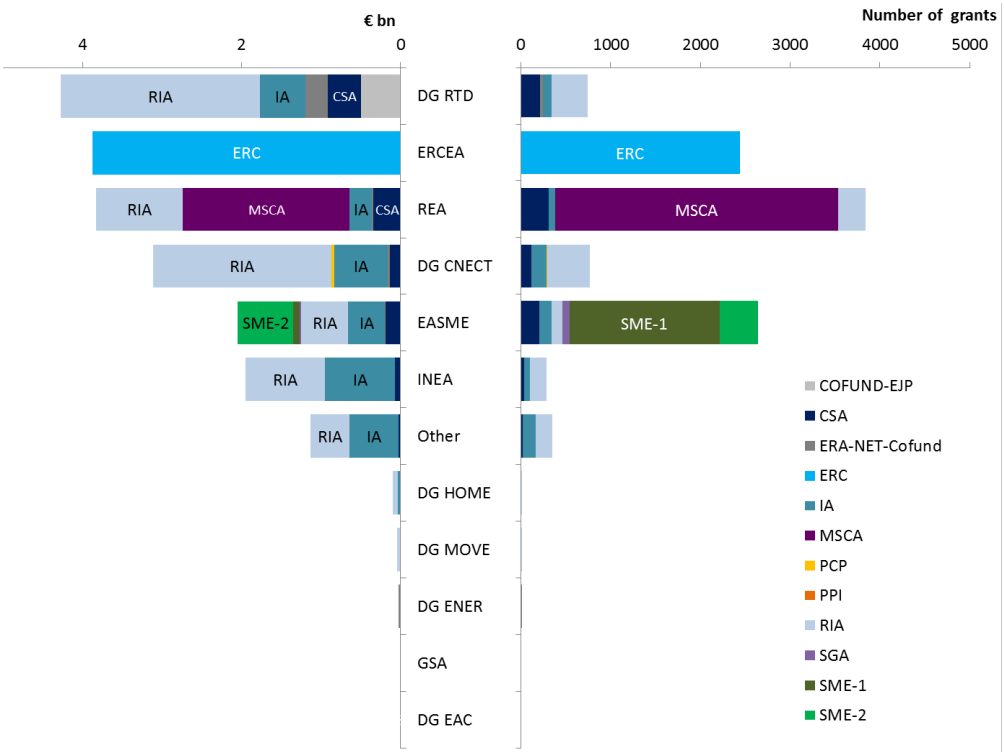
To help coordinate and deliver the programme, a Common Support Centre (CSC) has also been set up in the Commission. The CSC centralises services, which were previously decentralised. It provides services in legal support, ex-post audit, IT systems and operations, business processes, programme information and data to all research DGs, Executive Agencies and Joint Undertakings implementing Horizon 2020. This has brought considerable simplifications to Horizon 2020, both externally for the stakeholders and internally for the Commission services involved in Horizon 2020. A separate more detailed mid-term review of the CSC is underway and will be finalised by the end of 2017.

It seems that the most resource intensive parts of the programme (i.e. actions with a high number of grants) are externalised: the Commission implements larger but fewer collaborative grants (EUR 7.6 billion allocated to 1,550 grants)[11]; the Executive Agencies implement smaller and more numerous grants a large part of which are single-beneficiary[12] (EUR 11.7 billion allocated to 9,207 grants).[13] Based on the existing evidence, smaller and more numerous grants are more resource intensive, and agencies manage almost six times as many projects as the Commission[14]. The overall budget of Horizon 2020 is managed by nine different Directorates-General (DGs)[15] of the Commission and implemented by 23 different bodies.[16]

Figure 2 Horizon 2020 mid-term implementation by implementing body: budget allocation (right) and number of grants (left)



[10] Costs related to the work environment include: Rental of buildings and associated costs; Information and communication technology; Movable property and associated costs; Current administrative expenditure; Postage and telecommunications.
[11] Such as and the LEIT-NMBP, Research Infrastructures and SC1 programme parts are fully managed by the Commission
[12] Such as the SME instrument, ERC and MSCA actions
[13] The remaining 351 grants (EUR 1.1 billion) are managed by other bodies.
[14] The CBA study on the Executive Agencies (2013) assumes more resources are need to manage smaller and numerous grants compared to larger and few grants: the FTE days per 100,000 EUR are higher for smaller projects 7 to 10 FTE man days per 100,000 EUR (projects size from 50k to 1 million such as SME Instruments, MSCA-ITN, MSCA-Cofund) when compared to 4 FTE man days per 100,000 EUR for larger projects (project size from 5 – 6.8 million security, ICT, H2020 – food agriculture).
[15] DG Research and Innovation (DG RTD), DG Communication Network, Content and Technology (DG CNECT), DG Education, Youth, Sport and Culture (DG EAC), DG Energy (DG ENER), DG Internal Markets, Industry, Entrepreneurship and SMEs (DG GROWTH), DG Mobility and Transport (DG MOVE), DG Migration and Home Affairs (DG HOME), DG Agriculture and Rural Development (DG AGRI) and the Joint Research Centre (JRC).
[16] Six Commission DGs, four executive agencies, four public-public partnerships (P2Ps), seven public-private partnerships (PPPs), the European Institute of Innovation and Technology (EIT) and the European Investment Bank (EIB).



Source: EC DG RTD analysis based on CORDA, cut-off date by 1/1/2017

Figure 3 below briefly summarises further centralisation measures put in place to increase efficiency of Horizon 2020.

Figure 3 Centralisation measures under Horizon 2020

Centralisation measure	Description
Centralisation of the proposal evaluation process	REA takes care of the logistics of the evaluation and the management of the evaluation experts (except for ERCEA and EASME) as well as the validation of legal entities for the whole of Horizon 2020;
Common Support Centre	DG RTD hosts the Common Support Centre (CSC) which provides support with legal matters, IT, external ex-post audits and dissemination activities to all entities involved in the management of Horizon 2020;
Centralisation of policy and budgetary related issues	Policy and budgetary issues are also centralised in various departments of DG RTD outside the CSC (coordination of overall policy activities, evaluation of the programme, financial programming, international cooperation, management of the guarantee fund, coordination with executive agencies).

Source: European Commission

Horizon 2020 is more efficient in terms of administrative expenditure when compared to FP7. The administrative expenditure is particularly low for the Executive agencies. Currently the administrative expenditure of Horizon 2020 is below the allowed 5%[17] in the legal base and estimated below EUR 1131 million (excluding EIT, JRC and Euratom) in the first three years of the programme implementation. This includes the administrative costs of all

[17] 4.6% for the year 2020 only

DGs including the Common Support Centre and Executive Agencies.[18] The administrative expenditure of Executive agencies is particularly low: 2.75 % for ERCEA, 2.6% for REA, 0.77% for INEA and 2.7 % for EASME. As noted, based on the existing evidence from external evaluations[19] and Cost-Benefit Analysis[20], this is mainly a result of lower staffing costs (agencies are mostly staffed by Contractual Agents) and lower overhead costs thanks to a high degree of specialisation in each agency and lower overall number of employees. To compare, FP7 had a level of administrative expenditure of 5% for the FP7 Ideas specific programme and 6% for FP7 Cooperation, Capacities and People specific programmes[21].

The oversubscription to Horizon 2020 during the first three years (see Section 7.4.1) increased the cost of the evaluation process. Based on the cross-analysis of these different administrative sources containing the number of evaluators, associated costs and number of proposals evaluated in FP7 and Horizon 2020 [22], it is estimated that on average, 76% more proposals are evaluated per year under Horizon 2020 when compared to FP7 (19,340 proposals under FP7 compared to 34,025 under Horizon 2020)[23]. Proposals under Horizon 2020 are on average evaluated by more evaluators compared to FP7[24]: the average number of evaluators per proposal was between 3 and 4 for most programme parts in FP7, while it ranged mainly between 4 and 5 in Horizon 2020. However, each evaluator spends less time per proposal if compared to FP7: on average 0.7 days under Horizon 2020 compared to 0.8 days under FP7. The average cost per evaluation per day has also decreased (from EUR 606 under FP7 to EUR 568 under Horizon 2020). The observed decrease in costs comes from lower travel costs since most of the evaluations in Horizon 2020 are done remotely. It is estimated that the cost of proposal evaluation increased on average from some EUR 35 million per year under FP7 to some EUR 65 million under Horizon 2020. The increase in total costs is mainly due to the higher number of submitted eligible proposals to the programme.

In general, consulted stakeholders are content with the current support provided by the Commission services (including agencies). 73% (1,927) of consultation respondents state that the support provided by the Commission services during grant preparation and implementation is either "very good" or "good". The analysis of open responses to the stakeholder consultation also evidenced a few testimonials of good working relationships with the project officers. However, a majority of respondents who wrote something about this relationship underlined the delays they experienced in receiving answers to their request from the project officers and some ask for more personalised support from the Executive Agencies.

7.2.2. The impact of simplification and the new funding model

Simplification is a central aim of Horizon 2020, which should be fully reflected in its design, rules, financial management and implementation.[25]

[18] European Commission. The adopted legal base for the specific programme Horizon 2020 allows administrative expenditure of 5% of the overall Horizon 2020 budget for the period 2014-2020 (4.6% for the year 2020 only).
[19] Public Policy and Management Institute, Evaluation of the operation of REA (2012-2015), 2016 and Evaluation of the operation of ERCEA, 2016
[20] DG GROW 2013 Cost Benefit Analysis (CBA).
[21] Annual Activity Reports 2016, calculation by the Commission.
[22] CORDA, EMM2, FP7 Universe and Horizon 2020 Universe.
[23] CORDA, cut-off date by 1/1/2017
[24] CORDA and FP7 and Horizon 2020 Universe, cut-off date 1/1/2017. The difference remains high also if accounting for two stage proposals: 6 evaluators per proposal under Horizon 2020 against 4 evaluators under FP7.
[25] See Recital 20 of the Horizon 2020 Regulation. The assessment of the new funding model introduced in Horizon 2020 is also required by its Rules for Participation (regulation (EU) No 1290/2013 of the European Parliament and of the Council)

Compared to FP7, Horizon 2020 was constructed from the outset around a simplification[26] of its architecture, rules, procedures and control strategy including a simplified funding model. A single set of rules applies to the whole R&I support provided, ranging from frontier research over technological development to close to market activities. In order to ensure coherence of this legal frame with all other EU funding programmes the rules have been aligned to the Financial Regulation applicable to all EU funding programmes.

Figure 4 Horizon 2020 simplification measures and comparison with FP7

Simplification measure	Horizon 2020	FP7
Single reimbursement rate	A single reimbursement rate in a given project, without differentiation between organisation categories or types of activities. The reimbursement rate is up to 100% of the eligible costs for Research and Innovation Actions and up to 70% for Innovation Actions (with one exception: non-profit organisations are reimbursed 100% also in Innovation Actions).	Reimbursement is determined by a matrix of organisation categories and activity types.
Single flat rate	A single flat rate for contributing to the indirect costs. This flat rate of 25% is applied to the direct costs[27]	Indirect costs (overheads) are calculated by four different methods (two flat rate models, depending on the organisation categories; real indirect costs and a simplified method of determining real indirect costs. The real indirect cost options were a considerable source of financial errors.

Source: European Commission

In parallel, the Commission streamlined, harmonised and accelerated procedures and processes linked to programme and project implementation. **The harmonisation of all processes and guidance documents across all implementing bodies provides for a uniform application and interpretation of the rules, improving quality and stringency of procedures.** For example, the electronic-only grant management system has embedded many automatic checks: it provides for enhanced transparency and systematic automatic document management and archiving – allowing for IT supported detection of risks and irregularities. Horizon 2020 also makes **further use of the 2-stage approach** in parts of the programme, with the aim of reducing the burden of proposal writing and evaluation for unsuccessful applicants. In the first stage, the applicants submit a short project description that is evaluated. Successful applicants are invited to submit a full proposal in the second stage.

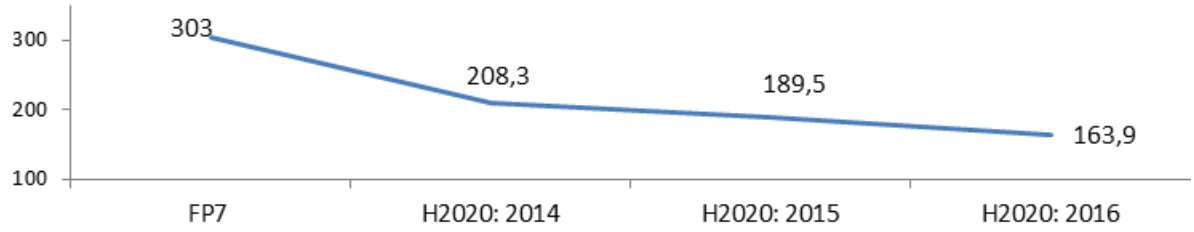
The first three years of Horizon 2020 have shown a significant reduction of the time elapsing between the closure of a call and the signature of the Grant Agreement (i.e. Time to Grant), from an average of 303 days in FP7 to an average of 192.2 days, which is a decrease of 36.6% (more than 110 days). The average number of days is continuing to decline. A 21.3% reduction in time to grant (TTG, 44.4 days) is observed from 2014 to 2016. The total number of projects signed within the TTG limit is 91.6%. For the SME instrument, which benefits from a particular reduced TTG (6 months for Phase 2 and 3 months for Phase 1), the current TTG is slightly higher than expected, i.e. about 106 days for Phase 1, and 185

[26] The use of simplified forms of grants under the MSCA (unit costs), streamlined ex-ante checks, reduced requirements for work time recording, reduced audit burden, an acceleration of the granting processes and fully paperless proposal and grant management. For further details, please see Horizon 2020 Monitoring Report 2015.

[27] Except costs for subcontracting, costs of financial support to third parties and in-kind contributions not used on the beneficiary's premises

days for Phase 2. Improvements are still expected, and already noticeable - in particular for Phase 2 TTG coming down from 252 days. More than 80% of the stakeholder consultation respondents agreed that the time taken to evaluate the proposal and to sign a grant agreement are either "good" or "very good".

Figure 5 Time-to-grant in days



Source: CORDA, Signed Grants cut-off date by 1/1/2017 (excluding grants to named beneficiaries & ERC)

As regards the new funding model it is based on two main features: a single reimbursement rate and a single flat rate, which is represents a major simplification compared to FP7 (Figure 4). This new funding model puts the focus on the costs that are directly related to the project. It was expected to simplify the financial management of projects, by a reduced complexity of the financial rules; reduce the financial error rate detected in ex-post audits; increase legal certainty for beneficiaries; increase the attractiveness and ease of access to the programme, in particular for newcomers, smaller actors, SMEs and industry; and contribute to the acceleration of the granting processes. **The thematic assessments confirm that the expected benefits have largely materialised.**[28]

Box: The impact of the funding model of Horizon 2020 against specific criteria

As noted in the legal base[29], the interim evaluation should assess the funding model of Horizon 2020 against specific criteria. The following provides a summary[30] of this assessment:

The participation of participants that have at their disposal high-end research infrastructures or have a history of using full-costing in the Seventh Framework Programme: Participation of research organisation and higher or secondary education institutions in Horizon 2020 is similar to FP7 and was not influenced by the funding model (22% versus 24% rate of participation for research organisations and 34% versus 37% for higher or secondary education institutions)[31].

The simplification for participants that have at their disposal high-end research infrastructures or have a history of using full-costing in the Seventh Framework Programme: The impact of simplification for those participants was assessed by the level of use of the "Large Research Infrastructure" (LRI) scheme. This scheme was designed to respond to the concerns of some large research organisations on the single flat rate for indirect costs. Until January 2017, 13 entities[32] lodged a request for an ex-ante assessment of the methodology for LRI[33] This confirms that the number of applicants for the LRI scheme remains modest.

[28] See in particular the thematic assessments for MSCA, FET, ICT, LEIT-NMBP, LEIT-SPACE, SC1, SC2 and SC4.
[29] See Article 32 of the Horizon 2020 Regulation.
[30] A more detailed assessment is included in Annex 1.
[31] Based on CORDA, cut-off date by 1/1/2017
[32] Nine research organisations, three higher education establishments, and one enterprise
[33] Four entities (research organisations) have received a positive ex-ante assessment while two (research organisation) have been found not compliant. For five entities the work is ongoing.; two entities have voluntarily withdrawn their application.

The acceptance of the usual accounting practices of beneficiaries: Based on the qualitative analysis of the open questions received through stakeholder consultations as well as the position papers, stakeholders note more should be done to match the organisations' accounting practices.

Extent of use of the additional remuneration to personnel as referred to in Article 27 of Regulation (EU) No 1290/2013: The feedback received from Member States' representatives and stakeholders indicates that the implementation of the additional remuneration scheme is complex. Furthermore, they noted the scheme has a negative financial effect on those beneficiaries whose usual remuneration practices are based on very variable levels of remuneration. In some Member States the salaries of researchers in the public sector are strongly dependent on availability of external funding. Under those remuneration schemes, project-triggered remuneration may count, for example, for as much as two third thirds of the total salary of the employee. That leads to situations where the cap of EUR 8,000 results in the ineligibility of a substantial part of the personnel costs. For certain groups of beneficiaries, the provisions on additional remuneration imply that the eligible personnel costs for the same person for the same work are lower in a Horizon 2020 action than in a FP7 project.

The **new funding model** has mobilised and largely satisfied stakeholders. It can also be assumed to have contributed to the attractiveness of Horizon 2020 as reflected in application statistics. For around 90% of universities and more than half of research organisations which have used in FP7 the 60% flat rate method for indirect costs, the Horizon 2020 funding model has brought little change compared to FP7 in terms of funding rate[34] and has therefore not had any major impact on the participation pattern of research organisations and universities. Responding to the concerns of some large research organisations about the single flat rate for indirect costs, the Horizon 2020 Rules for Participation have provided for a specific "Large Research Infrastructure" scheme that, as intended, is now being used for a selected number of large research organisations with expensive research infrastructure doing research as their core business. For industry and other organisations using in FP7 the real indirect cost option, the Horizon 2020 funding model represents a major change. An estimation of the effective funding rates was made, based on the known real indirect costs of the most frequent FP7 industry participants (non-SMEs) using the real indirect cost option. This analysis results in an estimated average real funding rate for (non-SME) industry in Horizon 2020 in the area of 58%, i.e. an increase of 4 percentage points compared to FP7 for this type of beneficiaries.

At programme level, the indirect costs in Horizon 2020 were estimated for all beneficiaries of RIA and IA projects on the basis of the ratio between real indirect and direct costs for participants in FP7 collaborative projects[35]. As a result, **the overall funding rate between FP7 and Horizon 2020 has not changed and remains 70% of total costs[36].**

Another feature of the Horizon 2020 funding model, the additional remuneration scheme has been perceived by Member State representatives and stakeholders as being difficult to implement and having a negative financial effect on those beneficiaries whose usual remuneration practices are based on very variable levels of remuneration. The above shows that the new funding model has overall had positive effects on stakeholder appreciation, time-to-grant and

[34] The funding rate is expressed as a percentage of the Commission's contribution to the total project costs.

[35] 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.

[36] The new funding model simplified the funding rate for beneficiaries, but made the monitoring of the funding rates for the programme as a whole more complex. 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 under Horizon 2020 programme is lower than the actual total project cost. To overcome the shortcomings of the collected project data, the Commission estimated actual indirect project cost under Horizon 2020 based on real indirect project costs reported in FP7.

attractiveness. The effects on the simplification of financial management in the projects and on the error rate cannot yet be assessed, as very few financial reports were yet submitted and no ex-post audits were yet finished.

One area for improvement is the broader acceptance of beneficiaries' usual accounting practice. Stakeholders indicate that there are still too many instances where they have to collect data and information specifically for obligations in their Horizon 2020 grants, in parallel to their usual accounting system. This concerns in particular the obligations on staff time recording, the accounting for depreciation of equipment and for internally provided consumables and services, the handling of personnel costs outside closed financial years and some accounting detail for beneficiaries outside the Euro zone. The Commission has already reacted to these concerns and adapted the Horizon 2020 model grant agreements accordingly. Another area for improvement concerns the unintended effects of the additional remuneration scheme with the EUR 8000 capping. Opportunities for further simplification will also open with the revision of the EU Financial Regulation and the Commission initiative on Budget Focused on Results. The Commission proposal for the revision of the Financial Regulation provides for better conditions for the use of simplified forms of funding (unit costs, flat rates, lump sums).

Still, stakeholders find that the costs of participating in Horizon 2020 have decreased but insufficiently. Further simplification and more flexibility are regarded as needed. In the Simplification survey[37] 77.5% of responding project's participants noted that the single reimbursement rate in a project is 'very beneficial' or 'fairly beneficial' and 74.3% that the single flat rate for indirect costs is 'very beneficial' or ' fairly beneficial'. In the interim evaluation stakeholder consultation slightly more respondents think that the cost of participating in Horizon 2020 compared to FP7 has decreased with the simplification measures.[38] Still, out of the 835 respondents who did not participate in Horizon 2020 (31% of the total number of respondents), 106 explained that the main reason was that the Horizon 2020 project implementation rules were cumbersome. Furthermore, based on the analysis of responses to open questions, stakeholders acknowledge that progress has been made but many mention that further simplification is needed. The analysis shows that more could be done in terms of cost reimbursement and to match the organisations' accounting practices (65.4% (1,732) of the survey respondents felt that the acceptance of organisations' accounting practices in the programme was "good" or "very good" and 17.9% (475) viewed it as "poor" or "very poor").

Stakeholder position papers: Simplification is welcomed but further steps are needed.

In their position papers, some stakeholders representing different types of stakeholder groups commented on the simplification measures under Horizon 2020 and have a positive view. In particular, they see the 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.

[37] In 2015 the Commission launched an online survey on the perception of the simplification measures by stakeholders, addressed to all contacts in ongoing Horizon 2020 grants. The results cover the first 20 months of Horizon 2020 implementation and was published on 30 May 2016. In total 4185 responded.

[38] 20% (521) of the consultation respondents shared the view that the costs of participating in Horizon 2020 are lower than in the previous FP7, 14% (364) felt they are higher and 36% (950) felt they are similar. However a high percentage of respondents (30.7%) declared they could not respond to this question due to lack of knowledge of FP7.

7.2.3. Financial instruments

The efficiency of the Financial instruments (FIs) can be assessed at an overall governance level involving DG RTD, the European Investment Fund (EIF) and the European Investment Bank (EIB); at a more operational level using financial intermediaries (in case of intermediated instruments) to implement the FIs; and at the level of the final beneficiaries.

The costs for DG RTD in using the EIB and EIF to manage the instruments includes setting up the contract ('Delegation Agreement') with these two entrusted entities; the allocation of funds, monitoring and reporting, and overall supervision. The costs of managing the financial instruments lies in the overheads, namely the costs of the personnel needed to process applications, monitor loans and investments, reporting to DG RTD/EIF and/or EIB and to manage the FI entities themselves (where new entities are created to specifically operate an FI, e.g. a new venture capital fund). The cost for the final beneficiaries relates to the price for the financing, typically in the form of interest and/or equity, and administration.

Overall, the assessment of the efficiency of managing the instruments is fairly positive.[39] Even if it might be difficult for financial intermediaries and other stakeholders to distinguish between the different financial instruments under the EIB Group, the fact that they are under the same organisation helps EIF guide financial intermediaries to identify and apply for the most appropriate instrument.

Results of a survey of intermediaries performed in the framework of the interim evaluation indicate that the costs of managing the instruments are generally in line with the expectations of the financial intermediaries and in line with other financial schemes they manage. The most positive assessment in terms of expectations versus actual costs relates to the level of human resources needed to implement the instrument concerned. However, there is some concern in relation to monitoring and reporting requirements. While there is an understanding among financial intermediaries that reporting is necessary, there is also a wish to simplify requirements and shift away from requirements that must be fulfilled manually. Some intermediaries also highlight that reporting and monitoring costs seem to be growing.

7.3. How efficient are the communication and application processes?

7.3.1. Communication and information activities

Horizon 2020 funded activities to attract programme participants. These were organised mainly by the executive agencies: EASME in 2015 had three 'infodays' attended by close to 2,000 participants, the agency is also using social media and participate in major events[40]. ERCEA is also active on social media, its website attracts more than half a million visitors yearly, and the Agency organises stands in 3 to 5 selected scientific conferences every year. REA oversaw the evaluation activities; in 2015 alone had more than 8,800 experts on site in Brussels, and handled 10,700 requests for information from the Horizon 2020 helpdesk. In the stakeholder consultation, 69.9% of the respondents rate the communication activities on Horizon 2020 to attract applicants as either 'very good' or 'good', whereas 22% find them 'poor' or 'very poor'.

[39] Interim evaluation of financial instruments under Horizon 2020 (2017), see Annex 2
[40] For example, the EU Sustainable Energy week, Green Week, SME – instrument Innovation Summit

Horizon 2020 encourages dissemination and exploitation of research results. Beneficiaries have an obligation to promote funded projects and their results, and communication forms part of the activities expected to generate project impact. To guide communication efforts, Horizon 2020 requires projects to develop and implement a communication plan, which goes beyond the project's own community to include "the media and the public".[41] Within the projects, a large number of communication activities are also undertaken to disseminate and communicate the projects' results of the knowledge generated. Validated periodic reports from the first 726 projects show that these have spent EUR 57.6 million on communication and dissemination covering many different types of activities including 308 brokerage events, 3,451 communication campaigns, 270 conferences, 1,626 workshops 2,385 press releases and 8,938 popularised publications.

Citizens are not an important target group of these activities, but rather a secondary or tertiary audience. Projects stating that they intend to target citizens typically mention websites, newsletters, publications, social media channels as means to reach the general public. However, it is only in cases where consumer engagement is a key for project success that proposals contain elements of a dedicated communication strategy for the public.

7.3.2. Application and evaluation process

In the first three years of Horizon 2020, 74,769 distinct higher or secondary education institutions, private companies, research organisations, public entities and others 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. Studies have shown that depending on their age and position, researchers spend between 5 – 10% of their time applying for research funding.[42]

From FP7 to Horizon 2020, the bureaucracy has been much reduced and overall process has been positively streamlined. However, the effort of writing winning proposals has almost doubled since FP7 calls, creating and overall higher costs of participation to Horizon 2020.
Italy, Satner Reply SpA

Three quarters (75%) of the respondents to the simplification survey with experience in FP7 and Horizon 2020, confirmed that, overall, the processes in Horizon 2020 are much simpler than in FP7. The survey results on the time spent on preparing proposals is presented in the box below.

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 EUR 100,000 and applies these numbers to the overall numbers of proposals and retained proposals in the first year of Horizon 2020 to calculate the cost of unfunded projects, which is estimated between EUR 268 million and EUR 2.68 billion.[43]

[41]) As an illustration, the mapping of SC2 funded projects show that they target a broad range of stakeholders as potential users of their outputs but dissemination and communication efforts are largely targeting stakeholders which are expected to be "immediate users" of project results.
[42] E.g. see http://www.eui.eu/Documents/MWP/Publications/20111012MWP-ACOSurveyResearchFunding-Full.pdf
[43]EUA Member consultation - A contribution to the Horizon 2020 mid-term review, http://www.eua.be/Libraries/publications-homepage-list/eua-membership-consultation-2016-a-contribution-to-the-horizon-2020-mid-term-review.pdf?sfvrsn=4 The EUA states that "the real costs for the development of proposals cannot be easily calculated and may also vary from one system to another". Among the factors that come into play: the seniority of the researchers involved, salary levels in the country, the extent to which proposal drafting requires the drafting of original text, the information required by the proposal template.

Box: Time spent on proposal preparation

- 52.3% of coordinators in a multi-partner project say that they spent more than 30 days, 32% stated that they spent between 15-30 days preparing a proposal.
- 14.3% of partners in multi-partner projects declare spending more than 30 days, 52.6% that they spend between 15 and 30 days.
- 19.3% of participants to single beneficiary projects (non-SMEs) state they spend more than 30 days, and 60.4% between 15 and 30 days.
- 59.8% of SMEs in mono-partnered projects state that they spent more than 16 days and 27.7% say that they spend less than 15 person days.

Source: European Commission Simplification Survey[44]

Based on the approach from the EUA **it is estimated that it costs Horizon 2020 applicants EUR 1908.9 million or EUR 636 million annually to write proposals**[45]. **Out of these costs it is estimated that EUR 1.7 billion would be spent on writing proposals that do not get funded including EUR 643.0 million for non-funded high quality proposals alone**.

Figure 6 Estimation of cost of proposal writing

	Eligible proposals (excluding resubmission)	Cost of writing proposals (EUR million)
High expense level: EUR 50 000[46]	22267	1113.4
Medium expense level: EUR 20 000[47]	24572	491.4
Low expense level: EUR 10 000[48]	18774	187.7
Very low expense level: EUR 5000[49]	23292	118.9
Total	**88905**[50]	**1908.9**

Source: CORDA per 1/1/2017, excluding resubmissions, estimation by Commission Services.

There is room for improvement in the current evaluation process. The thematic assessments of FET, LEIT-ICT, the SME Instrument and SC4 highlight **dissatisfaction with application procedures, proposal evaluation and selection and reporting procedures**. In addition they note that **the quality of feedback provided to applicants is an area for improvement.** This is also reflected in the stakeholder consultation results, where 62,2% (1647 of 2648) respondents that had participated in Horizon 2020 of the respondents assess the quality of the feedback from the evaluations as "good" or "very good", while 34% (905) judged it as "poor" or "very poor" (which was the highest score reached by the "poor" and "very poor" categories compared to the other items related to the implementation aspects of Horizon 2020 which were submitted to the opinion of respondents). The numbers show that NGO's are least positive (55.6% very good or good), followed by Academia (59.2% good or very good).

In the open questions of the stakeholder consultation, some respondents ask for more transparency and an improved quality of the evaluation feedback they receive. Respondents complain that not enough details are provided, that the quality of the feedback varies greatly from one evaluation panel to the other, and that discordant views can be provided to the participant.

[44] Available at: http://ec.europa.eu/research/participants/data/ref/h2020/other/events/survey/h2020_simplification-survey_final-report_en.pdf
[45] See detailed methodology in Annex 1.
[46] Instruments included: RIA and IA, COFUND-EJP/PCP/PPI/ERA-NET
[47] Instruments included: CSA, ERC ADG/COG/LVG/ POC/STG, MSCA Cofund/ITN/RISE
[48] Instruments included: MSCA-IF and SME-2
[49] Instruments included : SME-1 and Stage 1 applications in two stage applications
[50] Including Stage 1 proposals

The selection of experts for proposal reviews is also questioned - respondents stress that expertise in the field is not always available. Some mention evaluations should not only be done remotely. Reviewed position papers also echoed such concerns (see box below).

Stakeholder position papers: some aspects of the current evaluation process of Horizon 2020 proposals should improve.

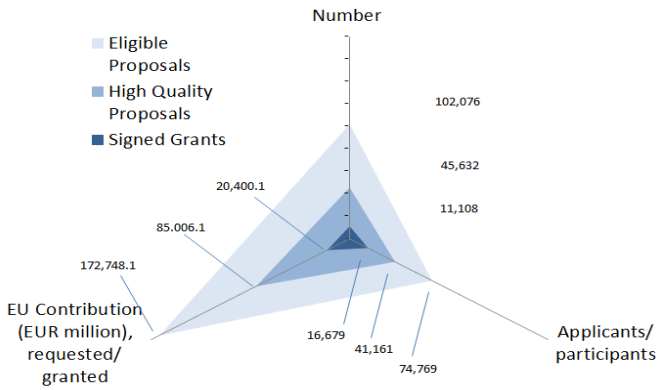
In their position papers some stakeholders from academia, research organisations as well as public authorities and business commented on the evaluation process and noted that the quality of the current process should improve. A variety of issues was highlighted, in particular: the Evaluation Summary Reports are reportedly too short and provide generic and not tailored feedback. A few stakeholders noted the reports were not accurate; evaluation committees should have a balanced representation of stakeholders including industry, business participants and SHH experts. Few business representatives further noted the selection rules of expert panels, especially around conflicts of interest seem to put off industry experts as evaluators; evaluators should have the necessary expertise and training and consensus meetings should be reintroduced.

7.4. How efficient is the distribution of funding?

7.4.1. Success rates and oversubscription

The strong increase in interest in Horizon 2020 means that demand vastly outstrips supply, leading to oversubscription. An additional EUR 62.4 billion would have been needed to fund all the proposals evaluated as high quality. The average success rate of Horizon 2020 dropped to 11.6 % compared to FP7, which had an overall success rate of proposals of 18.4%. While the popularity and high demand for parts of the programme show that they are offering support in the right areas, and that only the very best proposals offering scientific excellence are indeed being selected, too much oversubscription could cause disillusionment and dissatisfaction and leave good proposals unfunded and to be resubmitted. As of January 2017 Horizon 2020 attracted 102,076 eligible proposals (requesting funding of EUR 172.8 billion), 45,632 of these were assessed of high quality (44.7% of total eligible proposals); 11,108 grants were signed.[51] [52]

Figure 7 Overall proposal and grant data



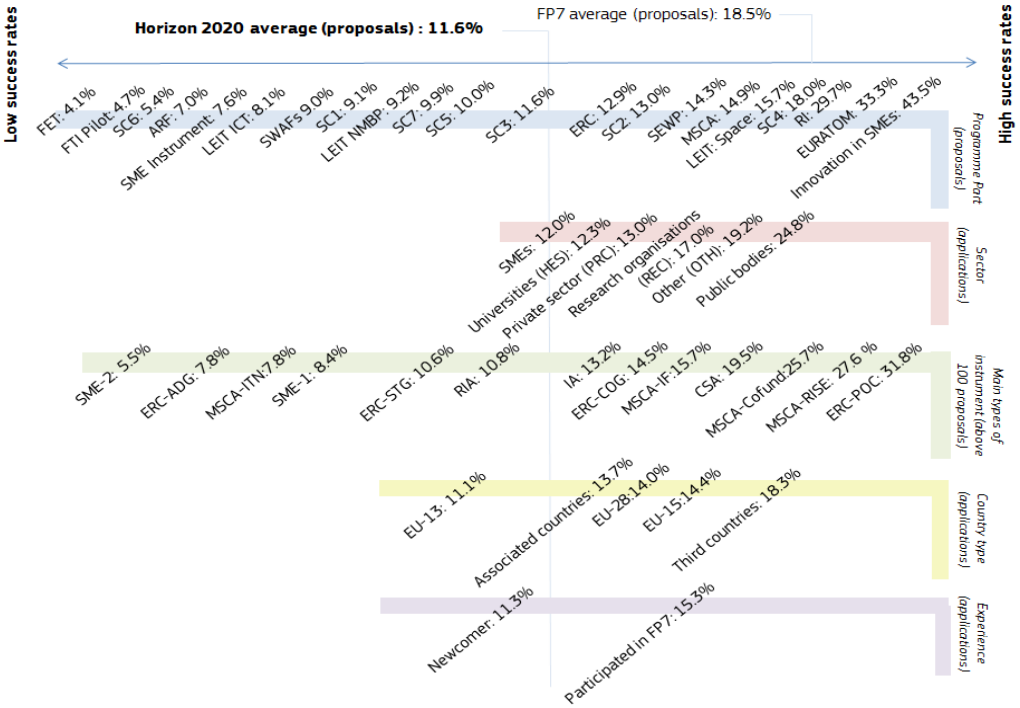
Source: CORDA, cut-off date by 1/1/2017

However, **oversubscription is unequally distributed throughout the programme parts in Horizon 2020 and varies across countries, sectors, instruments and levels of experience**. The success rates per programme part, types of instrument, country type and level of experi-

[51] Success rate measured in terms of EU financial contribution was 12.7% and in terms of applications 14.1%.
[52] Detailed implementation data covering the first three years of Horizon 2020 can be found in Annex – Part 2.

ence (newcomer to Horizon 2020 compared to FP7) are presented in the Figure below. Applicants with previous FP7 experience, from third countries, public bodies, applicants to the ERC Proof of Concept and MSCA-RISE have the highest success rates. The lowest rates are found in FET, the SME-Instrument and SC6, whereas the highest are found in Research Infrastructures, Innovation in SMEs and SC4[53].

Figure 8 Success rates (programme part, sector, type of instrument, country type and level of experience)

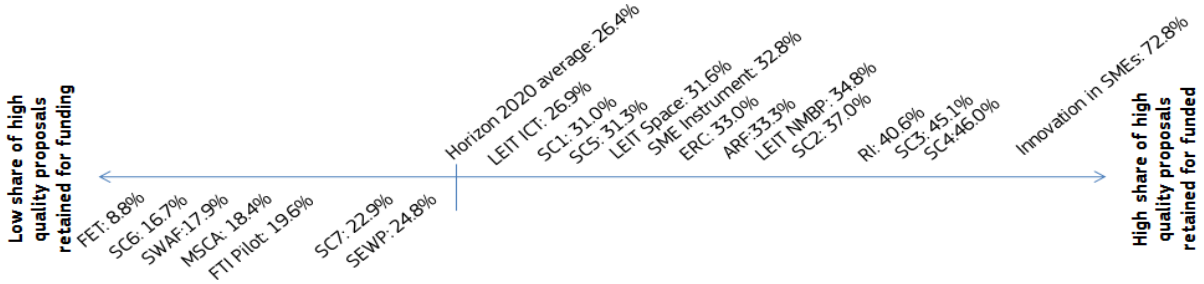


Source: CORDA, Signed Grants cut-off date by 1/1/2017 (excluding grants to named beneficiaries)

Figure 9 shows that the share of high quality proposals receiving funding represents up to 72.8% in Innovation in SMEs and less than 20% under SC6, SWAFS, MSCA and FTI Pilot. **This indicates an underfunding of substantial parts of the programme where the current budget supports less than 1 out of 5 high quality proposals.** FET has the lowest rate of high quality proposals funded, where less than 1 out of 10 is retained for funding. According to the FET assessment, whereas stakeholders have repeatedly called for the budget to be increased to match the clear demand and address this issue, the "backloaded" FET budget profile in the last years will also help to alleviate this.

[53] The calculation of success rates is based on full proposals, i.e one proposal is counted only as second stage of a 2-stage proposals, not including the proposals which are excluded in stage 1. This means that some parts of Horizon 2020 success rate actually report higher success rates, than would have been the case including stage 1. An example of this is SC4, which has a comparably high success rate, due to the exclusion of proposals in stage 1, as reported in Figure 34.

Figure 9 Share of high quality proposals funded



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

In some of parts of Horizon 2020 2-stage calls were used to cope with oversubscription. In the first stage the applicants submit a short project description that is evaluated. Successful applicants are then invited to submit a full proposal in stage 2[54]. In total in Horizon 2020 by 1 January 2017, 10,001 proposals were submitted in this staged approach, which equals a share of 9.8% of the total number of full proposals submitted. Of these 3,144 were invited to submit a full proposal.[55] Of the submitted full proposals 19.6% were main listed for funding, which is 8 percentage points higher than the average proposal success rate in Horizon 2020.

New rules were introduced in the 2016-2017 Work Programme for 2-stage proposals that regulated the number of proposals that passed to the second stage as a function of available budget: according to this rule, stage 2 proposals accounted for three times the available budget, or as close as possible. The share of proposals being invited to submit full proposals therefore depends on the number of proposal submitted at first stage, their quality, and the budget they request. For 2-stage calls closed in 2016, as effect of the new rule , out of 1,112 proposals submitted in the first stage, 416 submitted a full proposal in the second stage and 162 were finally retained: the success rate of second stage is 38.9%, almost doubling the success rate of all 2-stage calls (19.6%). The introduction of this new rule has so far proved to be effective.

Following a pilot in FP7 (XTrack), FET-Open (which previously used a 2-stage call) now applies a single-stage call with very short proposals (up to 7 pages). A survey among applicants and evaluators shows general satisfaction with this approach.

Oversubscription and the low success rate are among the most commonly quoted issues of the programme raised during the stakeholder consultation, leading to calls for the budget for those areas to be increased: a majority of respondents (89% or 3,099) “strongly agreed” or “agreed” that an increased budget is needed for financing R&I at EU level.

Stakeholder position papers: Oversubscription is one of the most commonly quoted issues of Horizon 2020.

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

[54] Unlike other parts of the Framework Programme the ERC has a single-submission, two-step evaluation process. Also since the 2015 calls (based on the results of the 2014 calls) applicants can be restricted from submitting proposals to future ERC calls for up to two years based on the score given to their proposals. These restrictions are designed to allow unsuccessful PIs the time necessary to develop a stronger proposal.

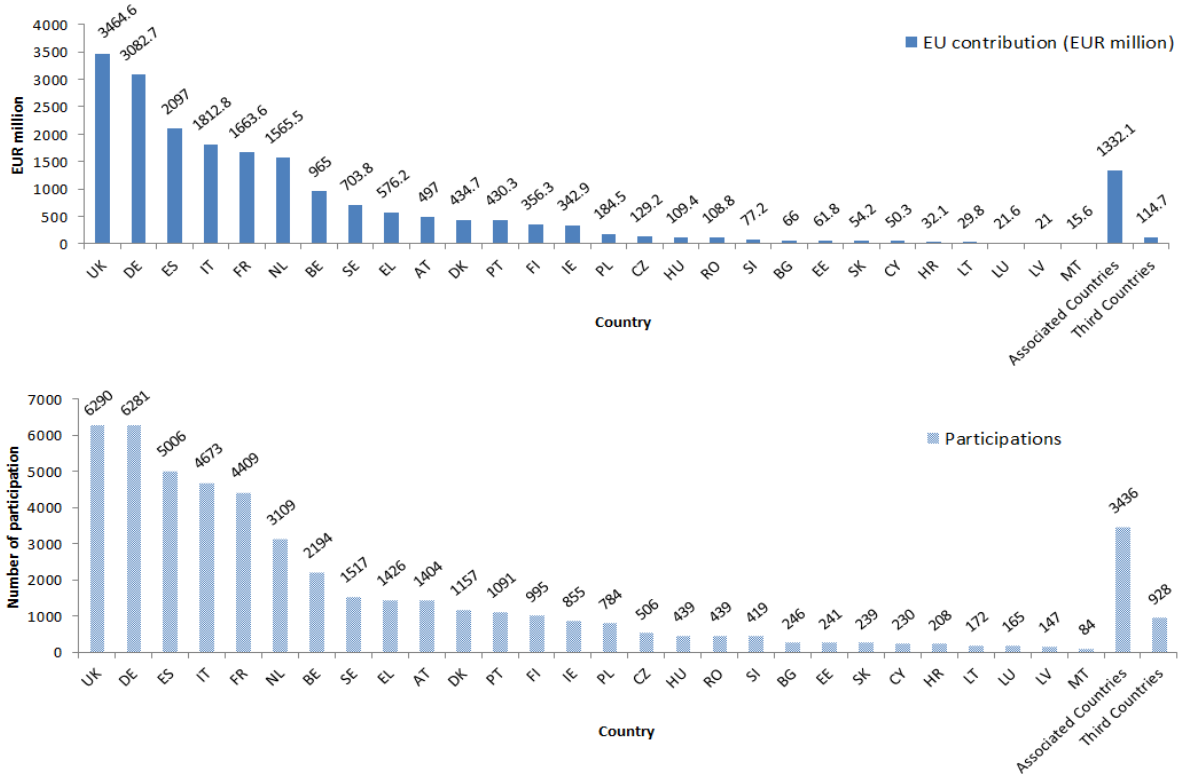
[55] Including 166 proposals that were invited, but for different reasons decided not to submit.

Stakeholders also proposed a variety of solutions on how to reduce oversubscription rate: increase budget especially for the bottom-up calls to better meet the demand; reduce scope of the narrower calls and improve and expand the 2-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 step one lighter. A few noted that the current introduction of 2-stage proposal procedure to manage oversubscription in certain calls is welcomed, but the process is not selective enough in the first stage.

7.4.2. Distribution of funding per type of organisation and country

Participants from 131 different countries benefited from Horizon 2020 in the first three years. EU-28 countries receive 92.9% of the funding (91.1% of participations). Associated countries account for 6.5% (7.0% of participations), with Israel and Norway being the most active, whereas third countries had 0.6% of the funding (1.9% of participations). In total, 87 third countries participate in Horizon 2020, with USA and South Africa being the most active. The share of funding allocated to the EU-13 is 4.4% and 88.5% to EU-15 countries. Germany and the UK receive the largest shares of funding and participations. Participants from the UK coordinate almost 1 out of 5 projects.

Figure 10 Summary graphs (EU contribution and participation per country)



Source: Corda, cut-off date by 1/1/2017

The funding disbursed under Horizon 2020 is so far concentrated. **Participants from five countries received 59.4% of the overall funding**, with participants from Germany receiving 17% of the overall funding, whereas participants from Bulgaria, Latvia, Lithuania and Malta receive 0.1% each. The five countries with the highest share of participants also represent 64.5% of the investment in R&I (GERD) in Europe. **There are big differences** (18.4 percentage points) **between the countries in terms of shares of SME participation -** with Hungary, Estonia and Cyprus having the largest share of around 30% of SME participation and Sweden, Romania and Croatia all below 20%. In total EU-13 have a lower success rate of 11.1% com-

pared to EU-15, which register 14.4%. Third countries have in total the highest success rate of 18.3%. In total 133 countries participated in Horizon 2020. Detailed performance of countries is provided in Annex 1.

> *We observe strong "old boys clubs" cooperation patterns, poorer visibility of EU-13 excellence but also week involvement of EU-13 in testing new technologies resulted from Horizon 2020 projects. Therefore efforts to support wider participation need to be significantly strengthened in all parts of Horizon 2020 and the next FP. Such approach would not only support less participating regions, but also clearly demonstrate European added value.*
>
> Poland, National Contact Point

Participants from EU-13 Member States represent 8.5% of the participations in Horizon 2020 and receive 4.4% of the overall funding, which is slightly more than under FP7 (respectively 7.9% and 4.2%). Overall the EC contribution to participants from EU-13 countries increased from approximately EUR 270 million per year in FP7 to EUR 300 million per year under Horizon 2020. Some EU-13 countries are in spite of overall lower Horizon 2020 contribution outperforming the EU-15 average. E.g. Slovenia, Cyprus and Estonia outperform the EU-15 averages, taking into account the size of the population, the number of researchers and national investments in R&D. Furthermore taking national investments in R&D into account, EU-13 Member States on average outperform EU-15 Member States by 6.7%. The variations in Horizon 2020 funding to a large extent can thus be explained by differences in national investments in R&I. Overall applications from EU-15 Member States (14.4%) have a higher success rate than applications from EU-13 (11.6%).

Figure 11 Key data on participation per country group

		Horizon 2020			
	FP7, EU-13	EU-13	EU-15	EU28	Overall
Share of EC contribution	4.2%	4.4%	88.5%	92.9%	100%
Average EC Contribution per year (EUR million)	272	302	6,015	6,318	6,800
Annual EC contribution per inhabitant (in EUR)	*3*	3	15	12	n.a
Annual EC Contribution per researcher FTE (in EUR)	*1,321*	1,271	3,808	3,475	n.a
EC Contribution per EUR million spent on R&D (public and private, GERD)	N/A	67,524	63,277	63,429	n.a
Share of participations	7.9%	8.5%	82.6%	91.1%	100%
Share of SME participation	9.3%	21.8%	21.2%	21.3%	20.7%
Share of newcomers participations	N/A	31.2%	19.7%	20.8%	21.1%
Share of private sector participation	28.7%	31.1%	34.2%	33.9%	33.2%
Share of unique participants	10.9%	11.7%	76.9%	88.6%	100%
Success rate of applications	18.0%	11.1%	14.4%	14.0%	14.1%
Share of Projects Coordinator s in Signed Grants	9.7%	5.1%	87.6%	92.7%	100%

Source: European Commission, cut-off data 1 January 2017, and HLEG report on FP7 ex-post evaluation

Noticeably, EU-13 countries record a higher share of SME participation that under FP7 (from 18.2% to 21.8%) which is above the performance of EU-15 countries. The private sector participation also increased compared to FP7 (from 28.7% to 31.1%). **There are however big differences between countries as regards the shares of SME participation -** with Hungary, Estonia and Cyprus having the largest share of around 30% of SME participation and Sweden, Romania and Croatia all below 20%.

As the size of these Member States vary greatly comparing on absolute numbers can be misleading. Normalising per inhabitant, per researcher and per million invested in R&D nationally nuances the picture:

- **Per inhabitant EU-15 receive EUR 44 compared to EUR 9 for the EU-13**. This however does not take into account the differences in the size of the R&I sector in the relevant Member States.
- Including the number of researcher FTE **EU-15 receives EUR 11,423 and EU-13 receives EUR 3,812.** Differences in salaries and reimbursement rates can partly explain this difference.
- Per EUR million invested from the private and public sector in R&I, the EU-13 receives **EUR 67,524 from Horizon 2020 compared to EU-15, which receives EUR 63,277. This is 6.7% higher for EU-13.**

Figure 1 Horizon 2020 contribution normalised by inhabitant, researcher and R&I investment nationally

Country	H2020 contribution (EUR million)	Horizon 2020 contribution: Per inhabitant	Horizon 2020 contribution: Per researcher FTE	Horizon 2020 contribution: Per EUR million spend on R&D
Austria	576	66	13,609	55,170
Belgium	965	85	17,518	95,806
Bulgaria	30	4	2,095	68,791
Croatia	32	8	5,042	85,644
Cyprus	62	73	71,860	768,657
Czech Republic	129	12	3,393	39,751
Denmark	497	87	11,887	61,706
Estonia	66	50	15,767	217,990
Finland	430	78	11,470	70,879
France	2,097	31	7,812	43,110
Germany	3,464	42	9,690	39,735
Greece	435	40	12,396	258,158
Hungary	109	11	4,298	72,008
Ireland	356	75	16,610	121,962
Italy	1,664	27	13,786	75,991
Latvia	22	11	5,978	141,825
Lithuania	21	7	2,585	54,264
Luxembourg	54	94	18,892	80,767
Malta	16	36	19,094	230,759
Netherlands	1,566	92	20,337	114,857
Poland	185	5	1,908	42,743
Portugal	343	33	8,663	149,794
Romania	77	4	4,422	98,703
Slovakia	50	9	3,492	54,245
Slovenia	109	53	13,848	128,243
Spain	1,813	39	14,806	137,627
Sweden	704	71	10,249	48,267
United Kingdom	3,083	47	10,654	70,251
EU-28	**18,953**	**37**	**10,426**	**63,429**
EU-13	**907**	**9**	**3,812**	**67,524**
EU-15	**18,046**	**44**	**11,423**	**63,277**

Source : European Commission

Some of the main causes of low participation by certain Member States in past EU Framework Programmes were: insufficient R&D investments in those countries; lack of synergies between certain Member States' national research systems and EU research; lagging system learning effects and access to existing networks; differential wage levels between countries; insufficient and ineffective information, communication advice and training.[56]

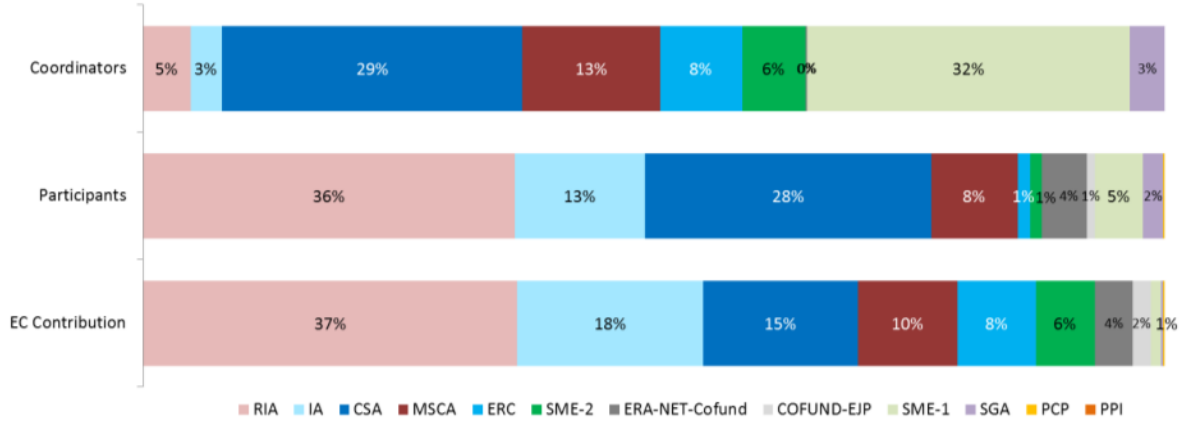
Widening participation is recognised and addressed as a cross-cutting issue in Horizon 2020. The different actions undertaken to widen participation across Horizon 2020 have successfully managed to raise awareness and bring EU-13 stakeholders closer to Horizon 2020, through networking, information sharing and exchange of best practices. **Some programme parts register however a better EU-13 participation than others, and better than in FP7, but still quite low.** The picture is therefore diversified and a causality link between measures in place and participation/success

[56] Commission analysis of September 2011, at the request of the Polish Presidency, see http://register.consilium.europa.eu/doc/srv?l=EN&f=ST%2014728%202011%20INIT This has been confirmed by other studies, analysis and public discussions, for instance the FP7 MIRRIS project.

rates cannot be defined. **Participants from EU-13 Member States represent 8.5% of the participations in Horizon 2020 and receive 4.4% of the overall funding, which is slightly more than under FP7 (4.2%).** Some EU-13 countries are in spite of overall lower Horizon 2020 contribution outperforming the EU-15 average. E.g. Slovenia, Cyprus and Estonia outperform the EU-15 averages, taking into account the size of the population, the number of researchers and national investments in R&D. Furthermore taking national investments in R&D into account, EU-13 Member States on average outperform EU-15 Member States with 6.7%. This implies that the variations in Horizon 2020 funding to a large extent can be explained by differences in national investments in R&I.

Most of the EC contribution received by participants from EU-13 countries come under Innovation Actions (37%) and Research and Innovation Actions (18%), followed by Coordination and Support Actions (15%), Marie-Sklowdowska Curie Actions (10%) and ERC (8%).

Figure 13 Distribution of EU-13 coordinators, participants and EC contribution per type of action



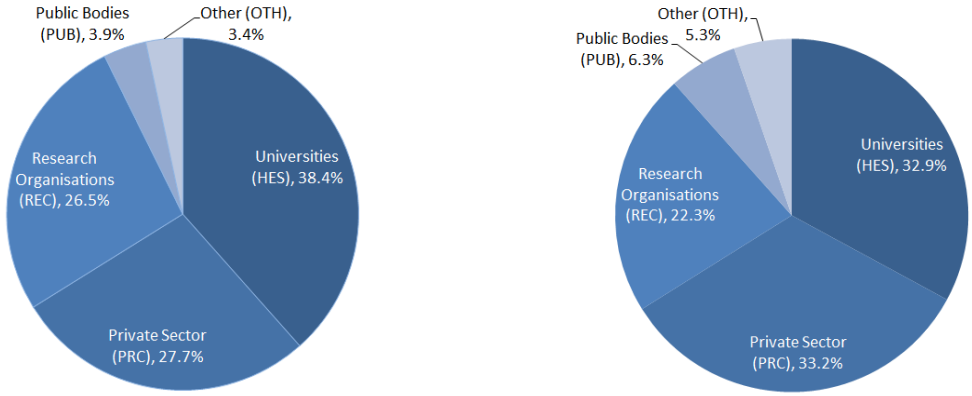
Source: EC DG RTD analysis based on CORDA, cut-off date 1/1/2017

By 1 January 2017, higher or secondary education institutions (HES) and research organisations combined attract 64.9% of the funding, private sector 27.7%, and public authorities and others 7.3%. Each HES participates on average 11.4 times and receive EUR 5.5 million, each company participates 1.6 times on average and receive EUR 0.5 million.

SMEs attract 16% of Horizon 2020 funding and represent 20.7% of the participations. **Under the LEIT and Societal Challenges pillars, the SMEs receive 23.9% of the funding and had 26.9% of the participation – exceeding by far the 20% target of funding in LEIT and Societal Challenges allocated to SMEs.**[57] The share of EC funding allocated through the SME instrument between 2014 and 2016 is 5.6 % of the total budgets of the specific objectives LEIT and the priority Societal Challenges and it represents EUR 881.7 million.[58] This share is increasing from 5% in 2014 and 5.1% in 2015 to 5.6% in 2016: the favourable trend is in line with the minimum target of 7%.[59]

[57] More information available at: https://ec.europa.eu/programmes/horizon2020/en/area/smes
[58] For the calculation of the share of EC funding allocated through the SME instrument, data are not based on Corda but on the budget earmarked to the SME instrument in the Work Programmes.
[59] Regulation (EU) No 1291/2013 establishing Horizon 2020, Annex II.

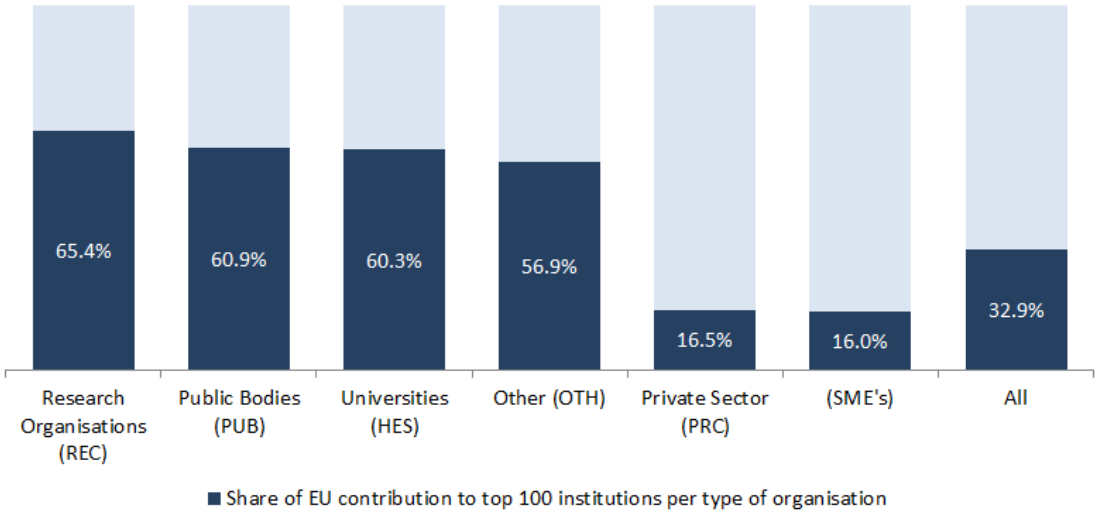
Figure 14 Share of participations and EU contribution per type of organisation (EU contribution left, participation right)



Source: Corda, calls until end 2016, Signed Grants cut-off date by 1/1/2017

Overall, in Horizon 2020, the 100 institutions receiving most funding received 32.9% of the total budget. Amongst research organisations and higher or secondary education institutions, this concentration of funding is particularly strong. The 100 research organisations receiving the most funding, got two-thirds (66.2%) of the funding, while higher or secondary education institutions in the top 100 received 60.5%. The centralisation is less pronounced for the 10367 private companies that participated in Horizon 2020, where the top 100 received 17.7% of the funding. This share was even lower for SMEs, where 16.2% was allocated to the top 100. **In FP7 the 100 organisations receiving the most funding, received 34.6% of the funding, which is 1.7 percentage points higher than in Horizon 2020**. The top 100 private sector companies received 16.5% in Horizon 2020, compared to 18.9% in FP7.

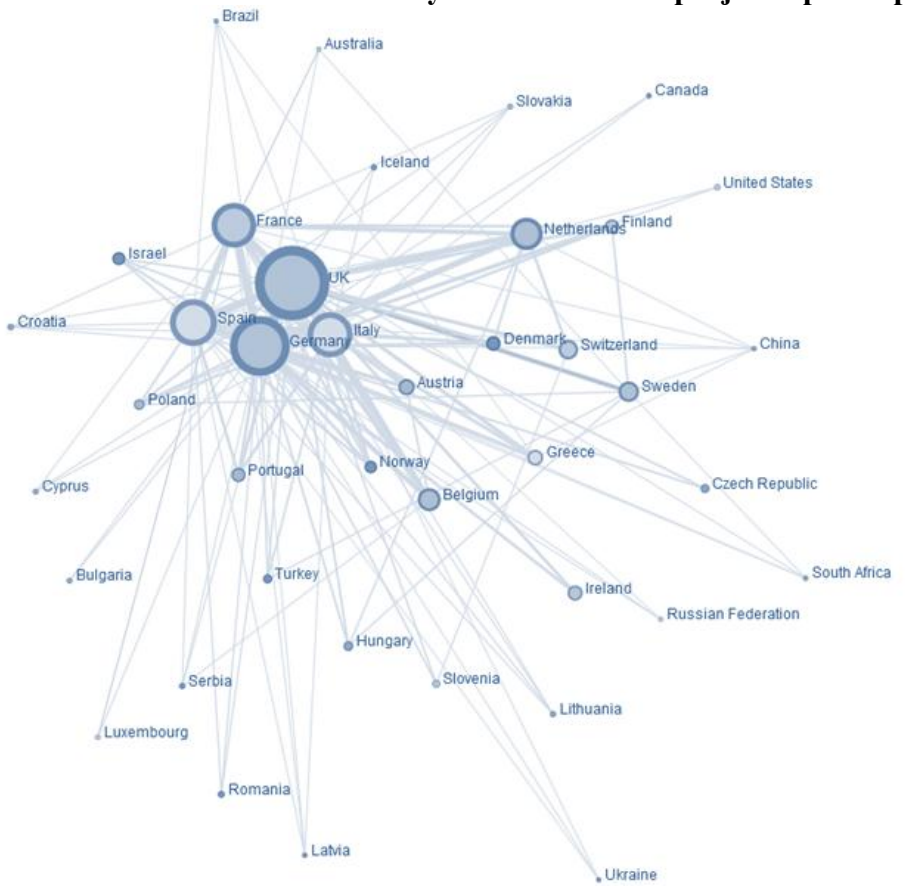
Figure 15 Share of funding going to the top 100 most receiving organisations, per type of organisation



Source: Corda, Signed Grants cut-off date by 1/1/2017

Figure 16 provides an overview of Horizon 2020 cooperation networks between countries based on the number of collaborative projects they participate in. The picture shows a concentration around larger and older Member States such as the UK, Germany, Spain, Italy and France, with Third Countries and newer Member States in the periphery of the network. The figure includes countries with over 20 projects and over 20 collaborations.

Figure 16 Horizon 2020 network at country level – based on projects' participations



Source: European Commission, based on JRC Technology & Innovation Monitoring (Cut-off date: 01/01/2017)

7.4.3. Distribution of funds per project size

Horizon 2020 is expected to provide an appropriate balance between small and large projects.[60] The RIA and IA actions involve on average 11.6 partners which is only a 3% decrease if compared to FP7 collaborative projects (12.0).

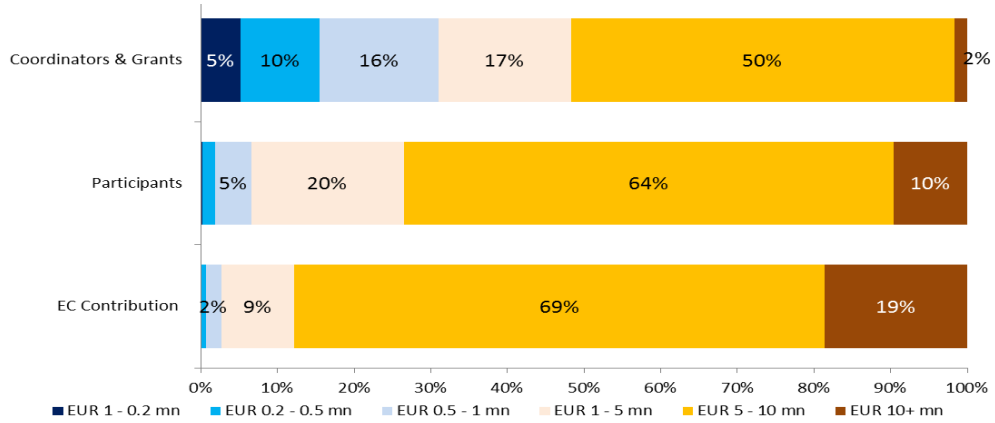
Based on a methodology developed by the Commission services combining budget and participation data[61], **the overall balance between large and small projects under Horizon 2020 remains similar to FP7.** Under FP7, 36.7% of collaborative projects were regarded as large and 63.3% as small, with 23.8% of the funding going to large projects and 76.2% to small projects. This ratio has been maintained in Horizon 2020, when looking at Innovation Actions and Research and Innovation Actions only (IA and RIA): 36.4% of the Horizon 2020 projects are regarded as large by having more than 3 participants per EUR million and 63.6% are small. In terms of funding and based on this approach 24.8% of the Horizon 2020 funding (IA and RIA) goes to large projects and 75.2% to small projects.

In terms of participation, large projects seem to attract a higher share of newcomers and EU-13 participants into the programme if compared to smaller projects.

[60] See Recital 23 of Horizon 2020 Regulation and Recital 13 of Council conclusions of May 2016. It should be noted that the notion of "large" and "small" project and the "appropriate balance" has not been defined in the Regulation.
[61] See Analysis 2, Annexes Part 2/3 Section 7 for more information.

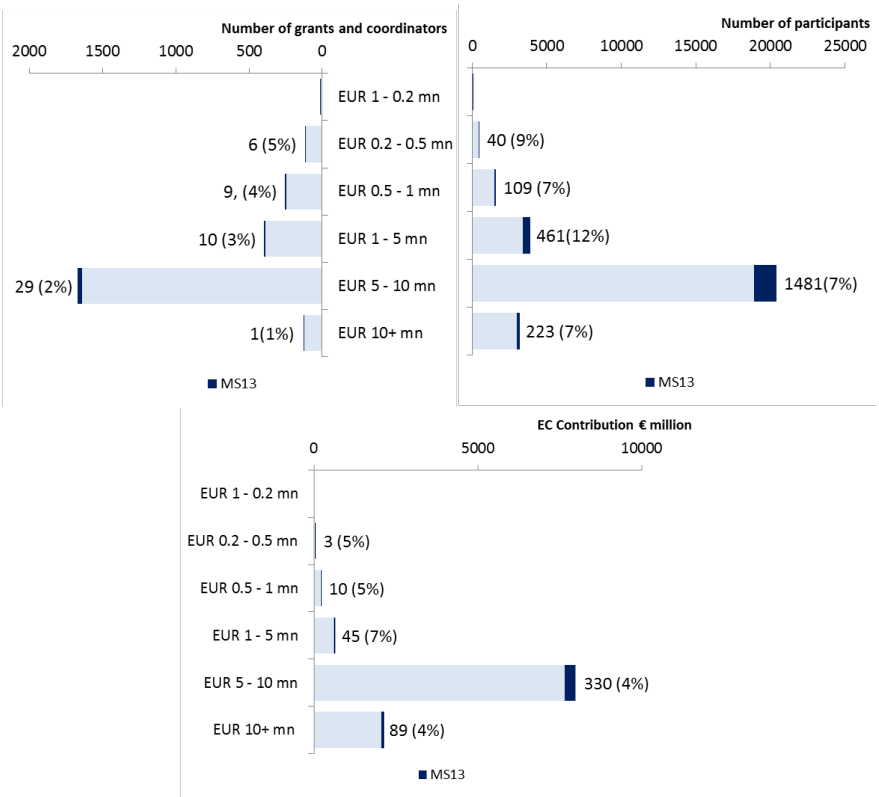
A majority of the EC contribution is currently allocated to projects above EUR 5 million (92%). A closer look at EU-13 participation patterns by budget categories shows that most EU-13 participants are within projects with budgets higher than EUR 5 million and 88% of the EC contribution by EU-13 received is currently from such large projects (Figure 17).EU-13 seem to coordinate and lead more if projects are smaller (but the current sample size is too low to draw conclusions). At the same time, EU-13 seem to participate best in the EUR 1 – 5 million bracket[62]. A full discussion on project size is available in Annex 1.

Figure 17 Share of total EU-13 coordinators, grants, participants and EC Contribution by project size



Source: EC DG RTD analysis based on CORDA, cut-off date 1/1/2017

Figure 18 Project size (budget) and participation of EU-13 (%)



Source: European Commission, DG RTD analysis based on CORDA, cut-off date 1/1/2017

[62] The share of EU-13 participants is significantly higher than in other brackets. There is no statistically significant differences between the share of participations in small projects under EUR 1 million or big projects above EUR 5 million.

In their open comments to the stakeholder consultation respondents asked for more opportunities for small projects (although some respondents are in favour of more support for large-scale demonstrators), more prescriptive calls (in order to avoid the current high number of applicants); and more funding opportunities for SMEs.

Stakeholder position papers: There needs to be a balance between small, medium and large projects.

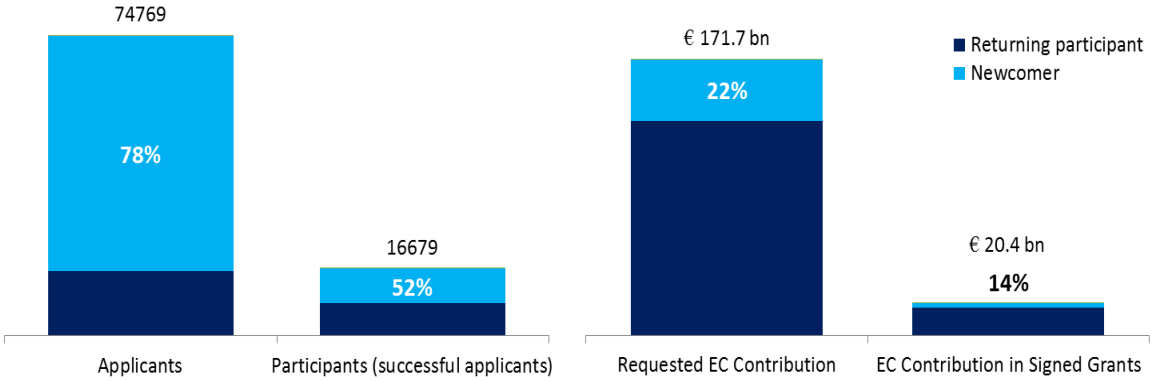
In their position papers, some stakeholders commented on the project size in Horizon 2020. The majority of those commenting noted a better balance between small, medium and large projects should be achieved within the programme. However, stakeholders do not seem to agree on how such balance should look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

7.4.4. Participation of newcomers

The ability to attract newcomers (not participating to FP7) is essential to the openness of Horizon 2020. 78% of all organisations that applied to Horizon 2020 funding in the first three years of programme implementation where newcomers. But their success rate is considerably lower when compared to returning participants (9.2% compared to 13.95%). In addition, on average each returning participant applied for the funding 17 times which increased their probability of success (newcomers on average applied only twice).

As a result, newcomers represent 52% of all organisations participating in Horizon 2020 (and almost half of them are SMEs), but they received only 14% of the total budget implemented in the first three years of the programme. The majority of newcomers participate in the IA and RIA actions (54%) followed by the SME Instrument (33%). The main underlying reason is that these instruments account for a large part of the total funding. A more in-depth analysis of newcomers (including gateways used for joining the Programme) is available in Annex 1. In FP7 70% of all organizations participating were newcomers at the programme end[63]. Horizon 2020 needs to continue attracting newcomers to reach a comparative share of newcomers at the programme end.

Figure 19 The number of (newcomers) applicants and participants (left) and the total requested and obtained EC contribution in signed grants (right)

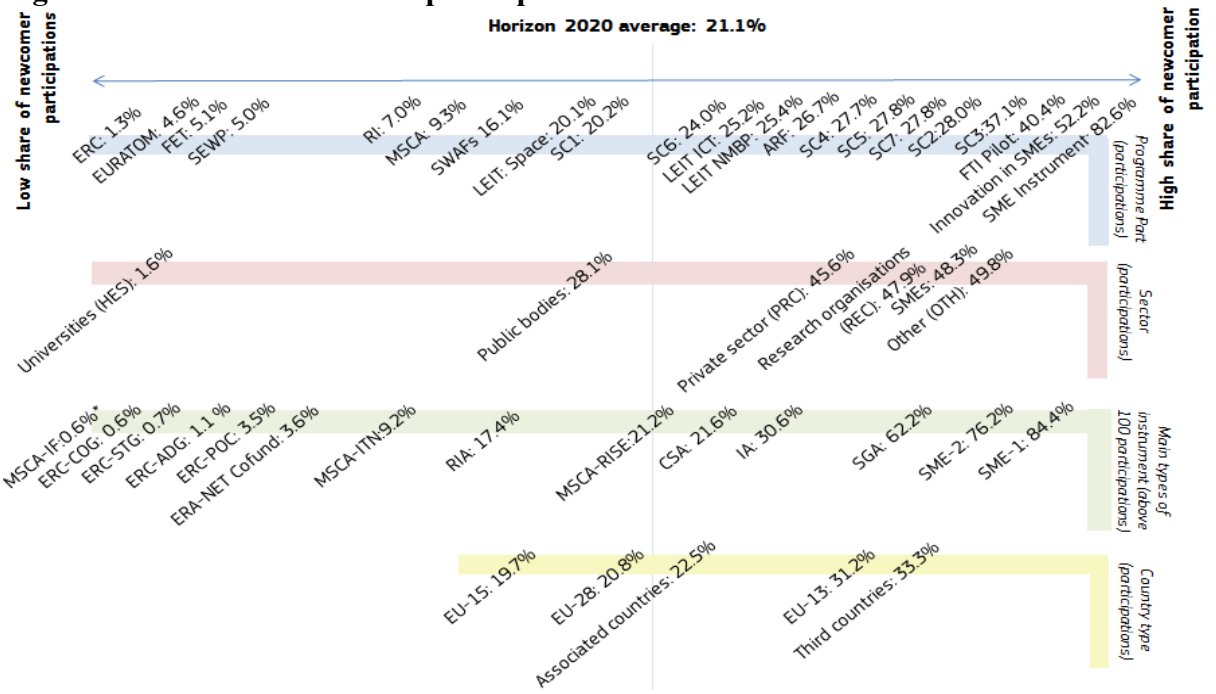


Note: The percentages refer to newcomers. The figures above the bar refer to total numbers for the programme as a whole. Source: CORDA cut-off date 1.1.2017

[63] Several studies (incl the ex-post evaluation of FP7) have shown the share of newcomers to be above 70%, however this information was not obtained in a structured way during the FP7 programme.

There are vast differences between programme parts, country groups, sectors and types of instrument in attracting and selecting newcomers. **In spite of the bulk of the newcomers having origin in EU-15, newcomers represent a larger share of EU-13 participations compared to EU-15 (31.2% against 19.7%), and the share of EU-13 countries in participations from newcomers is larger than in participations from returning participants (11% against 3%), suggesting that the Framework Programme is opening up the "clubs".** Regarding the instruments, the SME Instrument and Innovation Actions have above average shares of participations from newcomers compared to other funding instruments.

Figure 20 Share of newcomers participations

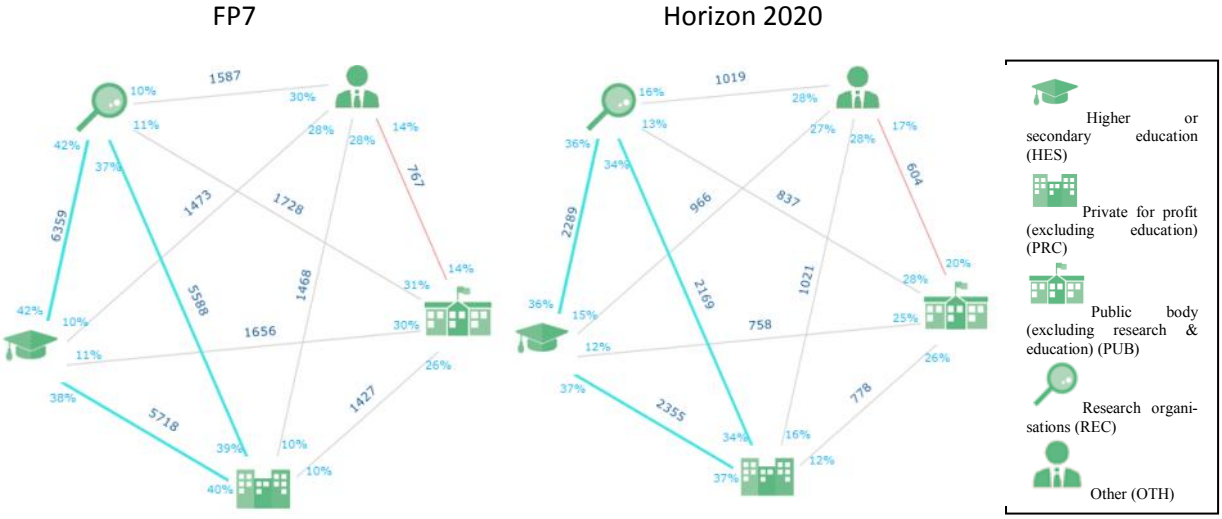


*Source: CORDA, Signed Grants cut-off date by 1/1/2017. *MSCA-IF list the host institution as a participant. The majority are European universities which explains the low share of newcomers.*

7.4.5. Intersectorality and profile of participating companies

Based on a review of the participations to collaborative projects, the main collaborations so far occur between the higher education sector and private firms (2,355 collaborative projects), the higher education sector and research organisations (2,289 collaborative projects) and between the private-for-profit sector and research organisations (2,169 collaborative projects). Private companies have become the main partner of the academic sector under Horizon 2020 projects, as opposed to research organisations in FP7.

Figure 21 Number of collaborative projects between types of institutions, FP7 and Horizon 2020



Source: JRC Technology and Innovation Monitoring tool data. Cut-off date: 01/01/2017; Graphics and computation: European Commission services

Looking at the main domains of academic publications of participants to Horizon 2020 projects (independently of their Horizon 2020 project) it appears that **Horizon 2020 projects are supporting interdisciplinary networks** (see Figure below)[64]. However, only a few unusual interdisciplinary collaborations are observed such as the collaboration between the energy field and computer sciences. Four main clusters of cooperation seem to be emerging based on the first three years of programme implementation, namely:

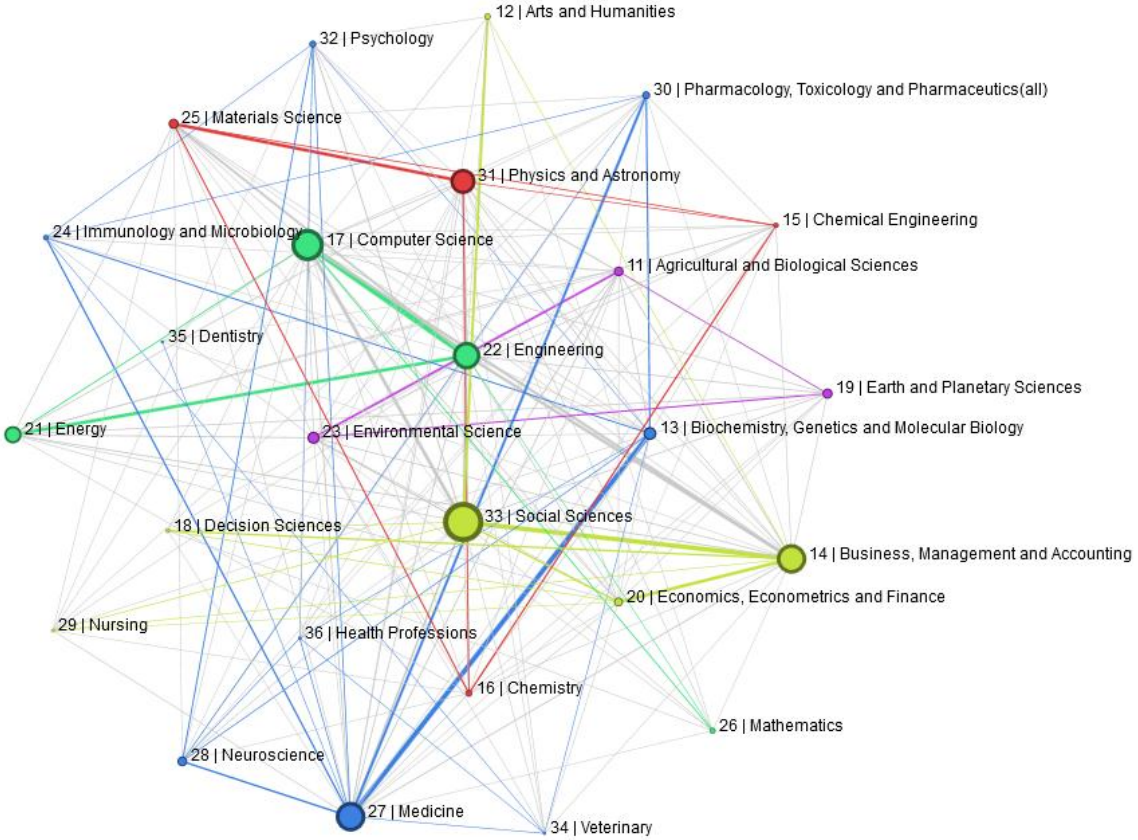
- Physics and astronomy, material sciences, chemical engineering and chemistry;
- Medicine neurosciences, immunology and microbiology, psychology, pharmacology, toxicology and pharmaceutics, biochemistry, genetics and molecular biology and veterinary fields;
- Social sciences business, management, decisions sciences, economics, econometrics, finance and nursing; and
- Computer science, engineering and energy fields.

Box: The value of intersectorality for breakthrough innovation – Example from SPIRE

Among the contractual Public-Private Partnerships (cPPPs) SPIRE is on track towards achieving a reduction of fossil energy intensity of up to 30% by 2030, a 20% reduction in non-renewable primary raw material intensity and a 40% reduction of greenhouse gas emissions by 2030, enabled by a systemic cross-sectorial integration of innovative processes and systems. Factories of the Future is another cPPP working on breakthroughs in industrial manufacturing, reducing the use of materials and waste generation by 20% compared to the situation today across the manufacturing sector.

[64] Horizon 2020 projects were classified according the Scopus bibliographic database which includes scientific, technical, medical, and social sciences (including arts and humanities). The classification was done based on text mining and machine learning performed by the Joint Research Centre of the European Commission.

Figure 22 Collaboration networks in Horizon 2020 projects between different academic fields



Source: JRC Technology Innovation Monitoring. Based on CORDA data cut-off date: 01/01/2017

Looking closer at industry participation, Figure 23 shows companies participating in Horizon 2020 by number of employees and EC contribution received (grants only). Companies involved in Horizon 2020 have a number of characteristics:[65]

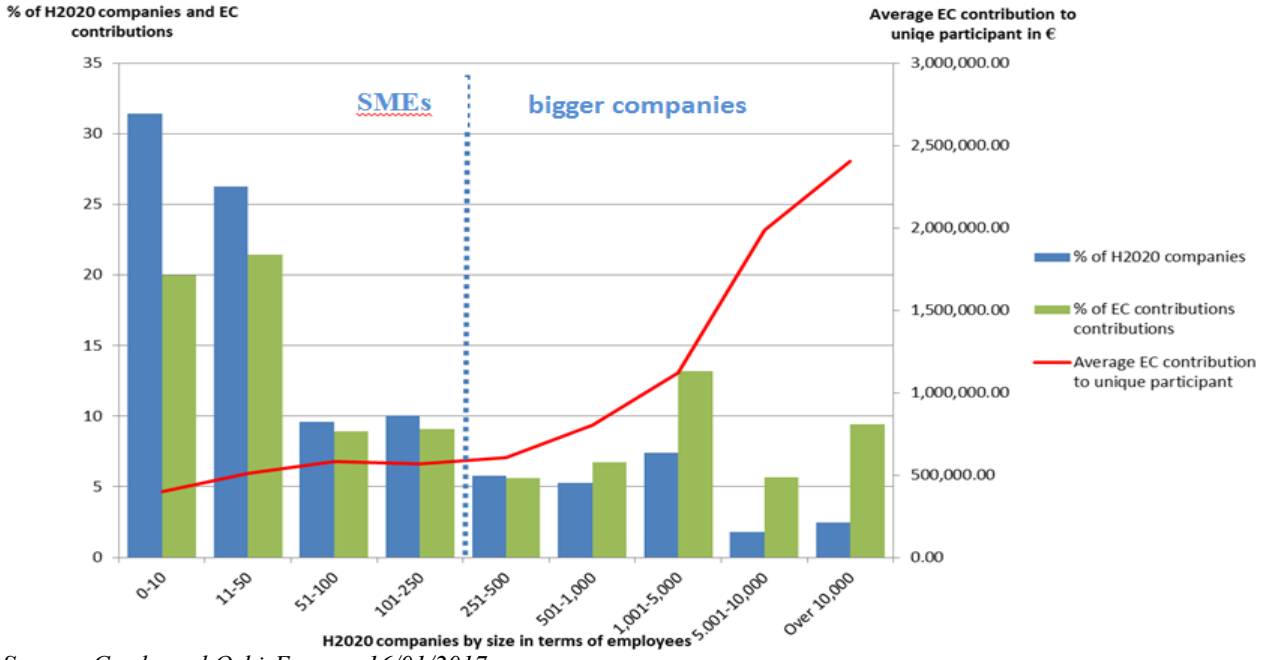
- **In terms of employees SMEs represent more than 75% of all Horizon 2020 companies and receive almost 60% of EC contribution**. More than half of Horizon 2020 companies have 50 or less employees.
- 73% of Horizon 2020 companies have revenues lower than EUR 50 million.
- 60% of Horizon 2020 companies were created after 2000 and 27% after 2010.
- The oldest and most established companies get the highest grants.[66]

Looking at sectoral patterns, 80 % of total grants to Horizon 2020 companies go to the three biggest sectors: 35% to Manufacturing, 30% to Professional, Scientific and Technical Activities, and 16% to the Information and communication sector. The amount of grants awarded to each sector roughly is proportionate to the number of companies in that sector: **the Horizon 2020 allocation seems to be not sector-specific** (chart below). The only slight exceptions are

[65] For full analysis, see Annex 2.
[66] The scope included in this analysis varies from the scope in CORDA. E.g. for SMEs in CORDA, these are mainly (except for the SME instrument) based on self-declaration, where as in this analysis of companies, the data in ORBIS were filtered on two SME criteria (less than 250 employees and less than 50 million in turnover) to identify SMEs..

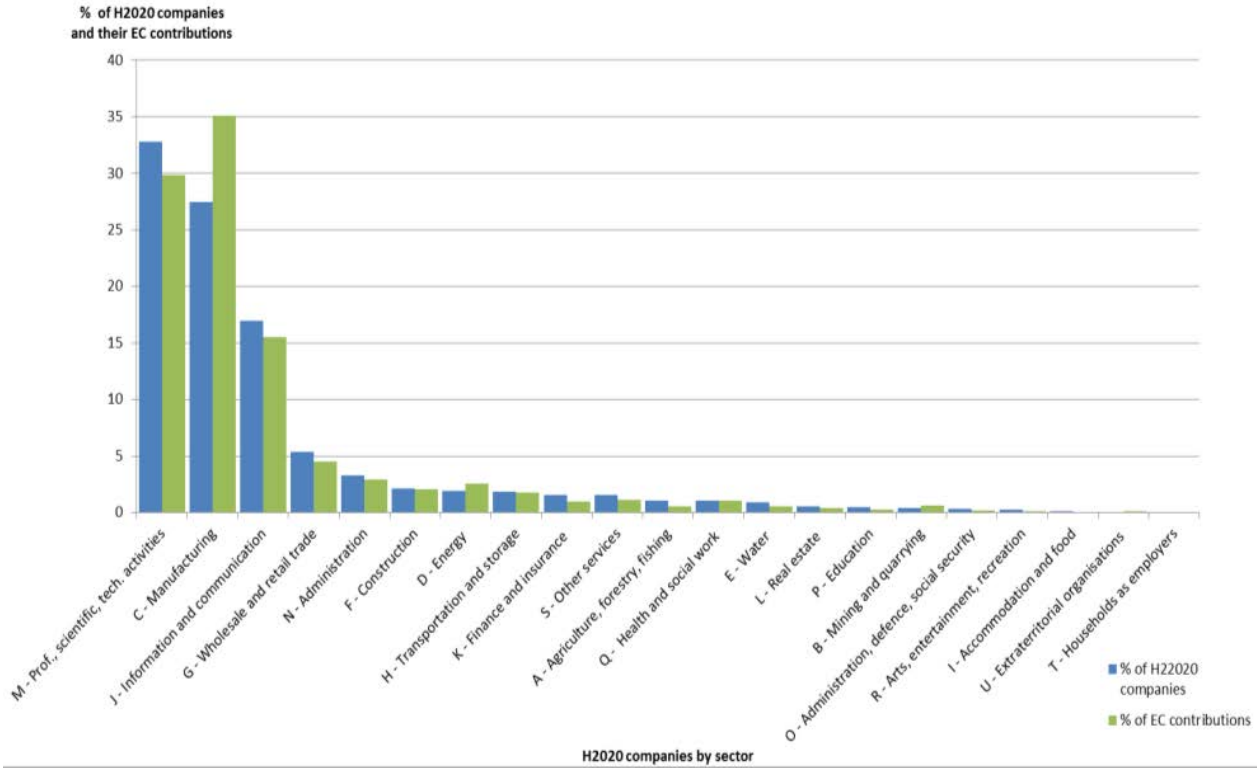
Manufacturing (relatively more grants) and Professional, scientific and technical activities (relatively less grants). This may be because of equipment costs in manufacturing and relatively smaller grants to consultancy companies. In terms of intersectoral collaborations of companies, the wholesale trade sector and the digital sector tend to collaborate more with other sectors.

Figure 23 Horizon 2020 companies by number of employees and EC contribution received (grants only)



Source: Corda and OrbisEurope, 16/01/2017

Figure 24 Horizon 2020 grants to businesses by sector (N = 9,748 companies)



Source: OrbisEurope, Corda, 16/01/2017.

7.4.6. International cooperation

International cooperation activities should be maintained at least at the level of FP7.[67]

Horizon 2020 has a broad international outreach, in total applicants from 188 countries have applied and participants from 131 countries have been funded (including EU, associated and non-associated third countries). Yet the mainstreaming of international cooperation across Horizon 2020 did not lead to a transversal increase of international participation across the programme. **The share of third-country participations and funding going to third-country beneficiaries has decreased when compared to FP7**, mainly due to the discontinuation of the dedicated schemes in FP7 and the change in the eligibility conditions for funding participants from Brazil, Russia, India, China and Mexico.[68] **Third countries represent 2.5% of the participations and 0.8% of the funding in internationally open collaborative projects** (compared to 4.3% and 1.8% respectively in FP7); and 1.9% of beneficiary participations (compared to 3.6% in FP7)[69] and 0.6% of the funding in all Horizon 2020 projects (compared to 1.3% in FP7). So far 87 third countries have participated in Horizon 2020 (compared to 131 third countries in FP7). Amongst countries that are not automatically eligible for funding from Horizon 2020, the most active in

[The discontinuation of Horizon 2020 would be] an absolute catastrophy. Our research has become highly international and our main partner is located in Germany. It is very difficult to find adequate local funding to enable co-operation into the EU and as such H2020 funding is invaluable. If this funding should fall away, our research effort would contract by about 70%.

S. van der Spuy, Stellenbosch University, South Africa

[67] See Recital 41 of the Horizon 2020 Regulation.
[68] See Performance Analysis of International Participation in Horizon 2020, European Commission, 2016.
[69] Taking the considerable share of international partner-organisations in MSCA into account, the participations of third countries are "3.9% of the participations (compared to 5.3% in FP7).

terms of participations are the USA, China, Canada, Australia and Brazil as compared to USA, Russia, China, Brazil and Australia under FP7. Nine of these countries have established co-funding mechanisms to provide funding to their participants in Horizon 2020 projects.

So far, projects resulting from joint/coordinated calls in Horizon 2020 have similar participations and EU contribution as in the corresponding period of FP7. Projects under public-private partnerships have either no or very few international participants (except for the Innovative Medicines Initiative) whereas public-public partnerships show a stronger international participation, with third-country participation share in ERA-NETs at around 5% and the European and Developing Countries Clinical Trials Partnership featuring the participation of 14 African countries. Participations in MSCA account for more than half of all participations of third countries in Horizon 2020. **There is also a greater level of investment in multilateral initiatives compared to FP7.** In health-related initiatives, during 2014-2015 around EUR 114 million were invested, leveraging around EUR 532 million from third countries. In activities related to climate action and the environment such as the 'Belmont Forum', the Group on Earth Observation (GEO) and the Intergovernmental Panel on Climate Change (IPCC), the total Horizon 2020 budget for these topics is close to EUR 200 million, while the total investment by all partners is estimated to be around three to four times this amount. Another example relevant in this context is the developing international maritime research component, notably across the Atlantic (Galway Declaration).

In terms of associations to Horizon 2020, there are now 16 countries that have signed an association agreement[70] Some countries (Switzerland, Norway, Iceland, Israel and the Faroe Islands) have long-standing participation in the EU Framework Programmes and a very strong performance. For the others (e.g. countries from the European Neighbourhood like Armenia, Georgia, Moldova, Tunisia and Ukraine) the association has contributed to the integration of their research and innovation systems in the European Research Area even though several still lack the national capacity needed to fully benefit from their association.

The scientific cooperation between the EU, US and Canada is proceeding with mutual satisfaction in the Arctic in particular under the **Transatlantic Ocean (and Arctic) Research Alliance** launched by the **Galway declaration** in May 2013. Two Arctic Working Groups have been established in 2014 with the US and Canada. The activity of these Working Groups has triggered an improved cooperation and the decision to invest in a consistent package of Arctic research activities in the Work Programme 2016-17 focused on climate change issues, which has attracted further US and Canadian investments.

Stakeholder position papers: A sharp decline in the participation of international partner countries is worrying.

In their position papers, a few stakeholders from different stakeholder groups are worried about the observed drop in global cooperation in Horizon 2020 and noted the issue should be addressed strategically. Some advised rules for participation and regulatory framework should be simplified for instance through a standard contract with global acceptance and guarantee of IP rights. Other noted the programme should introduce topics which explicitly flag international collaboration, have a ring-fenced budget or a separate pillar for international collaboration.

[70] Of these, 12 since the start of the programme and 4 in 2015 and 2016, including Switzerland, which was partially associated until the end of 2016 and is now associated to all parts of Horizon 2020.

7.5. To what extent is Horizon 2020 cost-effective?

It is early to compare the cost and the benefits of Horizon 2020. Specifically, as the benefits are still emerging: **The benefits of the R&I investments are an outcome of a complex set of interactions and investments made today are expected to bring return on a much longer timeframe.** As a reminder projects completed at the time of this evaluation represent only 0.6% of the funding allocated for the three first years of the programme.

The costs of Horizon 2020 relate to the amount of resources needed to have the programme up and running. This includes, for instance, the administrative costs of the Commission and the various implementing bodies, the cost of application (i.e. cost of writing proposals), the cost of proposal evaluation and the cost of managing the projects by the project coordinators. The efficiency section provides some estimates of such costs, however costs incurred by participants are difficult to estimate based on existing data.

As elaborated in the effectiveness section, the benefits of Horizon 2020 are numerous and hard to monetise. Compared to a reference scenario in which Horizon 2020 would have not been implemented, the results of macro-econometric modelling analysis are that every EUR 1 spent under Horizon 2020 brings an estimated benefit in terms of GDP increase between EUR 6 to 8.5 by 2030.[71] Applying this formula to the total Horizon 2020 direct budget of EUR 69.3 billion between 2014 and 2020[72], the expected benefit is in the range of EUR 400 to EUR 600 billion over the period from 2014 to 2030. **The macro-economic model further estimates that the annual internal rate of return of the Horizon 2020 is 30% by 2030**. This is in line with the expected return of public spending in research; based on economic literature it is estimated between three and eight times higher than the initial investment[73]. If these projections materialise, Horizon 2020 can be assessed as cost-effective.

7.6. Key conclusions on the efficiency of Horizon 2020

The actual cost-effectiveness of the programme is difficult to assess as the programme first at a very early stage of implementation and only partial effects can be measured so far (see Effectiveness assessment). However, based on the macro-economic modelling exercise, using projections up to 2030, the estimated rate of return of Horizon 2020 is 30% and its expected benefit is in the range of EUR 400 and EUR 600 billion over the period from 2014 to 2030[74]. If such projections materialise, the programme can be assessed as cost-effective.

In terms of programme management, the efficiency of Horizon 2020 is positively influenced by the **externalisation and simplification**. Compared to FP7, the externalisation increased efficiency since almost 60% of the budget is outsourced to the New Management Modes such

[71] This is based on projections up to 2030 of the NEMESIS macro-econometric model. It should be noted that the same model projected the economic performance of FP7 somewhat higher per EUR invested compared to Horizon 2020. According to the study, the lower performance of Horizon 2020 seems to be linked to the decreased co-funding rate.

[72] These figures include only first, second and third pillars of Horizon 2020 - hence excluding the specific objectives Spreading Excellence and Widening Participation (SEWP) and Science with and for Society (SWAFS), as well as Euratom, EIT and non-nuclear direct actions of JRC.

[73] The internal rate of return was calculated as the actualisation rate that equalizes the actualized sum of GDP gains to the actualized sum of the Horizon 2020 contribution. It increases slightly in time as annual GDP gains stay positive in most countries up to 2050 while EC contribution stops after 2022. This 30% rate of return is in line with the econometric literature results (cf. Hall, Mairesse and Mohnen, 2011). According to most studies, the overall value generated by public research is between three and eight times the initial investment, which in rates of return represents a median value between 20% and 50% (cf. Georghiu, 2015).

[74] NEMESIS econometric model.

as Executive Agencies which are more efficient in grant management compared to in-house commission services. There is evidence this resulted in increased administrative efficiency. Current administrative expenditure remains below the 5% mentioned in the legal base. The administrative expenditure is particularly low for the executive agencies mainly due to higher specialisation and lower staff costs. Simplification of participation rules has decreased costs for the participating stakeholders. The simplification efforts have had other positive effects, in particular on the Time-to-Grant (on average 192 days, 100 days faster than in FP7).

The new **funding model** has overall had positive effects on stakeholder appreciation, time-to-grant and attractiveness. While a direct comparison of funding levels is not possible, estimations show that the average real funding level in Horizon 2020 remains at the 70%, the same as in FP7. Another feature of the Horizon 2020 funding model, the additional remuneration scheme has been perceived by Member State representatives and stakeholders as being difficult to implement and having a negative financial effect on those beneficiaries whose usual remuneration practices are based on very variable levels of remuneration. One area for improvement is the broader acceptance of beneficiaries' usual accounting practice. The Commission has already reacted to these concerns and adapted the Horizon 2020 model grant agreements accordingly. Another area for improvement concerns the unintended effects of the additional remuneration scheme with the EUR 8000 capping.

In terms of the efficiency of the funding distribution higher interest from stakeholders resulted in lower **success rates** than in FP7. Many high quality proposals were not funded. At the same time, higher number of proposals resulted in increased cost of proposal evaluation and might have an impact on the quality of the feedback provided to applicants, which is an area of concern. There is scope for further reduction of administrative burden in both project administration and proposal writing. Despite the low success rate and costs borne by stakeholders for proposal submission, early evidence indicates costs on stakeholders are proportionate given the expected benefits from participation, which are expected to materialise in the future and go beyond the financial contribution received. The effects on the simplification of financial management in the projects and on the error rate cannot yet be assessed, as very few financial reports were yet submitted and no ex-post audits were yet finished.

In terms of **participation**, 52% of all organisations participating in Horizon 2020 are newcomers (and almost half of them are SMEs), but they received only 14% of the total budget. The majority of newcomers participate in the IA and RIA actions followed by the SME Instrument. Even if participants come from 131 countries, the funding is concentrated in terms of participants and countries, but to a lower degree than in FP7. The participation of low R&I performing countries remains low with noticeable performance differences and heterogeneity among the EU-13 countries and across Horizon 2020 programme parts. In general widening participation is limited by the excellence-based focus of Horizon 2020. There is also a greater level of investment in multilateral initiatives compared to FP7 but the decrease in participation of international partners in Horizon 2020 is a cause for concern. The decreased was mainly caused by the discontinuation of the dedicated schemes in FP7, the change in the eligibility conditions for funding participants from certain third countries and recent conflicts and socio-political developments in neighbourhood countries affecting their ability to participate.

8. HOW EFFECTIVE HAS HORIZON 2020 BEEN SO FAR?

This question aims to provide an insight into whether Horizon 2020 is on track to meet its objectives. Whereas detailed assessments of progress for each specific objective are provided in Annex 2, this assessment aims at providing a synthetic overview of the overall progress being made according to key expected impacts, which are not mutually exclusive and cover in each case the whole programme**: scientific impact, innovation/economic impact and societal impact**. The following analysis is structured according to these key strands of impacts, results and early outputs and identifies factors that might affect progress positively or negatively.

Overall it should be kept in mind that R&I are long term and risky endeavours creating knowledge, spill-overs and ground-breaking results that can only very partially be captured after such a short programme implementation.[75] The figures presented in the subsequent analysis are therefore a very small fraction of the output to be expected (projects completed at time of this evaluation represent 0.6% of funding allocated so far). In the following analysis quantitative data from monitoring systems and external studies is thus combined with qualitative data stemming from interviews, surveys of beneficiaries (and non-participants for the counterfactual analysis), project's reviews, expert groups as collected for the 18 in-depth thematic assessments performed for each programme part (see Annex 2) to provide a picture of the progress so far. Results from the stakeholder consultation contextualise the findings.

8.1. What is the progress made towards achieving scientific impact?

The objective of Horizon 2020 is to reinforce and extend the excellence of the Union's science base and to consolidate the European Research Area (ERA) in order to make the Union's research and innovation system more competitive on a global scale.

Expectations from Horizon 2020 for achieving scientific impact

Based on the Horizon 2020 impact assessment, **excellence remains the main guiding principle in Horizon 2020 as in FP7.** Scientific excellence remains promoted through the pan-European competition for funding, as well as the screening for excellence in all project's proposals. Therefore all actions across all Horizon 2020 pillars are expected to contribute towards achieving scientific impact.

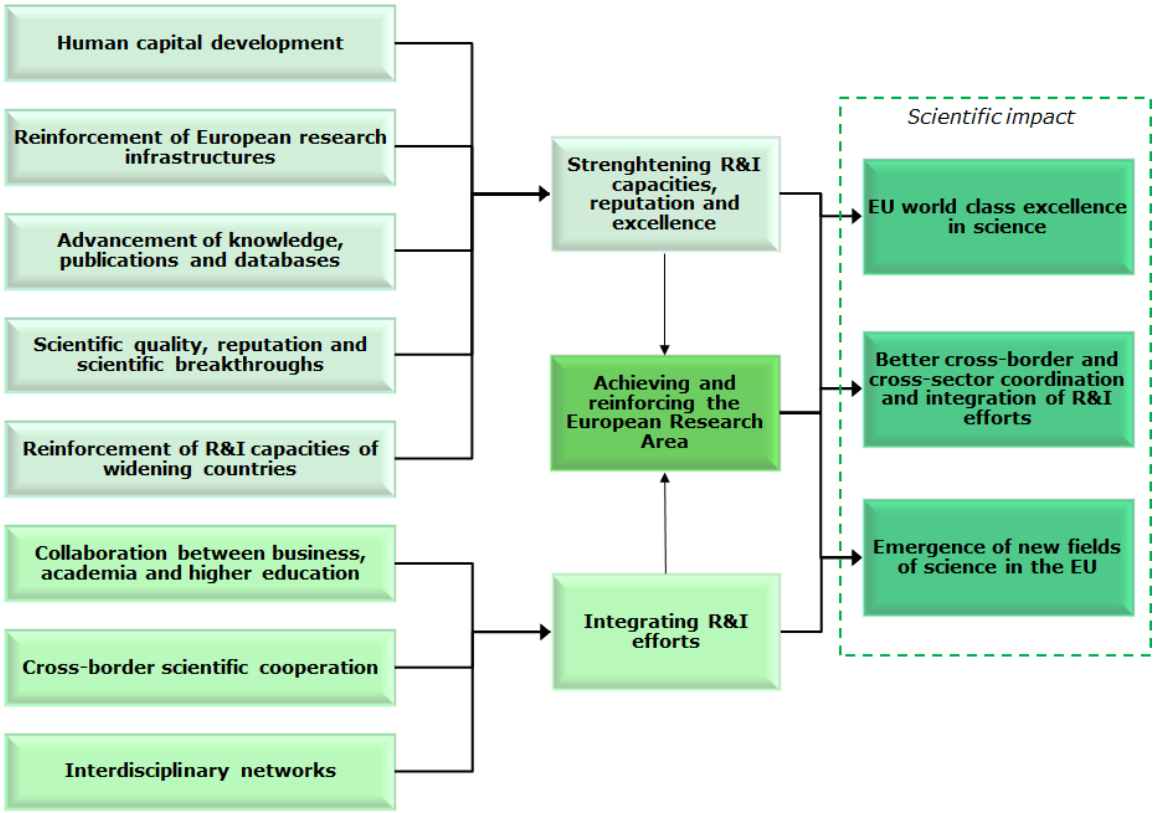
As regards the **continuous effort to spread excellence and build up R&I capacities across the EU-28**, the FP7 Capacities programme aimed specifically at developing the potential of EU-13 countries to participate to a larger extent in the programme. Horizon 2020 includes a specific programme part dedicated to 'Spreading Excellence and Widening Participation', in addition to making it a cross-cutting issue in the whole programme. The objective is to ensure that participants from all EU countries are able to take part in the programme through a reinforcement of the excellence base and more R&I-conducive policy frameworks.

Figure 25 provides an overview of the approach used for analysing progress towards the achievement of scientific impact. Overall - from the review of the programming documenta-

[75] *"Basic research is particularly important, as it gives rise to significantly larger knowledge spillovers than applied research while making applied research much more productive (Akcigit, Hanley and Serrano-Velarde, 2014). The history of science shows that many of the great breakthroughs resulting from scientific research were regarded as significant only in hindsight (Kirshner, 2013). They were not the result of a focused effort to achieve a specific impact, but instead reflected serendipity. Ensuring a balance between basic research, driven by excellence, and more focused, mission-oriented research is therefore an important challenge for public funding."* Chapter 5, The OECD Innovation Strategy - 2015 revision, http://www.oecd.org/sti/innovation-imperative.htm

tion - it is expected that Horizon 2020 will contribute to reinforcing Europe's scientific excellence; to improving trans-national and cross-sector coordination and integrating R&I efforts; and to enabling the emergence of new technologies or fields of science in the EU. Progress on these fronts is analysed according to early outputs and results on the strengthening of R&I capabilities, reputation and scientific excellence (human capital development, reinforcement of EU research infrastructures, advancement of knowledge, publications and databases, scientific quality, reputation and scientific breakthroughs and the reinforcement of R&I capabilities of widening countries) and on the integration of R&I efforts (cross-sectoral, trans-national and interdisciplinary collaboration). Progress on these strands is expected to support the consolidation of the European Research Area.

Figure 25 Approach towards analysing progress towards scientific impact



Source: European Commission

Summary box: Key findings on the progress towards achieving scientific impact

- ✓ Horizon 2020 is making progress towards delivering scientific impacts through the reinforcement of R&I capabilities, scientific excellence and reputation and through the integration of R&I efforts.
- ✓ Horizon 2020 succeeds in attracting and involving the EU's and world's best research institutions and researchers.
- ✓ In particular ERC and MSCA, but also other Horizon 2020 parts, train large numbers of researchers and contribute to Europe's human capital development, which in turns makes EU an attractive destination for excellent researchers worldwide.
- ✓ Pan-European research infrastructures supported by Horizon 2020 already contribute to Europe's excellent science with tools, materials and data accessible from across the EU and by supporting the mobility and training of researchers.
- ✓ Horizon 2020 has already succeeded in generating, and can legitimately be expected to continue to generate, a very large number of scientific publications and data. These are already to a large extent, but not yet fully, openly accessible to the wider scientific community and public.
- ✓ The first scientific publications resulting from Horizon 2020 are world class.
- ✓ Horizon 2020 has the potential to generate a large number of scientific breakthroughs.
- ✓ Horizon 2020 builds cross-sectoral, inter-disciplinary, intra- and extra-European research and innovation networks.
- ✓ Horizon 2020 is also making progress, albeit slowly, on spreading excellence in Europe.
- ✓ The Horizon 2020 funding measures are crucial to accompany the realisation of the European Research Area, notably through their effect on coordination, common agenda setting and pooling of resources, and to continue shaping the landscape of European research institutions.

8.1.1. Progress on strengthening R&I capacities, reputation and scientific excellence

One key objective of Horizon 2020 is to support the strengthening of R&I capacities, reputation and scientific excellence by supporting human capital development, European research infrastructures, the advancement and sharing of knowledge and scientific quality and breakthroughs. Early evidence indicates that the programme is making progress on these fronts.

8.1.1.1. Human capital development

Figure 26 Horizon 2020 Key Performance Indicators related to human capital development

Key Performance Indicators (KPIs)	Progress so far / Target
Human capital development	
MSCA-Number of researchers undertaking international mobility under the Marie Skłodowska-Curie actions.	27 000 (9000 per year) [76] Target: 65,000 researchers (incl. 25,000 PhD candidates)
MSCA- Number of researchers undertaking mobility between academic and non-academic sectors	4 000 Target: 65,000 researchers (incl. 25,000 PhD candidates)
Annual number of research positions advertised on EURAXESS Jobs	The number of research positions advertised on EURAXESS Jobs between 1 January and 31 December 2015 comprised 286,525 job vacancies and 62,088 fellowships.

Source: Corda, Signed Grants cut-off date by 1/1/2017

[76] To be funded under the budget of the MSCA Calls for the years 2014-16.

Horizon 2020 is already supporting human capital reinforcement throughout its activities, the most direct way being through the direct support to individual researchers in MSCA, ERC and FET. However, through the **development of partnerships, knowledge creation and circulation, the impacts of the programme on human capital are much wider**, as detailed in the thematic assessments. A study on the effects of participating in an FP project from a human resource perspective showed that researchers that participate in FPs strengthen almost all skills and capacities.[77] The Research Infrastructure programme also plays a major role in promoting research mobility, within the EU and more globally not only due to the movement of scientists to work at different sites but also due to the synergistic development of common standards, research protocols, tools and platforms, which are engendering a greater portability of skills, data and knowledge across the European scientific community.

As regards the share of researchers in the active population (indicator monitored under the Europe 2020 Strategy), the indicator is progressing well given that **the number of Full-Time Equivalent (FTE) researchers increased each year since 2010 and reached the value of 1.87 million FTE researchers in the EU-28 in 2015 (1.73 in 2013).** An external study[78] identifies a number of **300,000-340,000 researchers in the EU Framework Programmes teams which are fully or at least partly involved in EU-funded research activities**. These data imply that **EU research funding contributed to the activities of around 1 in 5 researchers in Europe**. Going further, the study indicates that the FP7 research teams had, on average, 24.4% more researchers in 2015 than compared to the year when the application for EU funding was made. The corresponding growth rate was estimated at 12.6% for the non-FP teams, resulting in 11.8 percentage points faster overall growth of the teams which participated in the EU FPs. This difference translates into some 45,000-50,000 additional research jobs created in FP7 when extrapolated and aggregated for the whole programme.

A more in-depth assessment of the effects of Horizon 2020 on the career, reputation or profile of researchers involved would require information on the individual researchers involved in the collaborative projects (e.g. through their DOI[79]), which is not available.

Box: Examples of reinforcement of human capital in Horizon 2020

Marie Skłodowska-Curie Actions (MSCA) have funded the training, mobility and career development of around 27 000 researchers during the first three years of Horizon 2020. All fellows will experience mobility be-tween countries and an estimated 12 000 will benefit from some form of cross-sectoral mobility out of or into an academic setting. Furthermore, MSCA are attracting and retaining excellent researchers in Europe, with around one in four fellows coming from countries outside the EU Member States or Associated Countries.

ERC: An analysis in 2014 of over 7,000 leading researchers in Europe found that 30% had applied to the ERC's calls and around one in six were ERC grant holders. According to the ERC thematic assessment, there is also already evidence of the longer term impacts of ERC grants on careers, on training highly skilled postdocs and PhDs, on raising the global visibility and prestige of European research and on national research systems through its strong benchmarking effect. A recent ERCEA analysis showed that 71% of the Starting Grant 2009 grantees, outstanding researchers on the verge of establishing an independent research career, made progress on their career path or improved their academic status as a result of the ERC project, most of them reaching a top academic

[77] 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

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

[79] DOI stands for Digital Object Identifier. It is a serial code used to uniquely identify electronic documents, such as scientific publications. For Horizon 2020 project reporting, publications resulting from funded projects are reported by providing their DOI. All related information on the publication is then automatically transferred into the project reporting system. This information is not available so far for individual researchers in Horizon 2020.

position. Over the course of the 6,500 currently running ERC projects around 28,000 PhDs and postdocs will be part of the teams. According to the ERC thematic assessment, the prestige of hosting ERC grant-holders and the accompanying 'stamp of excellence' are also intensifying competition between Europe's universities and other research organisations to offer the most attractive conditions for top researchers and to increase investment in research capacity and excellence.

A relatively high proportion of **ICT projects** participants perceive a fair or high impact of their projects on their ability to access new knowledge and increase staff skills. Another example is the **FET Flagships** that help recruit, educate and develop research talents in Europe. Building up new interdisciplinary science-and-technology communities is also a hallmark of **FET-Proactive**.

8.1.1.2.Reinforcement of European research infrastructures

Figure 27 Horizon 2020 key performance indicators related to the reinforcement of European research infrastructures

Key Performance Indicators (KPIs)	Progress so far / Target
Reinforcement of European research infrastructures	
Number of national research infrastructures networked (in the sense of being made accessible to all researchers in Europe and beyond through Union support)	National research infrastructures networked thanks to Horizon 2020 support by the end of 2015 were 363. The target by the end of Horizon 2020 is 900.
Number of researchers who have access to research infrastructures through support from Horizon 2020	33 741[80] Target: 20,000 additional researchers during Horizon 2020

Source: Corda, Signed Grants cut-off date by 1/1/2017

Joining forces to boost the ERA (best brains, the best solutions, the best research infrastructures); Horizon 2020 focus on areas where regional/national programmes are not sufficient and the EU level is vital; Excellent research infrastructures must be strongly supported because they are often the main reason why top scientists decide to come to Europe; know-how spreading in the EU; bringing disciplines together; international visibility of EU participants
Germany, Helmholtz Association

Thanks to Horizon 2020 support, a total of 363 national research infrastructures have been made accessible to all researchers in Europe and beyond, out of a target of 900 by the end of Horizon 2020[81]. According to the thematic assessment of Research Infrastructures, the development of EU research infrastructures has raised awareness of the burgeoning potential and stimulated scientific communities across the EU. In close conjunction with ESFRI[82], it has enabled the EU to be effective in conceiving and delivering large research infrastructure projects at the European and global scale. These would not otherwise have been realised because of their large size, cost and complexity, which has required an EU-wide common vision and the combined efforts of several Member States to initiate them. The *ESFRI Strategy Report on Research Infrastructures/Roadmap 2016* lists 29 such infrastructures that have reached the landmark (implementation) phase, and another 21 in development. These include world-leading infrastructures across all the disciplines of science. All are potentially open to all EU Member States, and many are attracting participative interest more globally. Thirteen new Pan-European research facilities are based on the new legal framework for the European Research Infrastructure Consortium, ERIC, which entered into force in 2009 and at least four more ERICs are expected to be launched in 2017.

The pan-European e-infrastructures support the networked provision of computing infrastructure and the development of major data-driven research infrastructures. A single and open Eu-

[80] This amount is calculated on FP7 grants as data from H2020 grants is not yet available
[81] A detailed assessment of progress made under the Research Infrastructure programme is provided in Annex 2.
[82] European Strategy Forum on Research Infrastructures: http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri

ropean space for online research where researchers enjoy leading-edge, ubiquitous and reliable services and open access to e-Science environments is being created through the federation of e-Infrastructure resources at regional, national, institutional and European level realising the European Open Science Cloud (EOSC) vision put forward in the European Cloud Initiative[83]. 35 e-Infrastructure grants have integrated, federated and/or consolidated e-infrastructure services into strong pan-European e-Infrastructures that will form the nucleus of the EOSC and enable the creation of new forms of science.

Example box: ELIXIR-EXCELERATE[84], a Horizon 2020 infrastructure project

Project Type: INFRADEV; Budget: € 19 million; September 2015 - August 2019

The project is aiming at accelerating the implementation and early operation of ELIXIR, the European life science Infrastructure for Biological Information, identified by ESFRI and the European Council as one of the three Europe's priority research infrastructures. With 41 partners in 17 countries this grant coordinates and enhances existing resources into a world-leading data service for academia and industry, grow bioinformatics capacity and competence across Europe, and complete the management processes needed for a large distributed infrastructure. Four use cases: rare diseases, human data, plant genotype-phenotype and marine metagenomics, will help best tuning the services.

The development of distributed European infrastructures and networked infrastructures based around the shared distribution and access to data, materials and tools has been transformative and stimulated scientific communities across Europe into cooperation - creating a solid basis for EU-level research. As none of the Horizon 2020 projects on Research Infrastructures has been concluded to date, it is not yet possible to provide information on the users supported. The number of researchers who had access to research infrastructures through FP7 support until 2015 is 33,741[85].

8.1.1.3.Advancement of knowledge, publications and databases

Figure 28 Horizon 2020 key performance indicators related to the advancement of knowledge, publications and databases

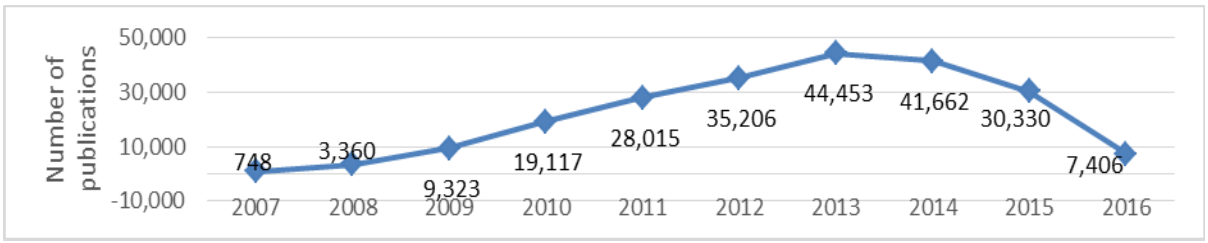
Key Performance Indicators (KPIs)	Progress so far / Target
Advancement of knowledge, publications and databases	
Number of peer-reviewed publications	4043 Target: FET: 25 publications/EUR 10 million ; Societal Challenges: 20 publications/EUR 10 million
Chapters in books	373
Number of Publications in conference proceedings/ workshops	3,138
Number of Books/Monographs	49
Number of Thesis/Dissertations	78
Other publications	548
Total number of Publications ➔ Peer-reviewed in Open Access	8,246 60.8% to 68.7%[86]
Number of projects that make scientific data accessible and re-usable and number of scientific datasets made accessible and re-usable.	65% of the projects covered by the scope of the pilot (2014-2015 figures) participate in the pilot and 34.6% opt-out. Outside the areas covered by the pilot, a further 11.9% of projects participate on a voluntary (opt-in) basis.

Source: Corda, Signed Grants cut-off date by 1/1/2017

[83] European Cloud Initiative - Building a competitive data and knowledge economy in Europe, COM(2016) 178 final
[84] https://www.elixir-europe.org/news/elixir-accelerates-major-horizon-2020-funding
[85] This amount is calculated on FP7 grants as data from Horizon 2020 grants is not yet available
[86] The lower bound is based on OpenAire (22/02/17), while the upper bound is based on Corda.

Even if not translated fully into measurable items, **the advancement of knowledge is one of the major effects of Horizon 2020**. Looking at the typical outputs measured under an R&I programme, **Horizon 2020 projects have already generated 8,246 publications[87]. About half of them (4,043) are peer-reviewed and include articles, reviews and conference proceedings.** While the publication output in the first three years of Horizon 2020 seems lower than the corresponding amount in the first three years of FP7 (13,431 - see Figure below), the apparent decline in number of peer-reviewed publications is an artefact of the lengthy peer-review system and the journal indexing process impacting all bibliometric databases. Also, based on the experience of FP7, the number of publications per year tends to increase significantly after the first three years of the programme and reaches its peak at its end. The current figures are, therefore, a small fraction of the total output to be expected. The remaining publications are mainly publications related to workshops, books or chapters in books, thesis or dissertations or other publications.

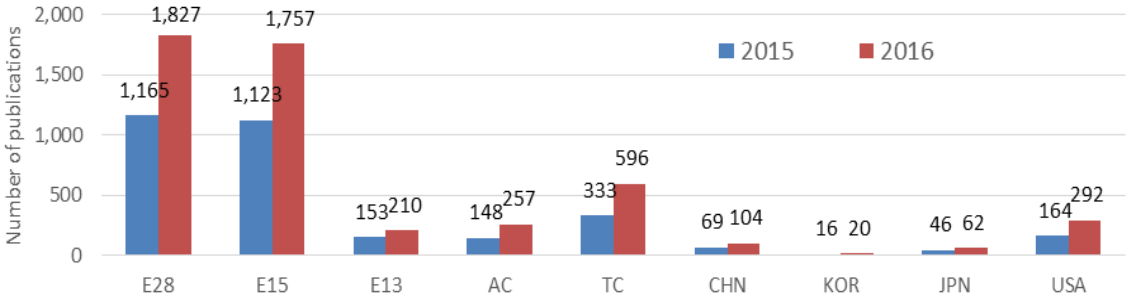
Figure 29 FP7 yearly peer-reviewed publications – all total output 2007-2016



Source: Scopus [study by Elsevier]

An analysis of the number of Horizon 2020 peer-reviewed publications based on Scopus data (2015 and 2016 only) shows an overall increase between 2015 and 2016. Whereas most publications come from the EU-15 geographical group participants from the USA record the highest number of Horizon 2020 publications for the non-EU countries, as also seen in FP7.

Figure 30 Total publication output of Horizon 2020-funded research per geographical group, per year 2015-2016

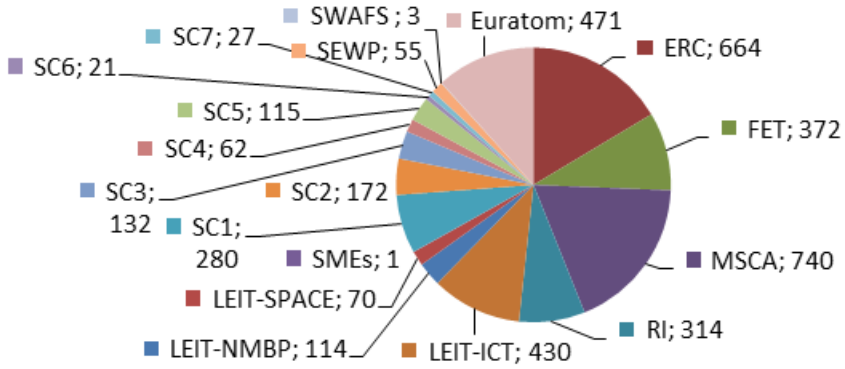


Source: Scopus [study by Elsevier]

[87] Data related to indicators on publications are self-reported by beneficiaries during and at the end of the projects, usually between 12 and 18 months from the projects'start date. There is a time-lag between the start of the project and the delivery of first scientific results. Based on the experience of FP7, the number of publications per year tends to increase significantly after the first three years of the programme and reaches its peak at its end. It is therefore expected that Horizon 2020 publication output will significantly increase in the next years, when a critical mass of projects will have achieved a higher level of maturity. Performing a comparison with FP7 at this stage would thus be premature.

Not surprisingly a slight majority (52%) of the peer-reviewed publications come from the Excellent Science pillar (mostly MSCA followed by ERC and FET)[88]. Also 15% of the peer-reviewed publications in Horizon 2020 derive from more industry-focussed LEIT projects, of which 70% from LEIT-ICT projects. In addition, 20% derive from projects in Societal Challenges, mainly from the Health Societal Challenge (SC1).

Figure 31 Number of peer-reviewed publications from Horizon 2020 projects per programme part



Source: Corda (cut-off date 1 January 2017)

Horizon 2020 aims at opening as much of the data from EC-funded research to the wider scientific community to maximize access and usage and reduce unnecessary replication. While open access to research data is applicable by default in Horizon 2020, the Commission also recognises that there are good reasons to keep some or even all research data generated in a project closed. However the OpenAire database and Corda data indicate that a **significant proportion between 61% and 69% of Horizon 2020 peer-reviewed publications are published in open access**.[89] This figure is confirmed by data collected by the Commission: 65.4% of the projects covered by the Open Data pilot (2014-2015 figures) make scientific data accessible and re-usable. Furthermore, outside the areas covered by the pilot, a further 11.9% of projects participate on a voluntary (opt-in) basis.

Stakeholder position papers: Views on the Open Data initiative diverge.

In their position papers, quite a few stakeholders representing different stakeholder groups commented on the Open Data initiative but their 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 pinpoint that an Open Access to data requires strict conditions to be met such as the waterproof Intellectual Property protection system needs to be put in place, the Open Access should be voluntary and evaluated by the beneficiary on the case-by-case basis - opting out should stay a possibility, a sustainable model should be ensured, involving all relevant stakeholders in the transition and governments should fund the extra costs that comes with keeping data open (for example for the ICT tools).

[88] The figure for FET is incomplete as for instance the two FET Flagships Horizon 2020 projects only started in April 2016 and have not reported publications yet; publications relating to the 2.5 year ramp-up phase funding in FP7 are 782 peer-reviewed scientific publications for Graphene and 272 for the Human Brain Project respectively.
[89] As calculated using OpenAire, 22/02/17.

8.1.1.4.Scientific quality, reputation and scientific breakthroughs

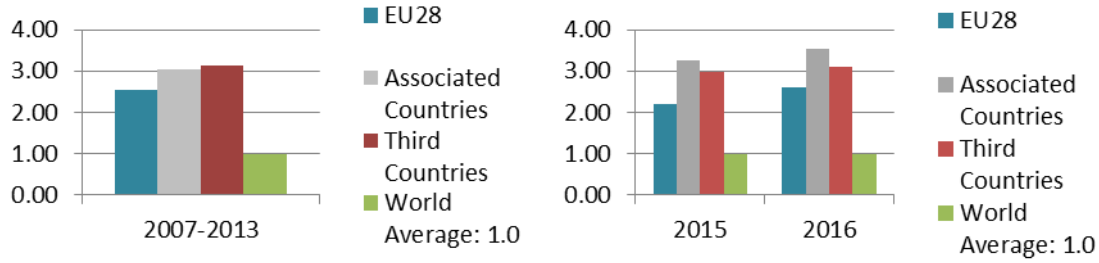
Figure 32 Horizon 2020 key performance indicators related to the progress towards scientific impact

Key Performance Indicators (KPIs)	Progress so far / Target
Scientific quality, reputation and scientific breakthroughs	
ERC – Percentage of publications from ERC funded projects which are among the top 1 % highly cited	7.0%[90] Target: 1.8

Source: Corda, Signed Grants cut-off date by 1/1/2017

Looking at the quality and influence of the outputs produced so far, there are already indications of the high quality and reputation of the activities performed. Looking at a proxy indicator on the quality of the publications produced, the preliminary assessment of the the Field-Weighted Citation Impact (FWCI)[91] of the 4,043 Horizon 2020 peer-reviewed publications confirms the trends observed in the period 2007-2013 for FP7: **publications from FP7 and Horizon 2020 projects are cited more than twice the world average (FWCI of 2.46).** For 2015 and 2016, the EU-28 group Horizon 2020-funded output was 3.74 times more represented in the world's top 1% of cited research than the EU-28's overall publication output. **For EU-15 and EU-13, Horizon 2020-funded output was proportionally higher in the top 1% category by factors of 3.65 and 5.57 respectively. The EU-13 group enjoyed the highest relative increase, between 2015 and 2016, over their own overall FWCI, with 1.84 and 2.29 ratio increases, respectively**.

Figure 33 Field Weighted Citation Impact for FP7 publications (left side) and for Horizon 2020 (right side)



Source: Scopus (Elsevier study, forthcoming)

While 664 peer-reviewed publications can be attributed to ERC under Horizon 2020 projects, 7% of ERC publications (973, since its creation in 2007) are among the top 1% highly cited in the world by field, year of publication and type of publication compared with 1.7% of publications with an EU author. In 2014, 20% of the Nature and Science papers that have authors based in the EU and the Associated Countries were ERC funded publications. ERC funding has gone from contributing less than 0.1% of EU top 1% publications in 2007 (2) to nearly 7% in 2014.

Whereas it is too early to identify major scientific breakthroughs for most of the Horizon 2020 projects, there is already early indication of potential breakthroughs. Qualitative analysis of ERC funded work since its creation in 2007 confirms the breakthrough nature

[90] Preliminary estimate based on ERC publications from FP7 projects.
[91] Field-weighted Citation Impact normalises citation differences between research fields, with a world average set to 1.0

of the work performed[92]. **The ERC, MSCA and FET, together with collaborative research themes, have supported at least 17 Nobel Prize winners prior or after the award of their prize and four ERC grantees have been awarded the Fields Medal after being funded by the ERC.** As an illustration, the 2016 Nobel Prize in Chemistry - Prof. Ben Feringa – was awarded support from FP7 (ERC Advanced Grant, Marie-Curie Action, Mobility programme and NMP programme) and Horizon 2020 (ERC advanced Grant) prior to the award of his Nobel Prize in Chemistry in 2016 (see Figure 34). As of December 2016, based on an ERC review, ERC grantees had been the recipients of 526 major prizes, awards and other forms of recognition.

The ERC is the single most successful European research funding instrument ever, raising our reputation and attracting talent to us due its strong recognition of bottom-up excellent science!
CESAER, Belgium

Horizon 2020 beneficiaries have also contributed to major scientific discoveries including the Higgs Boson at CERN[93], the detection of gravitational waves[94] and the discovery of a planetary system composed of seven Earth-like worlds (exoplanets) located relatively close to Earth in 2017[95]. FET-funded projects can also be expected to play a significant role in creating new knowledge and helping to develop high-risk innovative projects that can give the EU a competitive edge and to generate major breakthroughs in ICT.

Figure 34 Major recognition prizes (Nobel Prizes, Fields Medals, Wolf Prizes, Lasker Award, Millennium Technology Prize, Crafoord Prize, Abel Prize) received by beneficiaries of past EU Research Framework Programmes and Horizon 2020

Name of awardee	Award, year of award	Support granted before Horizon 2020	Support under Horizon 2020
Leif Andersson	Wolf Prize in Agriculture, 2014	FP7 (ERC AdG2011)	
Alain Aspect	Wolf Prize in Physics, 2010	FP7 (ERC AdG2010)	
Artur Avila	Fields Medal, 2010	FP7 (ERC StG2010)	
David C. Baulcombe	Lasker Award for Basic Medical Research, 2008,Wolf Prize in Agriculture, 2010	FP7 (ERC AdG2008)	
Thomas Ebbesen	Kavli Prize (Nanoscience), 2014	FP7 (ERC AdG2008)	
François Englert & Peter W. Higgs	Nobel Prize (Physics), 2012	FP7 (Marie-Curie Actions)	
Bernard L. Feringa	Nobel Prize (Chemistry), 2016	FP6 (Mobility); FP7 (Marie-Curie Actions, ERC AdG2008, NMP)	ERC AdG2015
Albert Fert & Peter Grünberg	Nobel Prize (Physics), 2007	FP3	FET
Andre Geim & Konstantin Novoselov	Nobel Prize (Physics), 2010	FP7 (ERC StG2007 for K. Novoselov)	FET
Michael Grätzel	Millennium Technology Prize, 2010	FP7 (ERC AdG2009)	
Martin Hairer	Fields Medal, 2014	FP7 (ERC CoG2013)	

[92] Based on a qualitative evaluation of 199 completed ERC-funded projects from the first two calls 71% of projects were considered to have made a scientific breakthrough or major scientific advance. A different peer review evaluation of a sample of top 1% most highly cited ERC-funded papers considered 21% of the 56 papers reviewed to have made a landmark contribution to their field, including the identification of new entities or phenomena, methodological advances in the study of a topic and the elaboration of theoretical principles.

[93] See https://ec.europa.eu/research/mariecurieactions/news/eu-marie-curie-actions-fellowships-news-18-07-2012-higgs-boson_ga

[94] See https://ec.europa.eu/research/mariecurieactions/news/20160615-eu-research-gravitational-waves_en

[95] See https://erc.europa.eu/sites/default/files/press_release/files/SPECULOOS_Highlight.pdf

Name of awardee	Award, year of award	Support granted before Horizon 2020	Support under Horizon 2020
Theodor Hänsch	Nobel Prize (Physics), 2005	FP5	FET
Ilkka Hanski	Crafoord Prize in Biosciences, 2011	FP7 (ERC AdG2008)	
Serge Haroche	Nobel Prize (Physics), 2012	FP6 ; FP7 (ERC AdG2009)	FET
Stefan Hell	Nobel Prize (Chemistry), 2014	FP4 (Marie-Curie Actions) ; FP7 (Health)	
Lars Klareskog	Crafoord Prize in Polyartheritis, 2013	FP7 (ERC AdG2009, ERC PoC2011)	
Elon Lindenstrauss	Fields Medal, 2010	FP7 (ERC AdG2010)	
Harmut Michel	Nobel Prize (Chemistry), 1988	FP7 (Health)	
Edvard I. Moser & May-Britt Moser	Nobel Prize (Physiology or Medicine), 2014	Edvard I. Moser: FP5 (NMP) ; FP7 (ERC AdG 2008 & 2013, Marie-Curie Actions, Health) May-Britt Moser: FP5 (NMP) ; FP7 (Marie-Curie Actions, ERC AdG2010, Health)	FET
Christiane Nusslein-Volhard	Nobel Prize (Physiology or Medicine), 1995	FP7 (Health)	
Stuart Parkin	Millennium Technology Prize, 2014		ERC AdG2014
James E. Rothman	Nobel Prize (Physiology), 2013	FP7 (Marie-Curie Actions)	
Jean-Pierre Sauvage	Nobel Prize (Chemistry), 2016	FP6 (Marie-Curie Actions, IST, Mobility, NMP)	MSCA, FET
Stanislav Smirnov	Fields Medal, 2010	FP7 (ERC AdG2008)	
J. Fraser Stoddart	Nobel Prize (Chemistry), 2016	FP4 (TMR) ; FP7 (NMP)	NMBP, MSCA
Endre Szemeredi	Abel Prize, 2012	FP7 (ERC AdG2012)	
Kajita Takaaki	Nobel Prize (Physics), 2015	FP7 (Marie-Curie Actions)	MSCA RISE
Jean Tirole	Nobel Prize (Economic Sciences), 2014	FP7 (ERC AdG2009, MSCA)	
John E. Walker	Nobel Prize (Chemistry), 1997	FP7 (Health)	
Torsten N. Wiesel	Nobel Prize (Medicine), 1981		FET
Anton Zeilinger	Wolf Prize in Physics, 2010	FP7 (ERC AdG2008)	
Peter Zoller	Wolf Prize in Physics, 2013	FP7 (ERC SyG2012)	

Source: European Commission

Example box: Result of ERC project amongst top ten physics discoveries of the last decade

ERC grantee Leo Kouwenhoven recently proved the existence of the "Majorana fermion", a particle theorised in the 1930s. Detecting Majorana's particles is not only exciting for particle physicists; thanks to their properties they could prove useful as stable "quantum bits" of information that could make quantum computers a reality. In October 2015, the result of Prof. Kouwenhoven's team was listed among the top 10 physics discoveries of the last 10 years by *Nature Physics*. The properties of the Majorana fermions could bring us one step closer to the much-talked-about high-speed quantum computers. In theory, the nature of the particles that can simultaneously be their own opposite could become a building block for quantum information processing and transmission.

Leo Kouwenhoven received an ERC Synergy Grant in 2012 together with Lieven Vandersypen and Carlo Beenakker to further work on bridging the gap between science and engineering in the field of quantum computing[96].

Microsoft has recently hired four leaders in the field of quantum computing, including Leo Kouwenhoven, who will now build a Microsoft lab on the Delft campus[97].

[96] http://www.tnw.tudelft.nl/fileadmin/Faculteit/TNW/Actueel/Nieuws/Archief_2013/07_juli_2013/Mourik_Zuo_copy_ENG.pdf

Example box: Results of the Graphene FET Flagship

The Graphene Flagship, which was launched in 2013 and will span over 10 years, is one of Europe's biggest ever funded research initiatives. It consists of an academic-industrial consortium of more than 150 partners in over 20 European countries. It covers the entire value chain, from materials production to components and system integration, and aims at developing applications in areas such as flexible electronics, printed electronics, 5G mobile technologies, batteries, aerospace, medical applications, filtration and automotive.

A recent remarkable breakthrough of the Flagship is the first fully functional microprocessor made from graphene-like materials that is a first step toward ultra-thin, flexible devices and holds promise for integrating computational power into everyday objects and surfaces. Another breakthrough is the development of graphene-based neural probes to examine brain activity in high resolution, which can help to better understand diseases such as epilepsy and disorders that affect brain function and motor control, as well as to improve neuroprosthetics by enabling control of artificial limbs. Additional promising results include highly efficient solar cells and ultrahigh sensitivity graphene infrared detectors (key for security screening).

In line with the progress registered to date on this front, **75% of the stakeholder consultation respondents think that Horizon 2020 is fully or to a large extent helping to foster excellent science,** whereas 2.9% think this is not the case at all. Looking at the breakdown by categories of respondent, research organisations and academia are above the average in favour of the statement, while even business recognises "to a large extent" that Horizon 2020 is helping to foster excellent science. The least positive are NGOs.

Stakeholder position papers: Excellence should remain the main driver of Horizon 2020 and subsequent programmes.

In their position papers, some stakeholders representing different stakeholder groups underlined that excellence should remain the highest priority and the driving principle of the Horizon 2020.

8.1.1.5.Reinforcement of R&I capacities of widening countries

Horizon 2020 aims to fully exploit the potential of Europe's talent pool and to ensure that the benefits of an innovation-led economy are both maximised and widely distributed across the Union in accordance with the principle of excellence.

The EU funding from Horizon 2020 to EU-13 countries remains at a low level even if slowly increasing (4.2% in FP7, 4.4% in Horizon 2020). All programme parts have to contribute to spreading excellence and widening participation as a cross-cutting issue. In addition Teaming, Twinning and ERA Chairs are the key measures falling under the dedicated programme part on Spreading excellence and widening participation (SEWP). Based on the information collected, by extrapolation, **it is expected that the SEWP projects will achieve their targets and contribute to the SEWP objectives**[98]. The main expected outputs from these projects are related to the **strengthened institutional, scientific and networking capacities of centres of excellence and knowledge and research institutions located in low performing regions and Member States** - on the basis of partnerships with internationally leading institutions and researchers -, **improved R&I policy frameworks and support provided to strategic planning and implementation**.

[97] http://www.nature.com/news/quantum-computers-ready-to-leap-out-of-the-lab-in-2017-1.21239

[98] The current ongoing projects (Teaming phase 1, Twinning and ERA Chairs) represent only 14% of the total available budget for the SEWP. The Teaming phase 2 projects, which have been approved but do not appear yet in the financial reporting because the grant agreements have not been signed yet, will allocate additional 17% of the SEWP budget (10 phase 2 projects of maximum EUR 15 million each) which is a significant investment for the selected institutions and countries.

Box: SUPREME, a twinning project for Polish energy infrastructure[99]

EU Contribution: EUR 1 million ; Start date: 01/11/2015

The transition from fossil fuels to renewable and sustainable energy sources has become the EU's top developmental priority, with low-performing countries in Central Europe facing the most urgent need. Poland's continuing economic progress has not come without significant costs; due to its history in electricity production, in 2009 it had the highest rate of production by coal of any EU Member State. This made Poland Europe's third largest polluter in terms of damage to society, home to six of Europe's 30 most damaging power-plants, and among Europe's worst for public exposure to harmful pollution. At the same time it was experiencing rises in domestic electricity demand twice the EU average. While Polish research now has expertise in many of the technologies needed for energy transition, it lacked critical knowledge in modelling, planning, integrating, and managing large scale renewable energy systems in a flexible and effective manner. The project twins one of Poland's best energy research centres, the Instytut Maszyn Przeplywowych Im Roberta Szewalskiego PAN with expertise in Denmark, the Netherlands, and Austria. Focusing on needed knowledge transfer in integrating energy technologies, the project's mix of extended staff exchanges, joint work, Summer Schools, and other events is expected to create a long-lasting and effective partnership with a strong impact on Poland's energy systems infrastructure.

With regards to Teaming phase 1, Twinning and ERA Chairs, 112 projects contribute to the SEWP's objectives in the 19 Widening countries. Out of a total of EUR 254 million allocated, 73% went so far to partners from low R&I performing countries. The number of projects currently under implementation varies among countries with Portugal, Estonia, Poland and Cyprus being most successful in terms of participation. **The Teaming action has attracted a lot of attention at political level, with submitted proposals either coordinated or supported financially by national or regional authorities**.[100] Equally, countries took the initiative to link the actions with their Operational Programmes in the European Structural and Investment Funds (ESIF) (e.g. Poland, Czech Republic). **The objective of strengthening framework conditions for R&I is pursued primarily by the Policy Support Facility**[101] **providing on-demand advice to policy makers on national R&I systems**.[102] Bulgaria, Czech Republic, Hungary, Latvia, Slovakia and Slovenia are currently combining widening actions with the PSF and will also benefit from investments for Teaming 2.

Together with Teaming, Twinning and ERA Chairs, COST[103] (promoting networking and connecting pockets of excellence) also plays a role in improving the international positioning of the R&I stakeholders in each country: there are currently 3234 ongoing participations in projects in Widening countries within the COST programme.

Box: Spreading excellence in Europe - Examples across Horizon 2020

In **Research Infrastructures**, a Memorandum of Understanding was signed in October 2016 between the CERIC-ERIC and SHARE-ERIC networks of research infrastructures to boost regional cooperation and collaboration in different fields (active ageing, transport and connectivity, education, research and innovation) and support scientists from low R&I performing countries to access research infrastructures.

The **European Institute of Innovation and Technology (EIT)** widened the geographical coverage of its Knowledge and Innovation Communities (KICs) by mainstreaming the EIT Regional Innovation Scheme (RIS) actions into KICs activities and earmarking a dedicated budget for 2016 activities. The RIS initiative is targeted

[99] http://cordis.europa.eu/project/rcn/200260_en.html

[100] In several countries (e.g. Poland), national competitions were held by relevant Ministries in order to identify the best proposals for facing the competition at the European level – a first in the history of Framework Programmes.

[101] Available at: https://rio.jrc.ec.europa.eu/en

[102] It has so far provided/is providing support to eleven countries. Bulgaria, Czech Republic, Hungary, Latvia, Slovakia and Slovenia belong to the group of countries which currently combine the Widening actions with PSF and will also benefit of significant investments for Teaming 2.

[103] Available at: http://www.cost.eu/

at countries which have no participating organisations into the existing KICs and belong to the 'moderate and modest innovators' groups identified in the 2015 Innovation Union Scoreboard.

In the **Bioeconomy/biotechnology** field a Letter of Intent was signed[104] in 2016 between the Bio-based Industries Joint Undertaking (BBI JU), its private member, Bio-based Industries Consortium (BIC), and 8 Polish regions for cooperation and awareness raising in the regions. The Lodz Bioregions Declaration[105] aims to establish a Central and Eastern European Bioregions Forum for the development of bioeconomy at local and regional levels, and to help establish synergies in the implementation of ESIF, including research, education and training, transfer of knowledge and other activities.

The **European Research Council (ERC)** also takes measures to enhance the awareness of the ERC grants schemes in countries which have been relatively unsuccessful in hosting ERC Principal Investigators, following a Working Group on Widening European Participation set up in 2013. The ERC also published guidelines for public authorities and other organisations that wish to set up fellowship programmes to fund short-term visits of potential ERC applicants to current ERC grantees' teams. Five countries - Czech Republic, Estonia, Hungary, Poland and Slovenia - as well as the Belgian region of Flanders, have set up such fellowship programmes so far.

64.7% of the stakeholder consultation respondents agreed fully or to a large extent that Horizon 2020 helps spread excellence and widen participation. The share is similar for EU-15 and EU-13 respondents, but respondents from third countries (72.3%) and associated countries (67%) are more positive. The most positive types of stakeholders are SMEs and individuals whereas the least positive are NGO.

Stakeholder position papers: Widening participation is crucial, but should not come at expense of excellence.

In their position papers, some stakeholders representing different stakeholder groups commented on a need for a more balanced participation of different stakeholders within 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 due to their lower research and innovation capacities. However, there seems to be an agreement that this issue should not be addresses by changing the nature of the current research funding which is based on excellence. Some other solutions were proposed such as: greater use of the 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 twining and teaming mechanisms, introduction of a milestone prize mechanisms, extension of the ERA Chairs to early stage researchers; and introduction of bottom-up networking instrument for experienced researchers across Europe.

8.1.2. Progress on improving R&I integration

One key objective of Horizon 2020 is to support the integration of R&I efforts across Europe by building trans-national and cross-sectoral bridges. Early evidence indicates that the programme is making progress on these fronts.

8.1.2.1.Collaboration between businesses and academia

The intersectoral collaboration patterns within projects is analysed under Efficiency (7.4.5). Looking at the types of outputs generated so far, **across the whole programme more than one publication out of 5 (21.5%) is so far based on the cooperation between academic and private organisations**. Going beyond traditional research and innovation projects, MSCA feature non-academic sector partners playing a strong role in joint researcher training projects and 25% of its publications are public-private co-publications. Also based on their thematic assessment FET projects – involving also high tech research intensive SMEs - have the potential to improve R&I integration and help achieve the EU's goal of becoming the

[104] European Bioeconomy conference, Lodz/Poland, 6-7/10/2016
[105] Available at: http://bioeconomy.lodzkie.pl/wp-content/uploads/dekl_en.pdf

world's leading research area and market for digital technologies by spreading new ideas, methods, approaches or technologies into the industrial R&D community. Thanks to their long duration, FET Flagships specifically enable the participating research groups to build up expertise and create durable links between academia and industry[106]. Also, while the involvement of industry (including SMEs) in the Research Infrastructures activities and projects is still limited, a number of targeted measures were launched to increase their interaction with industry in particular as regard the supply of high tech components.

8.1.2.2. Integrating the knowledge triangle of higher education, science, and innovation through the European Institute of Innovation and Technology

As part of Horizon 2020, the European Institute of Innovation and Technology (EIT)'s specific objective is to integrate the knowledge triangle of higher education, research and innovation and thus to reinforce the Union's innovation capacity and address societal challenges. The EIT is designed to achieve its goals primarily through the Knowledge and Innovation Communities (KICs) [107], which bring together higher education institutions, research organisations, industry and other stakeholders to create critical mass needed to stimulate innovation and operate in specific societal challenges. In the period covered by the Horizon 2020 interim evaluation, KICs operated in the fields of climate change, health, energy, raw materials and the digital economy and society.

The independent external evaluation of the EIT[108] has found that, even though the EIT has contributed to progress in addressing specific structural weaknesses in the EU's innovation capacity, there is a strong need to pursue the EIT's mission to integrate the knowledge triangle of higher education, research and innovation including industry.

The performance audit issued in April 2016 by the European Court of Auditors[109] contained a set of recommendations which are in an advanced stage of implementation. Further recommendations have been given through the report of the High-Level Group appointed by Commissioner Navracsics.[110] In particular, an amended EIT legal basis, revising the EIT's funding model, is expected to be tabled to the European Parliament and Council at the beginning of the second quarter 2018.

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[106] For example, in the GRAPHENE Flagship, this is key for advancing technology through different Technology Readiness Levels and for completing value chains needed to achieving tangible societal and industrial impact.

[107] The KICs are independent legal entities, structured around a partnership of core partners representing all sides of the "knowledge triangle". Each KIC has to develop and deliver a portfolio of activities in three areas: (i) Research/ Innovation projects: the KICs link universities, research institutes and business through their innovation project portfolios. Innovation projects comprise demonstrators, pilots, proofs of concept etc. All innovation projects are required to develop clearly identified products that address a specific business opportunity that is supported by a market study; (ii) education: a set of post-graduate (MSc/ PhD) programmes and executive/ professional development courses characterised by a multidisciplinary approach, significant business involvement in the development of learning outcomes and often, cross-border mobility; (iii) business creation and support activities: a range of business support services, often badged as a start-up accelerator scheme, to help entrepreneurs translate their ideas into successful businesses. These services focus on areas such as support for technology, market assessment, access to human resources and seed and venture capital through specific KIC innovation funds

[108] The independent external evaluation of the EIT is a mandatory requirement from the Regulation (EC) No 294/2008 as amended by the Regulation (EU) No 1292/2013 establishing the EIT (EIT Regulation).

[109] European Court of Auditors, Special Report 04/2016, http://www.eca.europa.eu/Lists/ECADocuments/SR16_04/SR_EIT_EN.pdf

[110] European Commission, The Future of the European Institute of Innovation and Technology (EIT) – Strategic issues and perspectives, https://ec.europa.eu/education/sites/education/files/eit-hlg-final-report_en.pdf

Most of the objectives/actions defined in the 2013-2015 EIT business plans have been accomplished, which is demonstrated by fact that **the EIT has achieved most its targets set for the KPIs and other indicators**, as shown by the figures below.

Figure 35 Key Performance indicators for the EIT

Indicator 1: Organisations from universities, business and research integrated in the Knowledge and Innovation Communities (KICs)		**2014**	**2015**	**2016**
	Target	240	450	500
	Actual results	550	800	1052*
Indicator 2: Collaboration inside the knowledge triangle leading to the development of innovative products, services and processes		**2014**	**2015**	**2016**
# Start-ups and spin-offs set-up	Target	30	280	400
	Actual results	181	250	381*
# Innovations	Target	300	800	1500
	Actual results	1184	2145	3565*

** Expected results, based on the indications in the KICs´ business plans. Source: EIT*

Figure 36 Innovation KPI performance of the KICs (2013-2015) [111]

Indicators	**2013-2015 Actual**	**2013-2015 Target**
Number of eligible applicants for EIT labelled PhD and Master programmes	12,783	11,577
Number of available seats for EIT labelled PhD and Master programmes	3,168	1,864
Number of new graduates	776	842
Number of business ideas incubated	1,249	1,076
Number of start-ups/spin-offs created	216	310
Number of knowledge adoptions (by KIC partners) that are direct output of a KIC Activity	429	326
Number of knowledge transfers (from one KIC partner to another KIC partner or to third parties) that are direct output of a KIC Activity	308	260
New or improved products/services/processes launched	212	290

Source: EIT

The number of start-ups and spin-offs set-up by the KICs is slightly below the target, even though KICs keep on generating new ventures at a faster pace. Business ideas are screened by the KICs, only the most promising ones are then passed to the following support stages (and encouraged to be transformed into new ventures); this aspect might partially explain the gap between target and actual results. Furthermore, some ideas might need a longer incubation period before being translated into a marketable proposal. Figures related to support to innovation show that those activities are producing outcomes beyond the initial expectations, as evidenced by the adoption and the transfer of knowledge within the KICs and towards external partners. The only indicator that falls behind is the one related to new products/services/processes launched; 73% of the target has been achieved. According to the survey of KIC partners, 70% of KICs´ partners believe that the KICs have been 'effective' or

[111] The figures concern the outputs and results of the three first wave KICs (which comprises EIT Digital, EIT Climate and KIC InnoEnergy), over the period 2013-2015. Note that the each KIC has also a set of KIC-specific KPIs that – as the core KPIs – are annually tracked, reported and audited.

'very effective' in supporting knowledge transfer between businesses and universities/ research organisations.

In the EIT stakeholder consultation, almost **90% of respondents said that Europe's innovation capacity depended on bringing together education, research, business and other innovation actors (knowledge triangle integration).** Furthermore, over 80% of stakeholders think that EIT's focus on specific societal challenges in the Horizon 2020 context is important. Overall, stakeholders have recognised the EIT's progress in bringing together education, research and business organisations to create pan-European networks in specific fields.[112]

8.1.2.3.Trans-national cooperation

Most of the EU-funded projects are collaborative projects with at least three organisations from different EU Member States or Associated countries, which is reflected in the trans-national co-publication patterns. Based on an analysis of co-publications **whereas scientific networks are widening within the EU-28 to include more smaller countries compared to FP7 the breath of the networks at international level is decreasing, which is a cause for concern given the higher impact of internationally co-authored publications.**

At the EU-28 level, based on an analysis of publications, the most frequent co-publications occur between the larger and more R&D intensive countries. The smaller research nations do collaborate often with each other and with at least one of the R&D intensive nations. The most represented countries in Horizon 2020 publications are Germany, the Netherlands, the UK, France, Italy and Spain. Whereas Germany, the Netherlands and the UK continue to co-publish largely between themselves as observed in FP7, Belgium and France also joined this trend under Horizon 2020. Spain and Italy remain part of their own group but are now co-publishing more with smaller Member States, including Cyprus, Romania, Croatia and Greece. While the Nordics and Ireland formed their own group under FP7, they now collaborate more with the eastern European countries. Further analysis of cooperation networks is provided under Section 10 on the EU added value of Horizon 2020.

Supporting the 'Open' character of the programme, **Horizon 2020 publications including authors from associated and third countries score up to more than three times as much as much as the world average**[113]. The most frequent co-publications occur between the EU28 group, the USA, Japan, Canada, China, Russia and Switzerland, just as in FP7. In addition, in FP7 many countries collaborated in publications with only one other EU28 Member State, and this has so far also been the case for Horizon 2020. However, under FP7 many non-EU countries also had extensive links with other non-EU countries, whereas under Horizon 2020 this link is currently only observed with the USA[114].

Box: Trans-national circulation of knowledge – Example from ERC and FET

ERC: The share of ERC publications with international co-authorship is 56% and 34% of all ERC reported publications have at least one author affiliated to an institution based in a non-ERA country. For the ERC top 1% highly-cited publications this rate is 46%. The collaboration with third countries is most intense

[112]http://ec.europa.eu/dgs/education_culture/more_info/consultations/european-institute-innovation-technology_en.htm
[113] Study on overall output of select geographical group comparators and related FP7- and Horizon 2020-funded publication output, Elsevier, 2017.
[114] For more information see section on EU Added Value

with US-based authors: 22% of all ERC reported publications have at least one US-based author or 64% of ERC reported publications written in a non-ERA collaboration (75% if only top 1% papers are considered). Another indication that ERC is viewed positively on the global stage is that since 2012 a series of "Implementing Arrangements" have been negotiated with peer funding organisations around the world providing opportunities for early-career scientists supported by non-European funding agencies to temporarily join a research team run by an ERC grantee in Europe. Also, the proportion of ERC grantees with non-ERA nationality in Horizon 2020 is about 9.1% (compared to 7.1% in FP7). However many of these were already based in Europe at the time of application. On the other hand, around 23% of the PhDs and post-docs in ERC teams were from outside Europe, the largest number being from China, the USA and India. This shows the potential of ERC PIs to attract talented early-stage researchers to Europe from around the world.

FET: The GRAPHENE Flagship has already held several international collaboration workshops with the USA, Japan and Korea, and has now put in place mobility funding grants for young researchers, in close collaboration with the US-National Science Foundation.

8.1.2.4.Interdisciplinarity

Interdisciplinarity is promoted throughout Horizon 2020 in order to develop solutions going beyond the scope of a single discipline or area of research practice. According to a study run by Elsevier[115], **the share of Horizon 2020 publications which are inter-disciplinary is relatively high and slightly increasing as compared to FP7.** For the EU-28, out of their total number of Horizon 2020 publications, 7.55% is inter-disciplinary (compared to 7.45% in the first three years of FP7). For EU-15, their share is 7.29% (compared to 7.53% in the first 3 years of FP7). For EU-13, their share is 10.19% (compared to 5.87% in the first 3 years of FP7). This means that **the EU-13 produces more inter-disciplinary publications when compared to the EU-15** and that the share of inter-disciplinary publications of the EU-13 countries in Horizon 2020 has doubled compared to their inter-disciplinary publications in FP7.

The Future and Emerging Technologies programme has so far 1,278 participations of researchers in world-class research teams pursuing grand interdisciplinary scientific and technological challenges. The range of topics addressed is very broad, e.g. Artificial Intelligence for creativity, robots inspired by living creatures; artificial limbs that can feel as well as move; understanding financial crises and global epidemics; unbreakable cryptography, artificial photosynthesis, quantum technologies, the human brain, new materials like graphene, nanotechnologies, and next-generation computing.

Box: Interdisciplinarity in Future and Emerging Technologies (FET)

[115] Elsevier, Study on overall output of select geographical group comparators and related FP7- and Horizon 2020-funded publication output, forthcoming

Interdisciplinarity is the hallmark of FET, with projects involving fields as diverse as ICT, engineering, biology, medicine, mathematics, material science, neuroscience, energy, music, economics, finance, climate science and many more. FET calls for genuine exchanges and mutual learning among distant disciplines, sometimes even creating new fields of enquiry at their intersection (e.g., neuro-IT). As an illustration, to achieve their objectives and technology development targets, each of the two FET Flagships seeks to foster synergies and establish collaboration across 100+ partnering organisations. The Flagships Panel recognises that, by bringing together researchers from different scientific disciplines and technology fields, the Flagships started creating an unprecedented level of collaboration and community building in Europe. For example, in 2016, HBP released its six ICT Platforms, which are the core of the emerging HBP research infrastructure for brain research. This was the result of an extensive multidisciplinary effort involving more than 750 scientific collaborators and engineers from 114 institutions in 24 European countries.

When looking only at the interdisciplinary Horizon 2020-funded research, the Field Weighted Citation Index (FWCI) for the period so far indicates that these **Horizon 2020 interdisciplinary publications are cited 78% more than the world average in this field** (FWCI of 1.78) and this is rising on a per year basis. As already highlighted in section 8.1.1.4, the FWCI of all Horizon 2020 publications so far, compared to the world average, is 2.46, which indicates that Horizon 2020 interdisciplinary publications have so far a relatively lower scientific impact than Horizon 2020 field-specific publications.

8.1.3. Contribution of Horizon 2020 to the achievement and functioning of the European Research Area

Horizon 2020 shall support the achievement and functioning of the European Research Area (ERA).[116]

According to the Treaty, it is the European Union's objective to strengthen its scientific and technological bases by achieving a European Research Area ('ERA') in which researchers, scientific knowledge and technology circulate freely, and by encouraging the Union to advance towards a knowledge society and to become a more competitive and sustainable economy in respect of its industry. **The Horizon 2020 funding measures are crucial to accompany the realisation of ERA, notably through their effect on coordination, common agenda setting and pooling of resources, and to continue shaping the landscape of European research institutions.** But, on its own, Horizon 2020 cannot change the structure of national research policies and systems nor remove the legal and practical obstacles for achieving the ERA.

As discussed earlier and summarised in the Table below Horizon 2020 supports the ERA policy priorities (e.g. researcher mobility and careers, research infrastructures, knowledge transfer, etc.), the monitoring of progress and foster stronger partnerships with Member States and the private sector to invest more efficiently. It leads by example in gender, ethical issues and Open Access to research results and encourages the development of framework conditions to help European researchers to remain in or to return to Europe, and make Europe a more attractive destination for the best researchers. A number of related actions that started with FP7, like ERAnets and the pilot ERA Chairs initiative are pursued in Horizon 2020. New initiatives,

> *"Horizon 2020 contributes considerably to establishing the European Research Area based on excellence. Mobility and bottom-up grants are vital instruments in this regard. Expected impact in SC6 often calls for unified solutions (one best practice to be implemented in all European nations). If H2020 made more room for diversified approaches, considering different geographical levels, instead of looking for only one possible European approach, the total European added value might increase further."*
>
> Denmark, Copenhagen Business School

[116] Article 5 of the Horizon 2020 Regulation.

like the "Teaming Competition for Excellence" and a more focused strategy of international cooperation are introduced in Horizon 2020 to better serve the objectives of ERA to promote scientific and technological excellence of the EU. **Horizon 2020 provides support to Member States and the main stakeholders in implementing the ERA reform agenda** across six key priorities, progress of which is summarised in the Table below.

75% of the stakeholder consultation respondents think that Horizon 2020 is fully or to a large extent 'helping to support the development of the ERA, a unified area open to the world, in which scientific knowledge, technology and researchers circulate freely'. Only 2.2% do not share this view at all. The least positive are umbrella organisations representing businesses and NGOs.

Figure 37 State of play on ERA priorities

ERA priority	Horizon 2020 support	State of play[117]
More effective national research systems	New 'Policy Support Facility' tool[118]	Most countries have made progress in the field of research excellence (average increase 6.4% over the period 2010-2013 and almost all of them have adopted national strategies for research and innovation). Several Member States are redefining their National R&I strategies further based on a broad concept of innovation, encompassing education, research and innovation to achieve greater efficiencies
Optimal transnational co-operation and competition on common research agendas, grand challenges and infrastructures	Public-Public Partnerships, European Strategy Forum for Research Infrastructures	The Framework Programmes since FP6 provide support to P2Ps, rising from EUR 380 million in FP6 (2.1% of the budget) and mobilising around EUR 1.25 million national funding to about EUR 2.5 million in Horizon 2020, representing 3.1% of its budget and expected to mobilise EUR 6 to 8 million national funding for transnational R&I projects. Participating countries consider the P2Ps as a cornerstone of the programme and key to the achieving of the ERA: ten Joint Programming Initiatives have been launched to date and all have adopted Multiannual Implementation Plans. In addition, in 2014-2016, some 48 ERA-NET Cofund actions were selected for funding. The European Commission has been working with the European Strategy Forum on Research Infrastructures (ESFRI) and the major result of this work is the ESFRI Roadmap. First published in 2006 and after its updates in 2008, 2010 and 2016, the ESFRI Roadmap identifies vital needs for new European Research Infrastructures for the next ten to twenty years. It is doing so in various scientific macro-domains, ranging from health and environment to social and cultural domains. The ESFRI Roadmap consists currently of 21 ESFRI Projects that are well advanced from a maturity point of view and 29 projects that have reached already their implementation phase, so-called ESFRI Landmarks. 13 pan-European facilities are based already on the new EU Regulation - the European Research Infrastructure Consortium, ERIC - which entered into force in 2009 and at least four more ERICs are expected to be launched in 2017. Horizon 2020 funding aims at sup-

[117] European Commission, 3rd ERA Progress Report: The European Research Area: time for implementation and monitoring Progress, 2016

[118] The Policy Support Facility provides topic-specific (mutual learning exercises) or country-specific (peer reviews of national R&I systems, or specific support to a policy reform) support at the request of Member States. Two Member States and one associated country have already been reviewed, while many other requests are arising. Recurrent feedback received on the PSF work has shown that the operational recommendations formulated by leading experts and policy practitioners prove valuable as catalysers and to support countries in implementing national R&I reforms. For example, the renewed Science Agenda of Bulgaria pays particular attention to the recommendations formulated by the dedicated PSF Peer Review.

ERA priority	Horizon 2020 support	State of play[117]
		porting the different phases of the research infrastructure life cycle from the preparation, implementation and long-term sustainability to the efficient operation and transnational access and use of research infrastructures. Preliminary results indicate that the number of national research infrastructures (networked thanks to Horizon 2020 support) was 363 by the end of 2015. The target by the end of Horizon 2020 is 900.
An open labour market for researchers facilitating mobility, supporting training and ensuring attractive careers	Euraxess, Marie Skłodowska-Curie actions and Resaver pan-European pension scheme	The number of research positions advertised on EURAXESS Jobs (as at November 2016) comprised 278,518 job vacancies and 64,777 fellowships .The number of Euraxess posts has increased by 7.8% a year on the period 2012-2014.
Gender equality and mainstreaming in research Encouraging gender diversity to foster science excellence and relevance	Gender integration across Horizon 2020, Science with and for Society funding scheme	Horizon 2020 integrates gender as a cross-cutting issue and funds institutional change in research organisations through the 'Science with and for society' funding scheme under Horizon 2020. The number of women grade A professors has increased on average by 3.4% over the period 2007-2014.
Optimal circulation and transfer of scientific knowledge for access and uptake of knowledge by all	Communication and dissemination of programme results, demonstration and pilot projects	Open access to peer-reviewed scientific publications resulting from Horizon 2020 is mandatory since 2017. The use of a Data Management Plan is required for projects participating in the Open Research Data Pilot. Based on 2014-2015 figures 65.4% of the projects covered by the scope of the pilot on Open Access participate in the pilot and 34.6% opted out for IPR reasons, personal data protection concerns, national security or other reasons. Furthermore, outside the areas covered by the pilot, a further 11.9% of projects participate on a voluntary (opt-in) basis. In order to comply with the open access publications requirement, beneficiaries must, at the very least, ensure that their publications can be read online, downloaded and printed. In 2014, approximately 52% of EU-28 publications were available in Open Access.
International cooperation	General openness to participation in programmes by any researcher in the world	The number of scientific co-publications with non EU countries increased on average by 4.1% over the period 2005-2014.

Source: ERA progress report 2016

8.2. What is the progress made towards achieving innovation and economic impact?

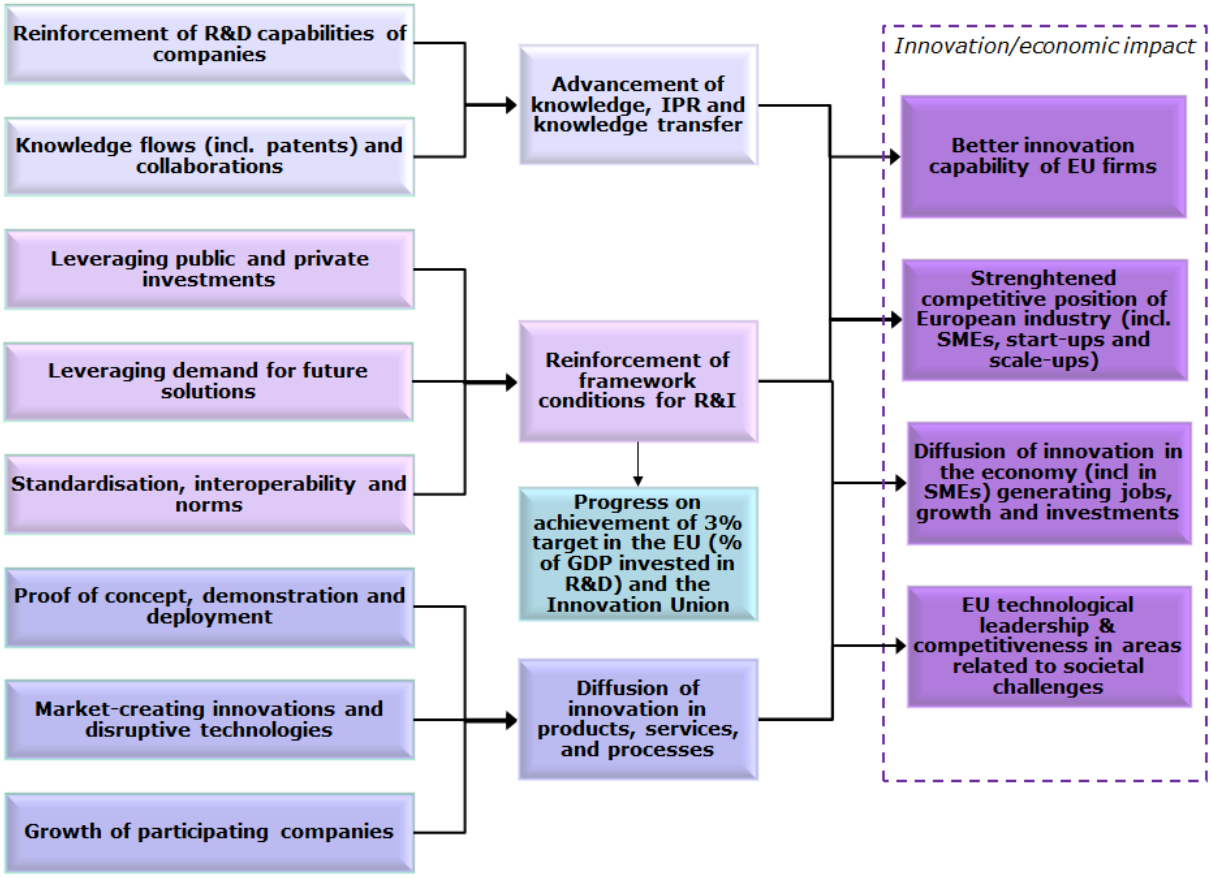
The objective of Horizon 2020 is to speed up development of the technologies and innovations that will underpin tomorrow's businesses and help innovative European SMEs to grow into world-leading companies.

Expectations from Horizon 2020 for achieving innovation and economic impact

Compared to FP7 Horizon 2020 is providing a **stronger emphasis on supporting closer to market applications and innovation**. Based on the Horizon 2020 impact assessment, it is expected that the 'seamless support form research to innovation, from idea to market' will allow for supporting all stages in the innovation chain through in particular more support for closer to market activities and an improved framework of public-private partnerships.

Figure 38 provides an overview of the approach used for analysing progress towards the achievement of innovation and economic impact. Overall - from the review of the programming documentation - it is expected that this will lead to a better innovation capability of EU firms; a strengthened competitive position of European industry; a European technological leadership and competitiveness in areas related to societal challenges; and the generation of jobs, growth and investments through the diffusion of innovation in the economy. These changes are expected to depend on the advancement of knowledge and technologies, IPR and knowledge transfer (reinforcement of R&I capabilities of companies, knowledge flows and collaborations), on the reinforcement of framework conditions for R&I (leveraged demand for future solutions, leveraged investments and standardisation and interoperability) and the delivery of close to market outputs and diffusion of innovation in products, services and processes (proof-of-concept, demonstration activities, innovations on the market, growth of participating companies).

Figure 38 Approach towards analysing progress towards innovation & economic impact



Source: European Commission

Summary box: Key findings on the progress towards achieving innovation & economic impact

- ✓ Horizon 2020 is creating networks between businesses, and between the business sector, universities and research institutions, which is key for bringing knowledge quickly to market and gaining industrial leadership.
- ✓ Horizon 2020 provides companies, and in particular SMEs, with access to risk finance to carry out their innovation projects, thereby addressing an important market failure.
- ✓ Horizon 2020 invests in demand-driven innovation through innovative instruments including procurement and prizes but with low levels of take-up so far.
- ✓ Horizon 2020 already generates large numbers of high quality, commercially valuable patents and other intellectual property rights.
- ✓ Horizon 2020 already generates proofs of concept and demonstrators and supports the deployment of innovative solutions supporting the commercialisation and diffusion of innovation.
- ✓ Horizon 2020 projects already produce new knowledge, strengthen capabilities, and generate a wide range of innovation outputs including new technologies, products and services.
- ✓ Horizon 2020 has potential in terms of generating breakthrough, market-creating innovation but such support can be strengthened substantially.
- ✓ Technological, regulatory, standards, technical and access to finance, as well as lack of customer acceptance of new solutions may impede Horizon 2020's full effectiveness in terms of market uptake.

8.2.1. Progress on advancing knowledge, IPR and knowledge transfer

One key objective of Horizon 2020 is to support the advancement of knowledge, IPR and knowledge transfer through the reinforcement of the R&D capabilities of companies, the creation of collaboration networks and public-private partnerships. Early evidence indicates that the programme is making progress on these fronts.

8.2.1.1.Reinforcement of R&D capabilities of companies

Under all programme parts **the development of new knowledge and related learning effects are amongst the most frequent outputs expected** from the projects. For private partners, acquiring new knowledge and building R&I capacity are decisive economic factors and even more for SMEs. As an illustration 49% of ICT project participants surveyed expect a high project impact on their ability to innovate, which is a prerequisite for the activities to achieve an impact in research, development and demonstration.

Horizon 2020 is the opportunity to establish R&D Know-How and expand your network of partners.
Austria, Fronius International GmbH

8.2.1.2.Knowledge flows and collaborations

Figure 39 Horizon 2020 Key Performance Indicators related to knowledge flows and collaborations

Key Performance Indicators (KPIs)	Progress so far / Target
Knowledge flows and collaborations	
Patent[119] applications	153 Target: 3 patent applications per €10 million funding
Patents awarded	39

Source: Corda, Signed Grants cut-off date by 1/1/2017

[119] Based on beneficiary reporting.

Across the thematic assessments, **the partnerships and networks that are created, allowing for knowledge exchange and technology transfer, are considered critical success factors for future innovations**. The flow of knowledge between the stakeholder communities, thanks to the creation of networks and partnerships, as well as the transfer of technology, data and information among the participants as well as with the broader community constitute key elements for the creation and diffusion of innovation. As an illustration, a survey of LEIT-Space industry participants indicates positive progress especially in an improved positioning in the international community and a strengthening of their international partnerships (45%) and improved links with industry (35%). One in four respondents also indicated positive effects on R&D capabilities, links with academia, and access to new markets. A relatively high proportion of ICT project participants[120] also perceive a high impact of their project in terms of access to international technological/scientific networks (over 80 % of participants perceived a high or fair impact in this area). Collaboration with both developers and end-users are important areas where the ICT projects are perceived to have an impact by over 40% of participants. Research-industry collaboration patterns (including research-industry) are discussed in the preceding section 8.1 on scientific impact.

> *It provides the opportunity to small/medium companies to enter smoothly into international projects and cooperation schemes. It is a good school to benchmark the abilities/competencies of our organisation against other SME or partners. It teaches cross cultural management and risks. It is a great opportunity to open the mind or wider the mind of our staff.*
>
> France, GNSS Technologies

Regarding the key performance indicators related to knowledge flows through Intellectual Property Rights (IPRs), **beneficiaries of Horizon 2020 projects have declared 187 IPR applications[121]so far of which 69 were awarded**. These are very early indications, and the numbers will greatly increase as projects are completed. The vast majority consists of patents (153 applications and 39 awards[122]) and trademarks (24 applications which have been all awarded). The limited amount of applications from Horizon 2020 projects so far is related to the short time span under consideration and thus cannot be compared to FP7[123]. Not surprisingly given the higher Technology Readiness Level (TRL) supported (TRL of 6, demonstration level) and the shorter duration of projects (Phase 1 runs up to half a year, Phase 2 up to 2 years), two thirds of patent applications and of trademarks applications derive directly from the SME instrument (phase 2) projects, while 34 patent applications result from projects in ERC-Proof of Concept which are also shorter term (maximum 18 months duration). Cross-checking the information on IPR applications by type of action, 112 out of 144 IPR applications in LEIT and Societal Challenges stem from SME-instrument Phase 2 projects (93 patents, 15 trademarks and 4 others). On the other hand, a limited number of IPRs are so far attributable to Innovation Actions and to Research and Innovation Actions, despite the fact that these actions absorb more than half of the Horizon 2020 funding.

Considering that in FP7 18% of projects in the Cooperation theme have reported at least one IPR protection[124], these elements would suggest that, while single-beneficiary projects (SME instrument Phase 2 and ERC Proof-of-Concept) have been so far more successful than collab-

[120] Survey performed within the thematic assessment of ICT projects under Horizon 2020 (CARSA, forthcoming).
[121] Beyond patents and trademarks, this category includes also Utility models, Registered designs and other.
[122] The bulk of patents are expected to come in from 2018 onwards, as the usual project lasts four years. It is difficult to compare this with the number of the first years of FP7. For FP7, patent applications are registered cumulatively in the Commission's Respir system (which does not cover all parts of FP7, e.g. no ERC and JTIs). Up till February 2017, FP7 projects register 2,380 patent applications.
[123] The European patent grant procedure may take three to five years from the application date. European Patent Office, https://www.epo.org/service-support/faq/own-file.html#faq-274.
[124] RESPIR-SESAM Research Performance and Impact Reports (FP7). Report generated on: 2017/02/03.

orative projects in applying for IPR, it is likely that IPR applications deriving from projects in Innovation Actions and Research and Innovation Actions will take a more significant share in the near future. According to an external study based on counterfactual analysis[125], **EU-funded research teams are around 40% more likely to be granted patents or produce patent applications (25% of respondents produced at least one IPR output in 2015) than non-funded units** (18%). The data also show that the **patents produced in the FPs are of higher quality and likely commercial value than similar patents produced elsewhere**.

Example box: Nanopilot, a Horizon 2020 LEIT-NMBP project on nanopharmaceuticals

Nanotechnology applied to medicine (nanomedicine) promises more effective and better targeted drugs, with reduced side effects for patients, but these nanopharmaceuticals are still at a very early stage of development. The aim of NanoPilot (RIA; 6.3 million EUR; January 2015 – December 2018). is to establish a flexible and adaptable pilot plant for nanopharmaceuticals. It will provide specific tools and services to SMEs and researchers to validate their technologies and to be able to produce nanopharmaceuticals of sufficient quantity and quality to enter clinical testing. Not only does this help to overcome R&D challenges, but it also offers a solution to the high cost of manufacturing (e.g. clean rooms and special equipment), as well as compliance with regulatory requirements. Three different applications show the flexibility of the planned facility: the treatment of dry eye syndrome, a HIV nanovaccine and a drug for the treatment of painful bladder syndrome. The pilot line will be validated in the project and will continue its certified services after the project, for further drugs and diseases. The consortium includes the operator of the pilot line, an SME, two university institutes which develop the nanopharmaceuticals, and a specialist institute on nanosafety.

8.2.1.3. Specific focus on Public-Private Partnerships (PPPs), including Joint Technology Initiatives and Contractual PPPs (cPPPs)

Two different types of Public-Private Partnerships (PPPs) are implemented within Horizon 2020.

The Joint Undertakings (JUs)[126] are PPP[127] in industrial research at European level. Currently seven JUs organise their own research and innovation agendas[128] and award Horizon 2020 funding for projects on the basis of competitive calls: Clean Sky 2 (CS2), Fuel Cells and Hydrogen 2 (FCH2), Innovative Medicines Initiative 2 (IMI2), Electronic Components and Systems for European Leadership (ECSEL replacing ARTEMIS and ENIAC), Bio-based Industries (BBI), Single European Sky Air Traffic Management Research (SESAR) and Shift2Rail.

The contractual public-private partnerships (cPPPs) involve dedicated arrangements between the Commission and private associations representing industrial technologies interests. On the basis of mutually prepared roadmaps, cPPPs provide direct input into the preparation of priorities for Horizon 2020 Work Programmes in pre-defined areas of significant industrial relevance[129]. Currently there are, ten contractual public-private partnerships[130] set up directly un-

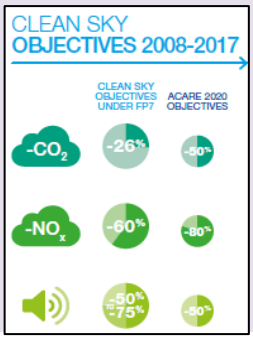
[125] PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming.
[126] Article 187 of the Treaty on the Functioning of the EU (TFEU) states that 'the Union may set up Joint Undertakings or any other structure necessary for the efficient execution of Union research, technological development and demonstration programmes'.
[127] In addition to the institutionalised PPPs, also the contractual Public-Private Partnerships (cPPPs) have a legal basis in Article 25 of the regulation establishing Horizon 2020. Please note that the assessment of cPPPs is not included in this document but will be part of the overall SWD, planned for 2017.
[128] An exception is the SESAR JU agenda which is set by the Member States and various Air Traffic Management. (ATM) stakeholders and the members of the PPP in the framework of the European ATM Master Plan.
[129] Moreover, depending on the cPPP, they can:

der Horizon 2020: Factories of the Future (FoF); Energy-efficient Buildings (EeB); European Green Vehicles Initiative (EGVI); 5G Infrastructure; Sustainable Process Industry (SPIRE); Robotics; Photonics; High Performance Computing; Big Data Value and - more recently – Cybersecurity. They are implemented through calls under Horizon 2020 with a total Union contribution of EUR 6.6 billion[131].

Example box: Public-private collaboration for greening European aeronautics – The Clean Sky Joint Undertaking

Launched in 2008 Clean Sky is the largest European research programme developing innovative, cutting-edge technology aimed at reducing CO2, gas emissions and noise levels produced by aircraft. Equally funded by the EU R&I framework programmes (FP7 and then Horizon 2020) and the industry, Clean Sky contributes to strengthening European aero-industry collaboration, global leadership and competitiveness. Through its six Integrated Technology Demonstrators, it aims to bring technologies to maturity that could, as a set of solutions, deliver a substantial majority of the environmental goals set under the Strategic Research and Innovation Agenda of the Advisory Council for Aviation Research and Innovation in Europe.

In 2017 the first Clean Sky programme is being finalised: some 20 large Demonstrators have been completed by 600 participants in 24 EU countries, bringing together thousands of experts from leading companies, universities, SMEs and research centres and thousands of components used in current aircraft and helicopters have been reviewed to identify the areas that can be significantly improved in order to reduce CO2 emissions and noise by 2020.



Clean Sky 2 is larger in scope than the initial Clean Sky Programme with a total budget of nearly €4 billion. Building on its predecessor's success, it aims to achieve a higher level of technology integration at aircraft level and to raise the maturity level of systems incorporating these new technologies. A regular schedule of two Calls for Proposals/Partners per year is foreseen through to 2020, with roughly €90 million available in indicative call value per year.

Example box: Public-private collaboration for keeping Europe at the forefront of technology development in Electronic Components and Systems – The ECSEL Joint Undertaking

ECSEL implements pilot lines which are large projects (IA) at high Technology Readiness Levels. These are providing a means for producing realistic research demonstrators in industrial environment, thus bridging the gap between research and innovation in the area of electronic components. This is a game changer for the increase of economic and innovation impact of EU funding to the strategic electronic components field. A similar type of actions is now implemented in the Photonic contractual Public Private Partnership with similar results and impact on the research and innovation ecosystems.

This section assesses the different types of PPPs on their openness, transparency and effectiveness based on an internal Commission assessment. More details are in the Annexes.

- help structure the research domain in the field including at Member State level, and contribute to the emergence of a real EU industrial policy in the field;
- support innovation take up;
- contribute to framing related policy issues, e.g. standard developments;
- help structure international cooperation issues in the field;
- provides a platform to link towards other sectors, especially in the context of identification of use cases.

[130] The first four take forward public-private partnerships established under FP7.

[131] Excluding budget for the Cybersecurity cPPP.

Box: Joint Undertakings monitoring data (February 2017)

- 35 JU calls launched and concluded.
- 1677 eligible proposals, involving 11.719 applications.
- 473 proposals (28%) retained for funding with a total EU financial contribution amounting EUR 2162.1 million.
- 351 signed grants totalling EUR 1.384,8 million of EU funding.
- Among the participants: 15.4% HES, 59.8% PRC and 18.7% REC. SME participation equals 19.5 %.

Contractual Public-Private Partnerships monitoring data

FoF, EeB, EGVI and SPIRE	5G, HPC, Photonics, Robotics, Big Data
➢ 27 calls launched and concluded ➢ 1,704 eligible proposals, involving 19,466 applicants. ➢ 231 signed grants totalling EUR 1.217,5 million of EU funding. ➢ Among the participants: 15.8% HES, 58.8% PRC and 20.3% REC. ➢ The number of SME participations is at least 29.9 % of the total.	➢ 6 calls (16 topics) launched and concluded ➢ 1,030 eligible proposals, involving 8,986 applicants ➢ 154 signed grants totalling EUR 713.3 million of EU funding ➢ Among the participants (in terms of funding): 33% HES, 40% PRC, 23% REC, OTH 2% and PUB 1%. In terms of participations: 30% HES, 45% PRC, 19% REC, 3% OTH and 2% PUB. ➢ The number of SME participations is at least 21% of the total.

More in-depth evaluations of Joints Undertakings and the Contractual Public-Private Partnerships will be available in Autumn 2017.

(a) Openness

Overall, the JUs and cPPPs demonstrate openness. All JUs have an open access policy towards membership. However, despite the straightforward and open criteria for membership, the size of the financial "entry ticket" or (annual) membership fees, influences substantially the type, size and/or composition of the entities that can become members and, hence, have access to the full package of JU benefits. Due to the substantial financial commitments that members have to make, SMEs, small universities and research organisations may face financial barriers in becoming a JU member. The openness to membership may also impact the participation in the Programme and the respective EU budget. The assessment shows that JUs apply an open participation policy in their programmes through the launch of "open calls". However, for several JUs, certain activities or topics and/or a predefined percentage of the budget is reserved for members only.

To demonstrate openness towards newcomers and players such as SMEs, small universities and research organisations, the JUs are applying a number of targeted measures ranging from applying variable levels of membership (e.g. full members vs. associated partners) with varying levels of (financial) commitments up to the launching of calls for proposals dedicated to non-members. Despite these efforts, many small stakeholders decide to abstain from membership due to the costly and long-term commitment expected from them. Instead, they prefer to participate in the open calls as "beneficiaries" rather than "members". With regard to SMEs, in addition to financial considerations that themselves constitute a barrier to membership, they sometimes face difficulties in participating in open calls. Poor networking capacities that deprive them from participating in strong and competitive consortia are a frequently cited reason. Conscious of these difficulties, the JUs take specific measures to stimulate and increase the presence of SMEs in their activities by, among others, providing for SME representation in the governing boards, simplifying the rules for participation, launching special calls for SMEs and defining call topics that are particularly appealing to SMEs. **Overall, considering**

the membership composition of the JUs and the top ranking beneficiaries in open calls, one can conclude that all JUs are attracting prominent players in their respective fields of activity not only in terms of size and position in the market but also in terms of R&D intensity and innovation potential.

The contents of roadmaps agreed in the context of cPPPs also feed into calls in the Horizon 2020 Work Programme and participants are subject to the same rules of participation as in other parts of the programme. For all the cPPPs agreed with the Commission, the percentage of EU funding allocated to non-members ranges from 47% to 77% depending on the partnership, and non-member participants make up from 54% to 77% in the 2014 calls. In addition, the associations constituting the private side are open to new members. In many industrial sectors and cPPPs, the associations work closely with related European Technology Platforms to develop their strategies and roadmaps. These platforms are also open to new members and do not require a financial commitment, thus opening up participation in particular to SMEs. SME participation varies across cPPPs and ranges from 11% to 35%.[132].**The strong participation of non-members, as well as highly innovative and research-intensive industrial players, shows that the priorities of the cPPPs are highly attractive to a vast range of stakeholders**.

Box: Joint Undertakings' openness in figures

- Overall for all JUs, 27% of the beneficiaries are newcomers.
- Overall 23,3% of JUs applicants are SMEs.
- SME Success rate for all JUs:
    - In terms of applications: 34,6%
    - In terms of requested EU contribution: 29,6%
- SME participation rate in JUs:
    - In terms of participations: 19,5% (slightly below Horizon 2020 overall : 19,9%)
    - In terms of EU contribution: 18,3% (significantly higher than Horizon 2020 overall: 15,9%)
- The JUs meet the Horizon 2020 objective of 20% participation rate for SMEs.

So far, JUs almost meet the overall Horizon 2020 objective of a 20% participation rate for SMEs. JU specific SME participation figures can be found in Annex 1.

Box: Participation in calls of Contractual Public Private Partnerships

cPPPs[133]	**FoF**	**EeB**	**EGVI**	**SPIRE**	**5G**	**HPC**[134]	**Photo-to-nics**[135]	**Robo bo-tics**[136]	**Big data**[137]
% of Non-members in the participations	77	75	67	73	71	62	80	58	78
% of Non-members in the EC funding	77	70	53	71	60	60	71	46	71

[132] cPPPs are not comparable with each other since not all of them have been active for the same time.
[133] Data referring to the 2014 calls (unless otherwise stated). Big Data cPPP entered into force on 1 January 2015, Cybersecurity cPPP on 5 July 2016.
[134] Approximate figures coming from 29 projects that started in 2015.
[135] Calculated for all funded projects in 2014-2016. The non-membership participation and funding is based on the 100 members of the board of stakeholders of the PPP.
[136] Relating to 2014-2016 calls.
[137] Calculated over all projects selected in the Big Data call of 2016. Both 'full members' and "associate members' of the Big Data Value Association (BDVA) are counted as 'members', the rest as "non-members".

% of Industry in the participations	61	57	60	59	64	22	51	37	55
% of SMEs in participations	>35	>33	>15	>27	>17	>11	>28	18	>25

Source: European Commission

The cPPPs are included in the Horizon 2020 Work Programme and applicants are then subject to the same rules of participation as in other parts of the programme. In particular, the percentage of participations from non-members is above 50% for all cPPPs, and in cases such as FoF, Photonics and Big Data a participation of above 75% is observed. The level of funding is also demonstrating this high participation from outside the cPPP association. **The average success rate in the cPPPs[138] is well above the overall average in Horizon 2020 at 11.6%.** In some cPPPs, the success rate demonstrated in terms of the ratio of successful proposals is far beyond this average, e.g. EGVI at 19.9% and SPIRE at 14.4%.

There is a major variation in EU-13 participation between the different cPPPs. At the same time, consortia that involve participants from the EU-13 are considerably more likely to be selected than quality projects that do not have members from the EU-13. By way of example, in the case of cPPPs under LEIT-NMBP, 41% of all selected proposals have at least one participant from the EU-13. Only 27% of the corresponding unfunded proposals in the same calls had at least one EU-13 participant. The highest participation of EU-13 partenrs (67%) is in the cPPP Energy-efficient Buildings projects. A significant finding is that both projects and quality proposals are very rarely coordinated by an organisation from the EU-13. As regards to newcomers to Horizon 2020, the overall average is 52.1%, as reported above. In the cPPPs under the NMBP programme, 33,0% had not participated in the previous Framework Programme. In addition, 54,6% had not participated in the NMP part previously, showing a large increase in interest for the programming under LEIT-NMBP.

(b) Transparency

The approach of the JUs towards their respective stakeholders is open and inclusive as they consider them as partners rather than competitors. The transparency of the cPPPs arises at two levels, at programming level, and at project level.

All JUs have put in place a wide range of mechanisms in order to ensure an open and non-discriminatory attitude towards their wider stakeholder community, including the general public. These mechanisms include various communication tools like an up to date, informative and interactive website, the use of social media, organisation of and/or participation in events, seminars and conferences and publications in written press. The JUs are employing the more "classic" range of communication tools but also other mechanisms that aim at enhancing inclusiveness and transparency, such as close cooperation and coordination with other JUs, including stakeholders' advisory bodies in their organisation and setting up separate Memoranda of Understanding with European regions seeking synergies with other (national and regional) programmes.

To disseminate project results as widely as possible, the JUs use a variety of tools. Most of them reserve a dedicated space on their website for the dissemination of project results and publishable project summaries; some also provide online a fully searchable project database. Project results are also widely communicated through publications and articles, social media and the organisation of, or participation in, dedicated events.

[138] 13,6% in the case of the calls for FoF, EeB, SPIRE, and EGVI for three call years, 2014-2016.

In general, JUs try to inform and raise the awareness of their beneficiaries on the existing common support services and existing IT tools provided to facilitate access to both project results and access to research data sets. However, only few beneficiaries so far seem to be convinced and willing to take this extra step. A lack of resources to sustain and maintain data generated by the project beyond its lifespan is one of the cited reasons.

At the level of programming, the process involving industrial stakeholders includes publicly available strategic research agendas and roadmaps. There are also Partnership Boards between Commission services (DG RTD/DG CNECT) and the industrial association to ensure relevant needs and innovation trends are reflected in the programme. In addition, the Programme Committee configurations with Member State representatives for the various parts of Horizon 2020 give direct technical input on work programmes and are formally invited to support the work programme on the basis of a vote. Thus, national administrations have a major say on the contents of the work programme.

At the individual project level, all cPPPs are fully integrated in the Horizon 2020 dissemination platforms. Moreover, the associations organise public events, forums, publications and announcements to further the added value and impact of individual projects. Open access to data has been introduced in the cPPPs: all new projects are by default in the programme, unless they opt-out with a justification. A step beyond the Open Access to project results is the Open Access to Data.

(c) Effectiveness and European added value

The progress towards achieving the common Horizon 2020 and JU-specific objectives is measured by a set of Key Performance Indicators (KPIs) common to all JUs[139] and a set of JU-specific KPIs[140]. The contractual arrangements with the cPPPs build on industrial roadmaps with ambitious goals and KPIs related to technological achievements as well as market needs. For the JUs, the KPIs are regularly monitored and reported on in the Annual Activity Reports of the JUs. Overall on the basis of early and partial data available on the KPIs and on the basis of expected results of the already funded projects (no project reports are yet available), **the JUs seem to be on track in terms of carrying out their planned activities, achieving their specific objectives and ultimately contributing to the overall Horizon 2020 objectives**. A detailed overview of the JU specific KPIs and their first measurement or estimates can be found in Annex 1.

Under the cPPPs, projects typically address industrially relevant demonstrators and pilots to validate technology developments and integration at higher technology readiness levels. Among the industrial commitments established for the cPPPs, they have to report on the development of new types of high-skilled jobs and of new curricula. **The projects within the NMBP cPPPs have reported a wide range of results regarding new types of new high-skilled jobs, the highest average being in FoF (Factories of the Future), with 3.5 new jobs profiles per project. EeB (Energy-efficient Buildings) projects currently report 0.8 jobs per project, with 1.6 in FP7. EGVI also contributed to save time in performing research activities while structuring the whole value chain and avoiding duplication of efforts. Several similar initiatives have been implemented at national level, testifying to the benefit of this specific funding scheme**.

[139] Based on Annex II (PERFORMANCE INDICATORS) to Council Decision 2013/743/EU).
[140] With the exception of SESAR JU that is not subjected to a predefined set of KPIs.

First estimates (see Annex 1) demonstrate that the **JUs are well on track in achieving and, in some cases, exceeding their legally minimum foreseen leverage effect**[141]. In the case of the cPPPs under the NMBP thematic area, the current leverage factors range between 1.5 and 3.5.[142]

In EGVI projects, on the basis of 2014 estimates, the additional private investments are expected to lead to a leverage factor of 3. In the Photonics PPP, the industrial investment has been estimated as being 4.3. This is based on confidential information received from 80 companies for their investment in 2014-2015. As with the JUs, the overall leverage effect of each cPPP can only be assessed beyond the end of the programme.

Figure 40 Contractual Public Private Partnerships today

	First call year	Maximum EU Funding (million €)
Factories of the Future (FoF)	2009	1150
Energy-efficient Buildings (EeB)	2009	600
Green Vehicles (EGVI)	2009	750
Future internet (5G)	2014	700
Sustainable Process Industry (SPIRE) **Robotics**	2014 2014	900 700
Photonics	2014	700
High Performance Computing	2014	700
Big Data	2015/2016	534
Cybersecurity	2017	450

Source: European Commission

8.2.2. Progress on reinforcing framework conditions for R&I

One objective of Horizon 2020 is to help reinforce the framework conditions to perform R&I in Europe through standardisation and interoperability efforts, the leveraging of demand for future solutions as well as of public and private investments for R&I. Early evidence indicates that the programme is making only slight progress on these fronts.

8.2.2.1.Standardisation, interoperability and norms

In the context of the global market, the development and/or compliance with international standards is a critical factor in competitiveness. The progressive evolution of the focus of the programme towards higher TRL makes increased attention to the development of standards and/or stronger requirements for compliance with existing standards even more important for commercialisation success. **To support the commercialisation or diffusion of innovation in the economy, some projects aim at the development of standards and norms in particular under the LEIT programme but progress seem to be limited so far.** Under LEIT-NMBP, projects deal with standardisation mainly by referencing standardisation bodies and specific standards relevant to their field of endeavour. Regulation activities, standardisation and norms account for about 14% of the expected outputs from the LEIT-NMBP projects. LEIT-Space interviewees criticise the **limited attention to the issue of standardisation of products and services**, despite the fact that interoperability is considered overall as the key to success. In LEIT-ICT, where the contribution to standards is part of the expected impacts of a

[141] Leverage effect defined as total amount of funds leveraged through a JU divided by the respective EU contribution to this initiative. As the number of signed grant agreements increases, a more detailed reporting on the leverage effect will be possible. However, the overall leverage effect can only be assessed at the end of the programme

[142] On the basis of a methodology accounting only for current investments and discounting future investments.

number of topics, a specific action was introduced in the WP 2016-17 to reinforce the EU presence in the international ICT standardisation scene.

8.2.2.2.Leveraging demand for future solutions

The use of new instruments such as the pre-commercial public procurement (PCP), public procurement for innovation (PPI) and inducement prizes clearly aim at leveraging demand for future solutions. **Evidence of outputs so far is however still lacking on the effects of the PCP and PPI** since the first projects were signed only in 2015[143].

Given the current lack of information and the small scale of the PCP and PPI so far, the main type of action supporting more user-driven innovation and leveraging demand for future solutions in Horizon 2020 comes from the inducement prizes, which provide alternative opportunities to develop innovative solutions by offering a reward for completing a specific technological challenge[144]. The first ones were launched in 2015: five inducement prizes with a budget of EUR 6 million[145] together with three recognition prizes with an overall budget of EUR 1.33 million[146] were selected. Up to the end of 2016, 12 Horizon inducement prizes have been launched and six more will follow in 2017. They target challenges such as Sharing of Spectrum, Breaking the Optical Barrier, Aging population, Mother and child health, CO2 reuse, Clean car engines, Cyber security, Materials for Clean Air, etc. For example, EUR 1 million under SC1 *Horizon Prize for Better Use of Antibiotics* was awarded to Minicare HNL for developing a rapid test to allow healthcare providers to decide which patients with upper airway infections can be spared from antibiotics[147]. However, **overall more could be done to support demand for innovative solutions and user-driven innovation.**

8.2.2.3.Leveraging public and private investments

Figure 41 Horizon 2020 KPI related to leveraging public and private investments

Key Performance Indicators (KPIs)	Progress so far / Target
Leveraging public and private investments	
Total investments mobilised via debt financing	EUR 29 600 million (2014 to 2016) Target: €25 billion
Total investments mobilised Venture Capital investments	No data available yet[148]. Target: €25 billion
Number of organisations funded and amount of private funds leveraged	5 700 organisations funded & EUR 13 235 million of private funds leveraged. (2014 to 2016) Target: 5,000 organisations funded & €35 billion of private funds leveraged

Source: Data from European Investment Bank

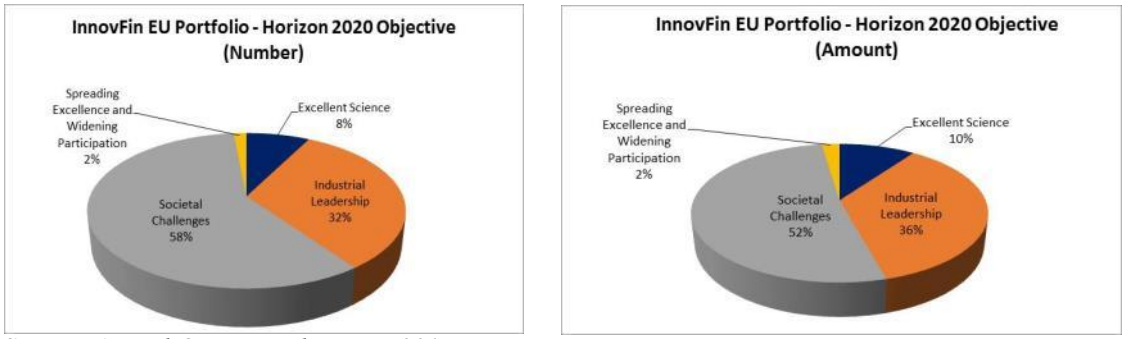
[143] In 2015, six projects were signed that are implemented through PCP or PPI (total EC contribution of EUR 18.5 million). Three PCPs of those are procuring early 2017, two other PCPs have finished the open market consultation and will start procuring soon. The PPI has not started procuring yet as certification of solutions is still ongoing. Three additional projects submitted under a deadline in 2015 were signed in 2016 (EC contribution of EUR 7.9 million). One PCP is already procuring, the other two PCPs of this batch are preparing the procurement. In the second semester of 2016 another 5 PCPs and 1 PPI projects from 2016 call deadlines were signed (EC contribution of EUR 25.2 million).
[144] They are only awarded based upon the achievement of the target set, solving the challenge defined
[145] There has been no budget executed yet.
[146] EUR 0.15 million of the budget has been executed so far.
[147] Available at: http://ec.europa.eu/research/horizonprize/index.cfm?lg=en&pg=prizes
[148] The instrument has been implemented as from 2015 after amendment to the Delegation Agreement between the Commission, the EIB and the EIF.

One key element for reinforcing the framework conditions for performing R&I in Europe is to ensure public and private funding are available beyond Horizon 2020 support from e.g. own funds of beneficiaries, risk capital, regional/national funds. While there is no official definition of leverage, it is assumed that it represents the additional investment mobilised by the project beyond the initial project total cost. This includes, for instance, venture capital investment or additional private/public investment in project results such as innovations. **Most projects are in their early stages and hence did not secure additional funding yet.** However, early evidence shows that **out of the 10,000 companies taking part in Horizon 2020, in the first three years 255 benefitted from the financial instruments in the Access to Risk Finance programme (InnovFin) for investments in scaling up**[149]. Under this programme, a total of 5,700 organisations have been funded – which is above the target set of 5,000 - and EUR 13,235 million of private funds leveraged (2014-2016) (target: EUR 35 billion). The total investments mobilised via debt financing in 2014/2015 is EUR 29 600 million, which is above the target of EUR 25 billion).

Stakeholders interviewed for the InnovFin interim assessment see the **effectiveness of InnovFin as particularly strong with regard to the objective of increasing private investment in R&I as well as increased risk financing (number of entities and volume of funds). They are more cautious about InnovFin's contribution to strengthening EU venture capital in terms of attracting institutional investments.**

The two pie charts below show the shares of the InnovFin EU portfolio going to different parts of Horizon 2020 in terms of amount and numbers of projects. In terms of both amounts and number of projects, most is going to Societal Challenges, followed by Industrial Leadership and Excellent Science.

Figure 42 InnovFin portfolio spread within Horizon 2020



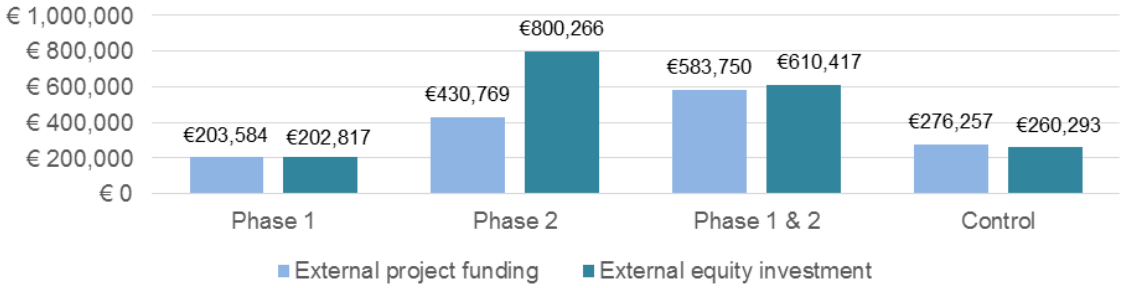
Source: Annual Operational Report, 2017

Also out of the 2,236 SMEs taking part in the SME Instrument by end-2016, 88 companies secured a total of EUR 481 million venture capital during or after the project.[150] These numbers are expected to increase in the years to come when more projects start delivering results. Based on the thematic assessment, SME Instrument funding indeed creates a leverage effect in the form of private co-funding of the innovation project. More private than public investors commit to co-financing SMEs that participated in Phase 2 projects, but the volume of public funding is increasing. The survey shows there is a **leverage effect of approximately EUR 800,000 per SME in Phase 2.** However the relatively small number of Horizon 2020 grant beneficiary firms accessing the Access to Risk Finance offer in their growth phase points to a

[149] Source : European Investment Bank, data per January 2017
[150] EASME, Accelerating Innovation in Europe, HORIZON 2020 SME Instrument Impact Report 2017 Edition

potential lack of integration/interconnection between the grant and non-grant based instruments available to firms at different stages of the innovation cycle.

Figure 43 How much funding have you attracted since you first applied or were first awarded an SME Instrument grant (excl. SME Instrument funding)?



Source: Technopolis, based on SME survey data, Sample size: 284 – 293 (Phase 1) 91 – 94 (Phase 2) 20 – 24 (Phase 1&2) 1,229 – 1,293 (control)

Box: The InnovFin Infectious Diseases (InnovFin ID) loan facility

The InnovFin Infectious Diseases (InnovFin ID) loan facility, launched in 2015, operated with the EIB aims to facilitate the development of innovative vaccines, drugs, medical and diagnostic devices or novel research infrastructures in the field of infectious diseases. By 1 October 2016, three deals have been concluded, with a total loan volume of EUR 45 million. The first loan went to the Swedish SME for the further development of a diagnostic device for HIV viral load testing[151]. The second loan was secured with the French biopharmaceutical company Transgene SA to develop new treatments for hepatitis, HPV-induced cancer and tuberculosis[152]. The third loan will help a Finnish IVD SME to finalise and scale up their manufacturing, validation and commercialisation of a diagnostic tool for Infectious Diseases[153].

The specific LEIT-NMBP survey of project's coordinators shows also positive signals with regard to additional investments in particular in the exploitation of results. 26% of LEIT-NMBP projects indicated that they have already invested additional funds – not initially budgeted – to pursue their exploitation objectives - mainly from private sources, but also public funds in a minority of projects. 91% of NMBP projects plan to mobilise additional funds to invest in exploitation. 29% of projects plan to rely exclusively on private funds for further commercialisation activities, while 62% plan to add public funds to the mix (private and public investment). In another field of intervention of Horizon 2020, the Teaming phase 2 projects under SEWP are expected to leverage more than EUR 100 million from public funding (ESIF and national) which are to be invested in complementary infrastructures and equipment.

Turning to the Public Private Partnerships (PPPs) and the contractual PPPs they aim to leverage private investment in key industrial sectors - with however different methodologies leading to differences in data interpretation. In both cases, the overall leverage effect of each PPP/cPPP can only be assessed beyond the end of the programme[154].

The results of a representative survey of Horizon 2020 project coordinators' point to a substantial self-declared leverage effect expected from their projects. 70% of the beneficiaries expect to secure additional R&D funding from private/industrial sources, and particularly in SC2, SC5, LEIT ICT, LEIT-Space and Fast Track to Innovation Pilot. Although this

[151] Available at: http://ec.europa.eu/research/index.cfm?pg=newsalert&year=2015&na=na-130715
[152] Available at: http://ec.europa.eu/research/index.cfm?pg=newsalert&year=2016&na=na-280116-2
[153] Available at: http://www.eib.org/infocentre/press/releases/all/2016/2016-175-finland-innovfin-european-support-for-innovation-in-finland.htm
[154] See dedicated section 8.2.1.3 on Public-Private Partnerships

result may be explained by the fact that beneficiaries of ongoing projects tend to overestimate their expected project outcomes, this is still a very high number and the success of the related activities should be further monitored in the future. In addition to private/industrial sources, a large majority of the beneficiaries expect to attract additional funding from other EU programmes (83%), public national/regional schemes (78%) and own sources (77%). Project coordinators based in the EU-13 expected to secure additional own and public national/regional funds less frequently than the EU-15 beneficiaries.

Figure 44 Do you expect that your consortium partners' involvement in the project will help them secure additional R&D funding in the future from the following sources? Horizon 2020 project coordinators (by funding source)

Horizon 2020 programme part	Own funding of project partners	Public national/regional schemes	Other EU programmes	Private/ industrial sources
Excellent Science				
FET (n = 15)	80 %	78.9 %	83.3 %	68.4 %
Research Infrastructures (n = 26)	76.2 %	95.5 %	100 %	77.3 %
Industrial leadership				
LEIT-NMPB (n = 95)	75,9%	71,7%	71,5%	72,4%
Subtotal within LEIT-NMPB: PPP projects (n=32)	63,8%	79,7%	75,9%	70,3%
LEIT-ICT (n = 182)	82,4%	81,5%	84,7%	82,5%
LEIT-Space (n = 36)	85,0%	92,1%	91,7%	81,5%
Innovation in SMEs (n = 32)	56,7%	58,3%	71,0%	32,6%
Societal Challenges				
SC1 (n = 100)	70,3%	74,7%	80,1%	68,0%
SC2 (n = 43)	83,9%	78,5%	88,1%	77,5%
SC3 (n = 131)	77,4%	75,3%	84,0%	66,9%
SC4 (n = 96)	74,2%	74,5%	77,2%	72,4%
SC5 (n = 71)	85,8%	85,7%	82,5%	76,4%
SC6 (n = 32)	80,8%	86,1%	88,5%	60,1%
SC7 (n = 31)	72,1%	76,8%	76,8%	71,3%
Spreading Excellence and Widening participation + Science with and for Society + other programmes				
SEWP (n = 24)	59.3 %	78.6 %	92.9 %	82.1 %
SWAFS (n = 9)	87.5 %	100 %	100 %	75 %
FTI Pilot (n = 10)	83.3 %	83.3 %	83.3 %	83.3 %
Euratom (n = 3)	100 %	50 %	66.7 %	33.3 %
Total	77.1 %	78.1 %	82.5 %	72.4 %
Total number of valid responses	**932**	**928**	**926**	**923**

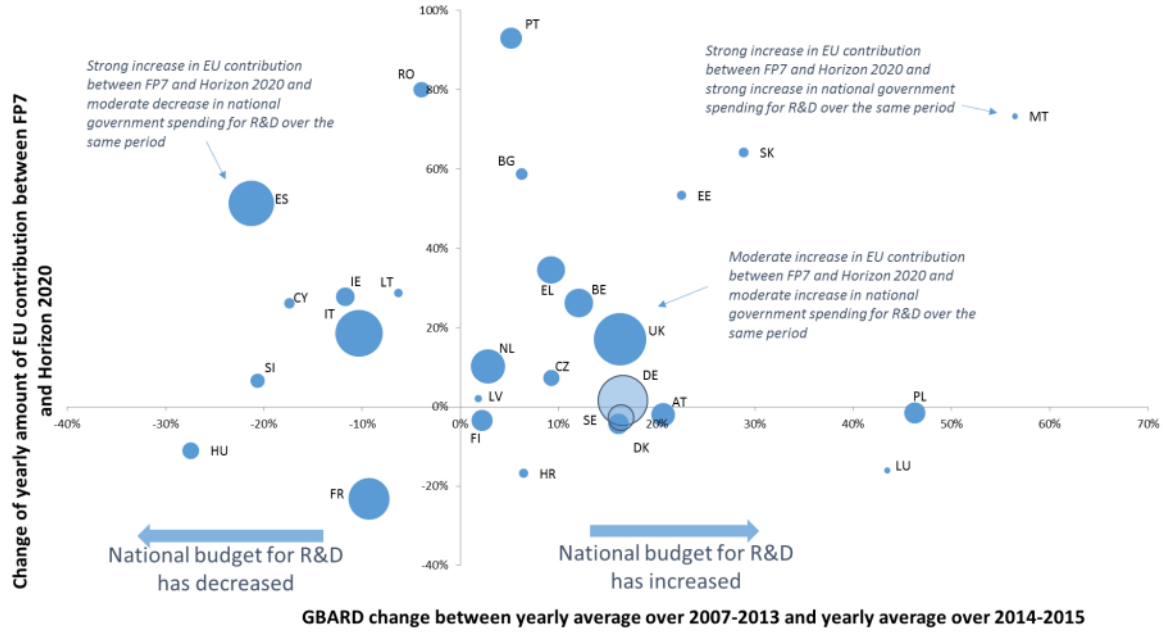
Note: This table shows the percentage of respondents who chose the "yes" option. N shows the maximum number of valid responses received to these questions in each Horizon 2020 programme part.Source: Survey of representative set of Horizon 2020 project coordinators, PPMI, 2016

Looking closer at the relationships between the different levels of R&I support, little statistical evidence is found about a complementarity or substitutability between funding received in the context of the Framework Programmes and the level of public funding for research at national and regional level. However comparing data on participation to the Framework Programmes at country level with national budgets for R&D over the same period still provides insights on the extent to which their evolution correlates or not.

All EU Member States are positioned in Figure 45 in terms of change in total government budget allocations for research and development (GBARD) and change in EU contribution received by participants in each Member State between the Framework Programmes[155]. Countries that are located on the left side of the graph have experienced budget cuts between the two periods, while countries on the right side have increased their national R&D budget. Participants from countries in the upper part of the graph receive in total more funding from the EU under Horizon 2020 than under FP7, while countries in the lower part receive less.

While some countries present simultaneously a decrease in their national budget for R&D and an increase in the EU contribution their participants receive from the Framework Programmes, this result is not systematic for all countries. Figure 45 shows a cluster of several countries that have experienced a moderate increase in both indicators, and even countries that have seen both funding measures increase strongly over the period.

Figure 45 Change in GBARD and change in EU contribution between FP7 and Horizon 2020 per Member State (size of circles: number of applications per Member State in Horizon 2020)

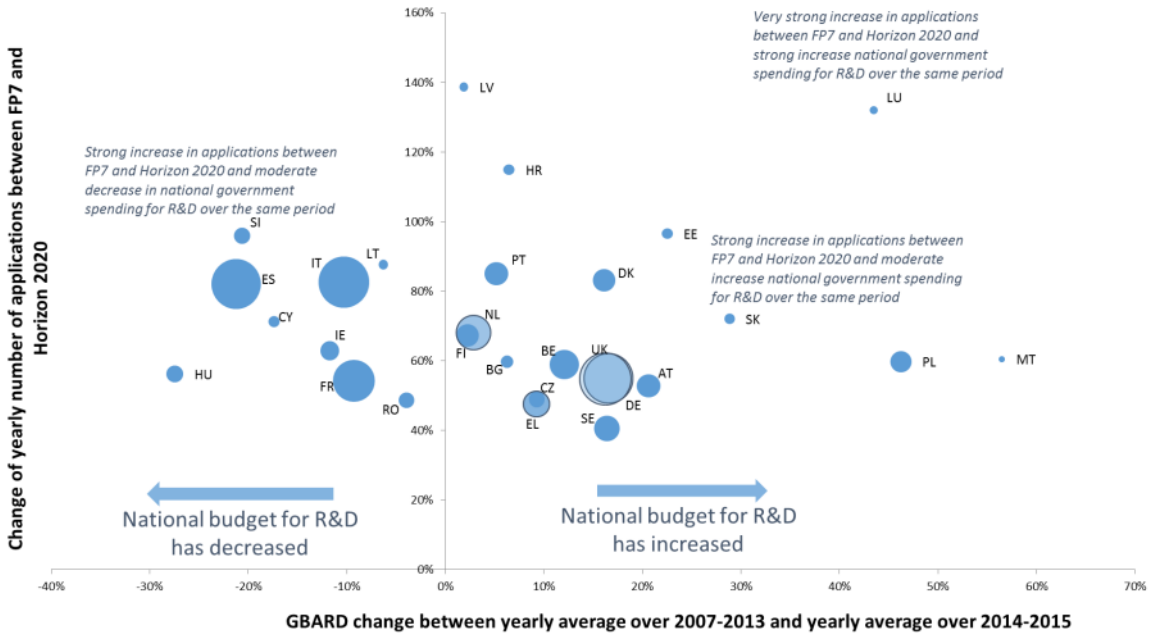


Source: Eurostat (GBARD) and Corda (EU contribution), analysis by European Commission, DG RTD.

Figure 46 illustrates an increase in the number of applications to the Framework Programmes for all EU Member States between FP7 and Horizon 2020. While a couple of large countries (Spain and Italy) present a strong increase in the number of applications combined with a reduction of national budgets for R&D, this situation does not apply to a majority of Member States. Hence, increases in applications to the Framework Programme do not seem to correlate with budget cuts of national governments. Overall - from this analysis - there is no direct evidence of a pattern in the way countries have mobilised together national and EU funding for their R&I activities over the recent years.

[155] To measure the change in GBARD between both periods, the yearly average GBARD is calculated over 2007-2014 and over 2014-2015 for each Member State (2016 is not yet available for most Member States). The growth rate between both averages is then computed. Similarly, the change in EU contribution between FP7 and Horizon 2020 per Member State is the growth rate between the yearly average EU contribution going to participants from each Member State under FP7 and the yearly average under Horizon 2020.

Figure 46 Change in GBARD and change in number of overall applications between FP7 and Horizon 2020 per Member State (size of circles: number of applications in Horizon 2020)



Source: Eurostat (GBARD) and Corda (applications), analysis by European Commission DG RTD.

8.2.2.1. Progress on the 3% target of the Europe 2020 Strategy and the Innovation Union

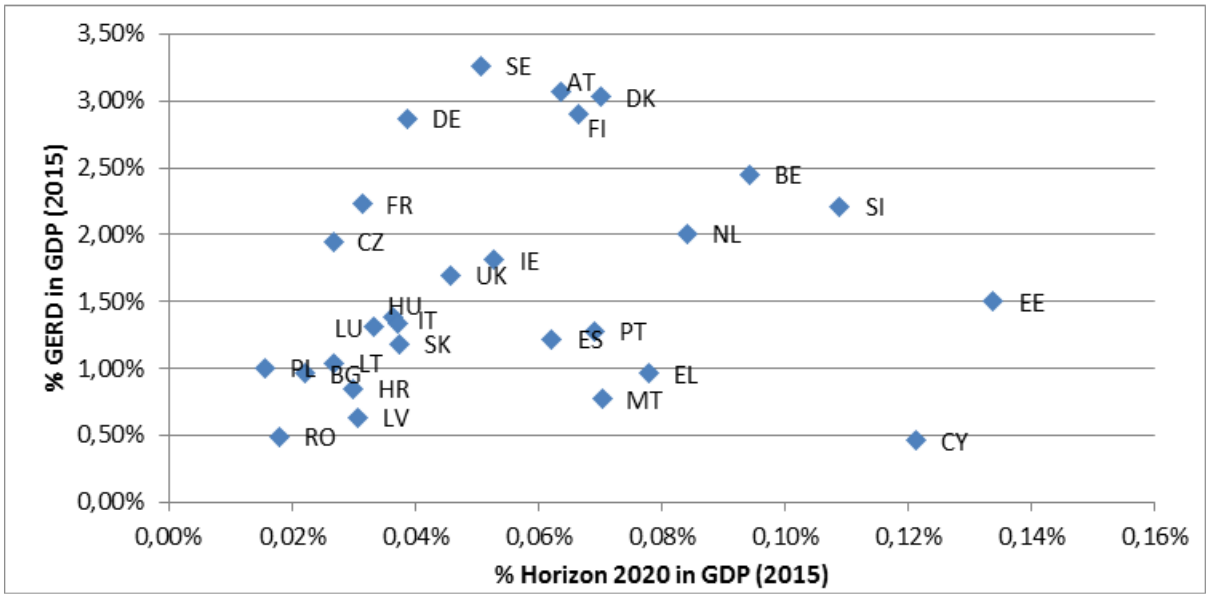
The Europe 2020 strategy for smart, sustainable and inclusive growth established in 2010 defined a headline target according to which 3% of the EU's GDP should be invested in R&D. **The R&D intensity (R&D expenditure as a % of GDP) in the EU increased from 1.93% in 2010 to 2.03% in 2013, but has stagnated since then**.

However, the contribution of Horizon 2020 to this target can only be limited, given that based on Eurostat statistics for 2015 and the average allocations of Horizon 2020 per year, the Horizon 2020 investment in 2015 represented less than 3% of the overall R&D spending[156] in the EU and approximately 10% of its public R&D allocations[157]. Considering that the overall EU R&D investment (both public and private) amounted to about EUR 300 billion in 2015, in order to meet the 3% target the EU should increase by an additional EUR 150 billion per year its public and private investment in R&D. In addition, quantifying the contribution of Horizon 2020 to this indicator would require a further breakdown of Horizon 2020 spending between R&D and innovation, which is not available.

The figure below puts in perspective the direct Horizon 2020 contribution (excluding in-kind contribution and indirect leverage effect) as share of GDP in 2015 (horizontal axis) and the R&D intensity in the same year (vertical axis) for each Member State. It is not possible to conclude that higher shares of Horizon 2020 contribution per country are directly correlated to higher R&D intensity in Member States.

[156] Gross Expenditures on Research and Development (GERD)
[157] Government Budget Appropriations and Outlays on R&D (GBARD)

Figure 47 Overview of Horizon 2020 contribution per country and research intensity of countries (as % of GDP)



Source: European Commission, DG RTD, unit A5, based on CORDA (Annual Monitoring Report 2015) and Eurostat data (2015).

The Europe 2020 strategy also put forward seven flagship initiatives. One of these is the 'Innovation Union'. Horizon 2020 implements the Innovation Union by bringing together all existing EU research and innovation funding, providing support in a seamless way from idea to market, through streamlined funding instruments and simpler programme architecture and rules for participation. Horizon 2020 implements a number of the specific commitments made in the Innovation Union, notably in: focusing on societal challenges, simplifying access, involving SMEs, strengthening the ERC, strengthening financial instruments, supporting public procurement of innovation, facilitating collaboration, and supporting research on public and social innovation.

In the context of the Innovation Union, the 2016 edition of the **Innovation Output Indicator[158] shows progress compared to the start year 2011 and the year before. On average, the indicator has progressed by about one percentage point per year in the reference period.** National performance varies significantly compared to the respective baselines. For this indicator as well, it is not possible to establish a clear correlation between the performance of Member States in terms of the Innovation Output Indicator and the share of Horizon 2020 funding in their GDP.

[158] The Innovation Output Indicator has 2014 as the latest reference year for the underlying data and is based on five output indicators (PCT patents, employment in knowledge-intensive activities, knowledge intensive exports and services, innovativeness of fast-growing enterprises)

Having marked a definite shift towards innovation, Horizon 2020 has contributed significantly to this flagship. The Innovation Union was evaluated in 2015[159] to take stock of the progress and set out next steps. The overall conclusion was: *'Six years after the Innovation Union was launched as one of the pillars of the Europe 2020 growth strategy, the evaluation shows that impressive progress has been made in numerous fields. Great progress has been achieved in making Europe a more innovative continent since the launch of the Innovation Union in 2010. Nevertheless, the world has evolved since then and new elements need to be taken into account to better tackle the challenge of innovation in Europe*'. There is still uncertainty about some of the legislative actions mentioned in the Innovation Union, regarding the Unitary Patent. The commitments that require greater involvement of Member States appear to have progressed to a lesser extent, either because of the long legislative processes (e.g. directives ratification), or because they are less binding in nature.

Figure 2 Innovation Output Indicator per EU Member State and share of Horizon 2020 contribution in GDP

Indicator	IOI (EUR)		% Horizon 2020 in GDP
Year nominal	2011	2014	2014
EU28	100,0	103,6	0,06%
Austria	95,3	104,0	0,07%
Belgium	100,5	99,8	0,09%
Bulgaria	61,6	68,3	0,03%
Cyprus	92,7	105,5	0,16%
Czech Republic	84,6	90,4	0,03%
Germany	118,9	120,8	0,06%
Denmark	116,7	114,9	0,08%
Estonia	78,5	78,1	0,15%
Greece	74,5	73,5	0,10%
Spain	84,2	83,7	0,07%
Finland	112,4	112,2	0,09%
France	105,7	110,8	0,04%
Croatia	62,9	59,8	0,03%
Hungary	92,4	92,7	0,05%
Ireland	119,3	122,3	0,08%
Italy	90,6	89,9	0,04%
Lithuania	61,5	58,5	0,02%
Luxembourg	133,8	117,5	0,05%
Latvia	72,3	70,6	0,05%
Malta	75,0	87,3	0,04%
Netherlands	103,5	106,5	0,10%
Poland	79,1	81,2	0,02%
Portugal	70,7	73,0	0,08%
Romania	71,3	75,0	0,02%
Sweden	127,2	124,5	0,07%
Slovenia	85,5	87,2	0,11%
Slovakia	87,5	91,6	0,01%
United Kingdom	105,6	110,5	0,06%

Source: European Commission, DG RTD, based on Corda and Eurostat data

The Digital Agenda for Europe aspires to make every European digital. The contribution of Horizon 2020 to the Digital Agenda is analysed in the box below.

Box: Contribution of Horizon 2020 to the Digital Agenda for Europe

The Digital Agenda for Europe – a Europe 2020 Flagship aspires to make every European digital. The EU's Digital Single Market Strategy[160], launched in May 2015, builds on these foundations, aiming to remove regulatory barriers and move from 28 national markets to a single one, to unlock online opportunities and make the EU's single market fit for the digital age. This was followed by a communication package outlining plans for Digitising the European Industry (DEI) in 2016. The forward looking strategy aims at bringing the technologies which are driving the new industrial revolution to European industry and society. Horizon 2020 is a key instrument to support the DEI objectives. The Digital Agenda indicator allows tracking spending related to digital R&I throughout Horizon 2020. Preliminary data - based on an indicator[161] aimed at estimating the ICT component of

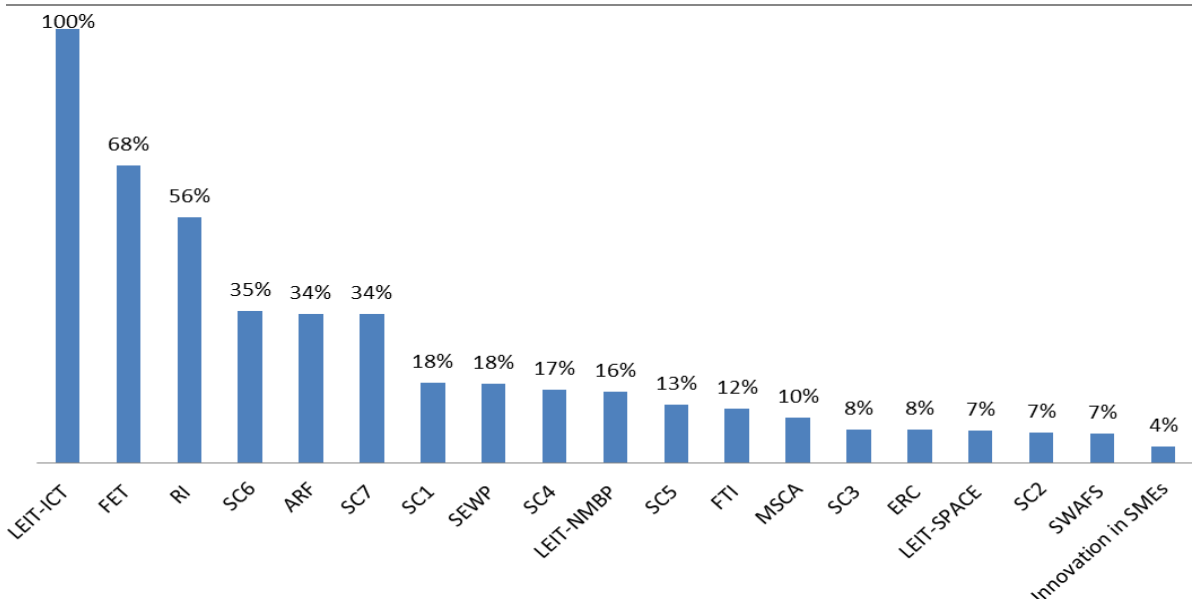
[159] Available at http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2015/state_of_the_innovation_union_report_2015.pdf

[160] Available at: http://europa.eu/rapid/press-release_IP-16-1407_en.htm

[161] "Digital Agenda" tracker, based on the RIO-marker methodology: Projects for which ICT R&I is the principal (primary) objective are marked with 100%, indicating that 100% of the project budget contributes to ICT R&I. Projects for which ICT R&I is a significant, but not predominant objective are marked with 40%, indicating that 40% of the project budget contributes to ICT R&I. This indicator has been recently introduced and may be subject to furhter refinement.

projects - for the calls up to January 2017 show that about EUR 5.3 billion (or 30% of overall EC funding in Horizon 2020) are contributing to ICT R&I, thus providing an important input to the progress towards the Digital Single Market objectives. This budget goes beyond what is allocated through dedicated topics to ICT and signals the cross-cutting nature of digital technologies and their societal relevance.

Figure 49 EC Contribution to the Digital Agenda, Share of EC contribution (%), by programme part



Source: CORDA data, extraction 1 January 2017

8.2.3. Progress on delivering close to market outputs and diffusing innovation in products, services and processes

One key objective of Horizon 2020 is to deliver close-to market outputs and diffuse innovation in products, services and processes (proof-of-concept, demonstration activities, innovations on the market, growth of participating companies). There are already signs of progress on this front, mostly from the few SME Instrument and ERC Proof of concept completed projects, and the review of a set of ongoing projects. However there are also already indications that more could be done to support service innovation and user-driven innovation and to alleviate barriers to reach the market and ensure innovation take up.

8.2.3.1. Proof of concept, demonstration and deployment

Figure 50 Horizon 2020 Key Performance Indicators related to proof of concept, demonstration and deployment

Key Performance Indicators (KPIs)	Progress so far / Target
Proof of concept, demonstration and deployment[162]	
Within the innovation actions, share of EU financial contribution focussed on demonstration and first-of-a-kind activities	86.5% was focussed on demonstration and 7.7% of first of a kind activity
Number of prototypes	229
Number of testing activities	801
Nr. of clinical trials	81
Nr. of projects with innovative products	160
Nr. of projects with innovative processes	73
Nr. of project with innovative methods	76

[162] Based on beneficiary reporting.

Key Performance Indicators (KPIs)	Progress so far / Target
Number of participating firms introducing innovations new to the market ..(of these SMEs)	538 (299) Target: 50% of participating SMEs introducing innovations new to the company or the market (period of the project plus 3 years)[163]
Number of participating firms introducing innovations new to the company ..(of these SMEs)	471 (251)

Source: Corda, Signed Grants cut-off date by 1/1/2017

Even if this is still early in terms of implementation, **Horizon 2020 is already making progress in supporting proof-of-concept, demonstration and deployment of innovative solutions but this could be further reinforced.** Currently, 87% of the funding within innovation actions is allocated to demonstration actions and 8% to first-of-a-kind activities[164]. Results from the Fast Track to Innovation (FTI) pilot are presented in a dedicated section (8.2.3.5). Internet of Things (IoT) large scale pilots launched in 2016 will notably make use of the portfolio of technologies and tools so far developed and demonstrated in reduced and controlled environments and extend them to real-life use case scenarios with the goal of validating advanced IoT solutions across complete value chains with actual users and proving its enormous socio-economic potential.

Not surprisingly given their shorter term nature and their higher TRL, **projects within the SME instrument (Phase 2) are producing so far more closer to market outputs per EUR 100 million compared to other types of action**, followed by innovation actions. So far, **3.6% of participating SMEs introduced innovations new to the market and 3.0 % innovations new to the company.** According to the thematic assessment of the SME Instrument, Phase 1 of the SME Instrument is effective in fostering a better understanding of the feasibility of an innovative idea and its development among the beneficiaries. Positive effects were created also on the SMEs' strategic intelligence and their capacity to manage innovation processes. The integral coaching system set up for both Phase 1 and Phase 2 projects has been an important enabling factor for these positive developments among the beneficiaries. Clear benefits include e.g. fine-tuning the business plan, and better networking. **Phase 1 SME Instrument beneficiaries show a steeper growth path than unsuccessful applicants, as well as in their capacity to take a strategic approach to risk identification and management.** Other areas of major improvement were 'innovation project formulation', 'idea management and involvement of staff, clients, and suppliers in innovation' and the 'overall innovation strategy' (30% of respondents).

The LEIT projects are also on track to deliver innovations (output involves demonstrators, pilots, and increase in the TRLs visible) and bring clear market orientation. Nevertheless, related to the emphasis to higher TRLs **some concerns were raised by the experts on an apparent trend of diminishing funds in Horizon 2020 for lower TRLs (2-4).** In particular, in the field components and systems (LEIT ICT) while the investment in ECSEL to address industrial challenges is well justified, the diminishing funds in Horizon 2020 for lower TRLs raise concerns. Notwithstanding the impact orientation, for NMBP, there are concerns regarding the limitations to cover for the lower TRLs (between blue sky research and TRL 3-4 e.g. FETs).

[163] Based on survey of beneficiaries.
[164] The remaining 5% of the projects are not classified.

Box: Illustrations of how proof of concept, demonstration and diffusion of innovation are supported under Horizon 2020

The **ERC Proof of Concept Grant** (PoC) aims to explore the commercial and social potential of ideas arising from ERC grants. Since 2011 there have been around 540 Proof-of concept projects supported and 180 concluded. Of the first 140 projects around 20% of them spun-out a new venture. In November 2015 the European Business Angels Network (EBAN) awarded its first-ever prize for "Innovation in Science Venture Finance" to the ERC as recognition of its efforts to bring frontier research closer to the market[165].

LEIT ICT projects aim at translating R&I into commercially viable undertakings, thus helping bridge the gap between research and the market. Ongoing projects include Demonstrating/Piloting Activities primarily relating to areas such as Content Technologies and Information Management, Robotics and Future Internet, Micro-and Nanoelectronics and Photonics and the ECSEL JU. First of a kind market replications are expected in a number of projects. The **Innovation Radar** identified 274 innovations in Horizon 2020 ICT projects[166], the majority of which are significantly improved products or new products which are going to be exploited either commercially (170 innovations) or internally by the organisations (61). For some of them (53) there are no plans for exploitation yet.

According to the **LEIT-NMBP** assessment, 75% of the projects aim at developing a new product; 60% a new process; 24% a new service[167], and 4% an organisational or business model innovation. Particularly relevant are demonstrators on technology integration in an industrial environment, for example those from the dedicated Pilot Lines call, which include also open access pilot lines for SMEs. A total of 77 pilot lines have been developed so far. The NMBP work programme has set out specific requirements with regard to an initial description of the business plan already at proposal stage. This requirement stems from evidence that dealing with business plans at the end of the projects would be too late to be effective.

The FET Innovation Launchpad is modelled after the ERC Proof-of-Concept scheme and seeks to give innovators and entrepreneurs freedom and flexibility to innovate from results of previous or ongoing FET-funded projects. In order to create a wider and more diverse support base from which to take these innovations forward, the participation of new actors and of young and high-potential researchers and high-tech innovators is further encouraged in FET WP2016-17 (already with success in WP2014-15).

Under **Societal Challenge 2** flagship projects are expected to create direct and indirect employment in some of the lagging regions of Europe. For example, the FIRST2RUN project is a flagship demonstration of an integrated biorefinery which is expected to revitalise local economies across Europe by reconverting old industrial sites and creating skilled jobs: an estimated 60 new skilled jobs will be created for every kiloton of bioplastics produced, taking into account the whole value chain, from agriculture to the end life of the final products.

Under **Societal Challenge 7** the C-Bord project intends to develop and test a comprehensive and cost-effective solution for the inspection of containers, and large-volume freight, in order to protect EU borders. In doing so, it proves its capability through live field trials under real conditions at different border control points

8.2.3.2.Market-creating innovations and disruptive technologies

Looking at the disruptive character of the innovations supported by Horizon 2020 which could have the potential to generate growth and jobs, **there are already expectations of innovation breakthroughs but the early stage of programme implementation does not allow seizing the potentially ground-breaking impact of longer term projects**.

Innovation actions belong to the key new actions introduced in Horizon 2020 to help bringing discoveries to the market. Most of them demonstrate the application of new knowledge in real-life conditions. The very first projects started in 2014 and it still is too early for them to produce final results (expected only in 2018-2019). Looking into the projects based on proposal texts of 227 innovation actions a study[168] identified three categories of projects:

[165] http://www.eban.org/eban-winter-university-2015-in-copenhagen-highlights
[166] Data up to July 2016.
[167] indicating that these will play a role in the current tendency in European industry to introduce services.
[168] Grimpe, C. et al., Study on innovation in Horizon 2020 Innovation Actions - A content analysis of 233 innovation project proposals awarded in 2015, Final report to the European Commission, 2017. For this study, 227 Innovation Actions were

- 'Pioneering' projects: scoring high on technological novelty, market scope and innovation readiness, but low on ecosystem embeddedness (64 projects out of the 227 projects). They seem to focus on breakthrough technological results that may create markets. Pioneering projects involve relatively more private companies, esp. SMEs, and research institutions.
- 'Diffusing' projects: emphasising ecosystem embeddedness and scoring lower on the other three aspects (58 projects). They aim at the diffusion and exploitation of the innovative solution in the ecosystem. The diffusing projects involve less companies and more public bodies.
- 'Sustaining' projects: the remaining 105 projects pay only modest attention to each of the four aspects. They are dominated by higher education institutions.

Whereas it is still too early to characterise these innovation actions and their impacts, these initial findings indicate that **a quarter of innovation actions have a disruptive, market-creating potential, and that companies and research institutions play a leading role in these initiatives**.

As another new instrument to directly support innovation, the assessment of **the SME Instrument** shows that it **caters for different types of innovation strategies, including both incremental and disruptive innovation strategies and the relatively short innovation cycles of SMEs**. A large majority of SME Instrument surveyed applicants state that their project has the potential to shape/ create new markets (74% think so to a large extent), to change value chains (67%), and is technologically new (56%). Moreover, a majority of respondents finds their innovation project radical (60%). However the SME Instrument focusses especially on product innovations,[169] product performance innovations, business model innovation. **Service innovations, network innovations, and customer engagement innovations are less supported**. Interviewees, agencies and SMEs surveyed all concur in their assessment that **the SME Instrument is an effective tool to speed up the introduction of innovations on the market**. **More than half (53%) of Phase 2 beneficiaries have already reached the market, or expect to do so in less than one year.** A relatively high proportion of multi-beneficiaries from both Phase 1 and Phase 2 together reported that their innovation was already on the market (24%).

Box: The Open Disruptive Innovation scheme under the SME instrument[170]

The Open Disruptive Innovation (ODI) scheme is the most popular topic within the SME instrument (one-third of proposals submitted). According to project participants, it contributes to the growth of highly innovative SMEs including start-ups. The most popular innovation fields of applicants include health, photonics and cloud computing. The case study interviews and desk research indicated that projects which implemented at least one Phase of the ODI scheme gradually increased their turnover and number of employees. Phase I supported in developing business market strategy which helped to expand their innovative product further. The turnover already increased slightly and the participants are expecting a gradual increase in the following years.

Many disruptive innovation products and services implemented under the ODI scheme have been commercialised and put to widespread use. For instance, after Phase I Global PERES, which offers an innovative device and mobile application designed to detect freshness of product and a risk of food poisoning, became popular in Europe and in the US.

selected that started in 2015. The texts of the granted projects were analysed using content analysis methodology, based on keywords that indicate four innovation aspects: technological novelty, market scope, ecosystem embeddedness and innovation readiness.

[169] Not normalised for a potential overrepresentation of successful applicants, which causes relatively high percentages.

[170] Source : CARSA study

Project participants indicated that the ODI scheme supported their disruptive innovation to be further developed and expanded. Particularly Phase I was pointed out as essential. It supported SMEs to gain more knowledge and experience of entering to new markets and further helped to build a contact network for new potential clients. Project participants indicated that throughout the Phase I they all have established good networks in Europe. Overall, the scheme is highly selective with a funding rate of 5,3% of the total ICT submissions. According to desk research unsuccessful proposals often fail due to the lack of a) market analysis to assess the competition and b) a robust and realistic emphasis on the commercialisation at the end of the project. There is only a small amount of projects which received grants for Phase II after the implementation of Phase I.

Beyond the Innovation Actions in the cPPPs, the LEIT-NMBP portfolio has also a fair share of projects that are new to the world or at least the EU (41%), according to the coordinators. The remainder (59%) is somewhat less novel, mostly a combination of existing technologies and their adaptation to another application area or sector, or to the specific production processes of a company (new to the company). The degree of 'radical' innovation seems to be a matter of individual project ambition, can be related to the expected impacts in topics, or is inherent in the technology (e.g. nano-medicine, biotechnology). **The ambition in terms of innovation is higher in RIA projects and projects with lower TRLs. Interestingly, projects coordinated by a private company are also associated with a higher level of ambition in terms of innovation than the ones led by a higher education institution or a research institute.**

A Commission consultation (Call for Ideas[171]) conducted in 2016 revealed that **a large number of stakeholders consider that important gaps still exist in EU support for disruptive, market-creating innovation and other forms of support for young innovative companies, such as effective mentoring and coaching schemes**; that a genuinely bottom-up approach should be introduced to allow projects from any sector(s) to apply for funding; and that the funding instrument landscape remains too complex and difficult for innovators to access.

As presented in the Box below, while supporting established innovators and technological novelty, the programme has not been able yet to fully capture the potential of young, fast-growing companies.

Box: The involvement of leading companies in Horizon 2020

Comparing various lists of innovative companies with the Horizon 2020 participants, many of the top 'established' innovative companies take part, but – despite many positive examples, e.g. in the health sector[172] – **almost none of the young and quickly growing innovative companies take part to Horizon 2020**. Bigger companies and established innovators included in the European Patent Organisation top 50 European Patents Applicants, the R&D Scoreboards, and Thomson Reuters top global innovators rankings are greater beneficiaries of Horizon 2020 funds than younger innovators from the Wired Europe's hottest start-ups, Deloitte's fastest growing European tech companies, Forbes' most innovative companies, and CB Insights' Unicorns list. Out of the first ranking only two benefited from Horizon 2020 funding thus far. Additionally, CB Insight's list of unicorns or young fast growing companies reaching a capitalisation of $1 billion indicates that 18 out of the 176 are EU-based. Yet, no company in this list is currently benefiting from Horizon 2020. In similar lines, only 12% of the companies from the MIT smartest companies and 3% from the Forbes most innovative companies rankings participate in Horizon 2020.

8.2.3.3.Growth of participating companies

Across the thematic assessments, **Horizon 2020 is seen as generating a potential to improve the competitive advance of participants. The expected improvement mainly re-**

[171] https://ec.europa.eu/research/eic/pdf//eic_call_for_ideas-overview.pdf#view=fit&pagemode=none
[172] In Societal Challenge 1 (SC1 - health), Horizon 2020 has funded 2 of the 11 top spin-off European healthcare companies which later became unicorns: Galapagos and Immunovia.

lates to access to new markets and the competitive position of partners internationally. While it is too early to have information on the growth of participating companies, early evidence collected in the thematic assessment suggests that **the SME Instrument has a good potential to reach its intended effects on the profitability and growth of the beneficiary innovative SMEs**. **There are clear indications that SME Instrument beneficiaries realise faster growth paths than control groups and the scale-up of their activities is more likely and/or more significant**. Phase 2 beneficiaries that went through Phase 1 report higher profitability, while Phase 2 beneficiaries report stronger market presence, even at the implementing stage of their project. The SME Instrument is intensively used by start-ups, especially the Phase 1 strand. The characteristics of Phase 2, in terms of e.g. time-to-grant and cash flow constitute a hindering factor for a more intensive participation of start-ups in that component of the instrument.

Based on a review performed under SC2, **expected direct impacts on growth and jobs of 55 SME Phase 1 and 26 Phase 2 projects under SC2 include EUR 1.5 billion / EUR 1 billion of additional turnover for the next five years, and the creation of 1500 / 1000 jobs over the next three years respectively.** These impacts do not include indirect impacts generated through supply chain and multiplier effects.

Providing an indication of potential growth paths, an external study[173] found evidence of the improved research capabilities and excellence of the FP7 research teams. According to the counterfactual analysis of FP7 survey data, the beneficiary teams grew indeed at 24.4% versus 12.6% in the control group. **The estimated impact of the EU FPs on the growth of the research teams is thus positive and amounts to 11.8%.** Based on the counterfactual analysis of R&D budget data, it was further estimated that the beneficiary teams increased their R&D budgets by 22.4% since their application for EU funding. The corresponding value for the non-FP teams was -2.2%, leading to a **24.6% difference in the budget leverage created due to participation in the EU FPs.**

Barriers to innovation

From the thematic assessments **the factors that have been identified as potentially impeding full effectiveness in terms of fostering innovation with respect to market uptake and commercialisation are mainly technological, but relate also to the capacity of innovation systems to address a range of issues, from regulation and standards to technicalities and access to finance, to customer acceptance of new solutions and a lack of access to a sufficient pool of end-users.** There is also no evidence available so far on approaches allowing for the identification of the dual-use potential of project results with a view to diversify their market potential.

A study by the European Investment Bank on Access to Finance for KETs companies[174] shows that many KETs companies, especially small and middle-sized ones, struggle or fail to obtain adequate debt financing, hampering their uptake of new technologies. Despite the favourable conditions of the market, the banking sector does not meet the specific needs of many KETs companies, because of a general aversion to risk, but also because of a lack of knowledge of the KETs sectors.

[173] PPMI study, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming.
[174] Available at: http://www.eib.org/attachments/documents/innovfin_access_to_finance_conditions_kets_en.pdf

53% of the public consultation respondents think that Horizon 2020 is fully or to a large extent helping to foster European industrial leadership. Only 3.6% think this is not the case at all. The most positive respondents are businesses. If the contribution of the programme to this objective is assessed positively by a large majority of respondents, a comparatively low number of respondents (17%) agreed fully with this statement, which is far less than the number of respondents who did so for the contribution of the programme to fostering excellence in science.

8.2.3.4. Specific focus on the Fast Track to Innovation pilot

The Fast Track to Innovation (FTI) has been implemented in the form of a full-scale pilot in 2015 and 2016. It addresses industry-driven consortia seeking quick market uptake of new solutions. It offers substantial funding to test, demonstrate and validate innovations that can be co-developed by all sorts of actors with complementary backgrounds, knowledge and skills, with the aim to (re)shape value chains. **The FTI pilot evaluation concludes that the FTI is deemed a useful addition to the portfolio of Horizon 2020 instruments and needs continued support; given the levels of demand, the budget of EUR 100 million per year could be increased by at least double**[175]. Key aspects of the evaluation are summarised in the table below.

Figure 51 Key findings from the Fast Track to Innovation pilot evaluation

	Key findings of the evaluation of the Fast Track to Innovation Pilot
Contribution to innovation	The FTI is highly relevant to the broad policy goals of Horizon 2020 to promote innovation and its application. The main focus of the FTI is to take mature ideas to the market within a period of three years, by supporting a wide spectrum of activities from validation and piloting to testing and EU quality labelling. Most coordinators of funded projects made reference to overcoming barriers regarding the scale and scope of demonstration and validation activities thanks to FTI support, thereby substantially reducing risks and increasing attractiveness for future investors. 82% of the project coordinators are developing product innovations; process (29%), service (21%) and organisational (4%) innovations are also supported. 89% of project coordinators is convinced that successful completion of their projects will lead to world novelties, while an even higher percentage (96%) indicated that their innovation under development is radical – and not merely incremental – in nature. This will be re-examined in the context of the final evaluation of the FTI pilot
Industry participation	75% of all call beneficiaries in 2015 are private-for profit organisations (i.e. industry); together they will absorb over 70% of the 2015 call budget. 46.5% were registered SMEs (95 individual entities in total). This ensures market relevance and prospective tangible return on investment in the FTI, including by providing a stepping stone to scale-up of participating companies, in particular SMEs. With respect to the latter, the funding impact could be strengthened with mentoring support to participating companies. Only 16% of funding available under the call in 2015 is to go to companies counting more than 1,000 FTE – i.e. larger companies; nevertheless, as part of the stakeholder consultation feeding into the assessment, some parties called for reconsidering the intervention rate of 70% - uniform across Horizon 2020 - for this type of entities, referring to the risk for deadweight, even if FTI project coordinators and unsuccessful applicants indicated that the intervention rate and access to funding were respectively only the fifth and the seventh most important reason (out of ten) to apply. A breakdown by NACE codes helps to understand the main areas of commercial activity of

[175] 'Assessment of the 2015 Response to the Fast Track to Innovation Pilot (FTI Pilot). The assessment is mainly based on qualitative input from the side of early-stage project coordinators.

	Key findings of the evaluation of the Fast Track to Innovation Pilot
	funded firms; Architectural and Engineering Services (NACE M71) was the most prominent activity (15.1% of the firms), followed by Manufacture of machinery and equipment (NACE C28, 9.1%), Scientific Research and Development (NACEM72, 9.1%), Manufacture of computer, electronic and optical products (NACE C26, 8.6%) and Computer programming, consultancy and related activities (NACE J62, 6.6%).
Participation of newcomers	FTI emerged as the third most attractive Horizon 2020 activity, with 41.1% new industry applicants, following a comparison between FTI actions, other innovation actions and SME instrument actions across Horizon 2020 priorities in terms of new applicant participation Around 40% of FTI applicants indicated that they had previously participated to FP7; this can be explained by the fact that the FTI – unlike the SME instrument for instance – targets consortia, which by definition require connections and operational experience for their construction and administration to be successful.
Operational effectiveness and financing	Certain administrative requirements (in particular the need to comply with most of the standard features and templates for innovation actions) are deemed to have a restraining effect on the FTI's potential effectiveness. Average time-to-grant (TTG) was progressively reduced over the three cut-off dates in 2015, but with 237 days is nowhere near the six months defined in the legal base. Only 25% of project coordinators considered that they would achieve the target of reaching full commercialisation three years after project start. This raises the concern that projects are selected which have relatively mature innovation development and/or which lack adequate preparation and planning for the commercialisation process, which points to a potential lack of commercial investment expertise at the level of the evaluators. In order to ensure selection of more appropriate projects, clearer guidance on the role of Technology Readiness Level (TRL) classification is recommended, together with more emphasis on business plan and market readiness during the appraisal process, as well as a review of the competencies of experts selected for appraisal, possibly in connection with a specific call for experts with direct commercial experience to add to the existing pool.
Leverage of private investment	Project coordinators were asked whether or not since starting their projects their innovation had received further external investment. A third (32%) was either in receipt of or had plans for external investment in place. However, 29% also indicated that there had been no external investment in their innovation and did not expect any in the future. These figures may while change as projects – which were at best launched since six months at the time of the survey – progress along the innovation cycle. Follow-up interviews suggest that leveraging further investment is difficult. Most often, investors wait on the technology to be demonstrated at a large/commercial scale which points to the need for specific mentoring/coaching services

Source: FTI pilot evaluation

8.3. What is the progress made towards achieving societal impact?

Horizon 2020 responds to the policy priorities and societal challenges that are identified in the Europe 2020 strategy and aims to stimulate the critical mass of research and innovation efforts needed to achieve the Union's policy goals.

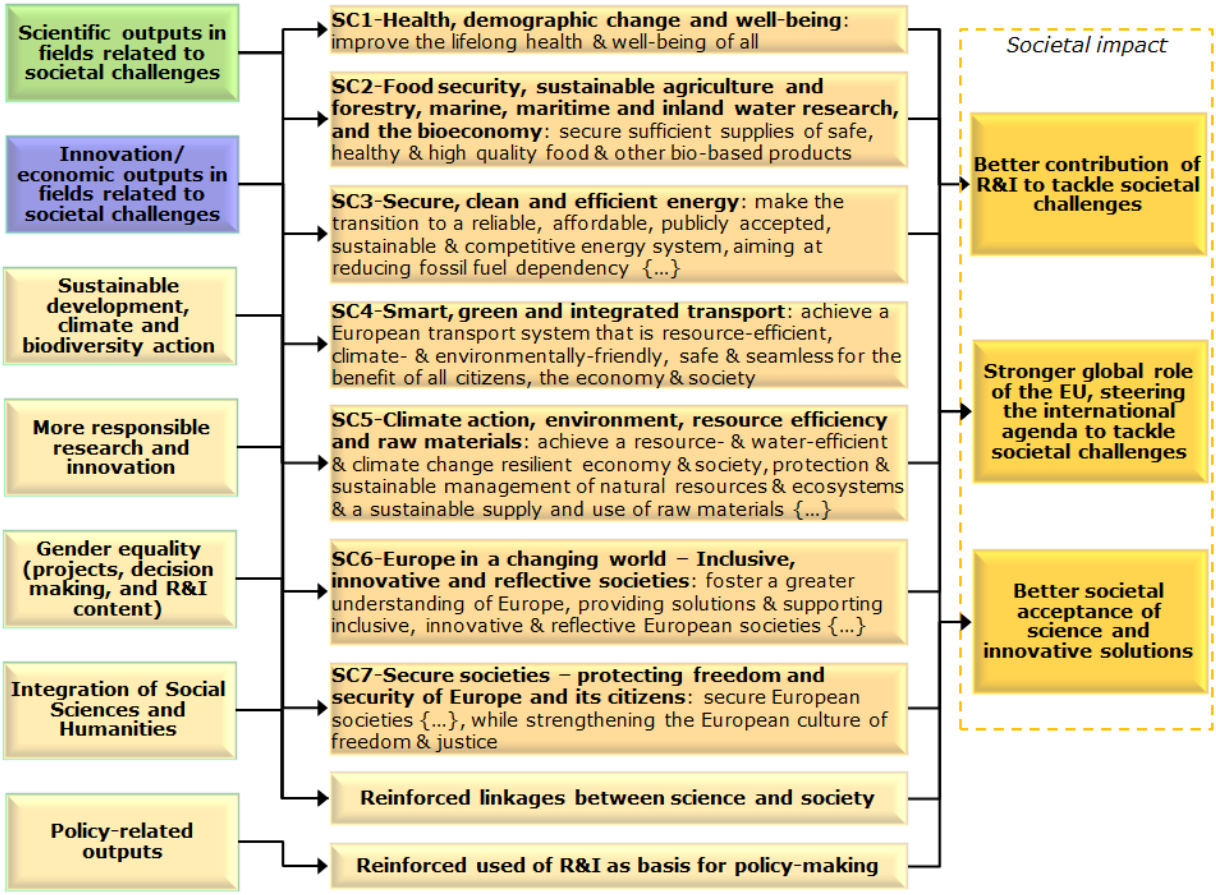
Expectations from Horizon 2020 for achieving societal impact

Whereas FP7 was focused on specific domains, Horizon 2020 puts **more emphasis on societal impact** and aims at contributing through research and innovation to tackling the major societal challenges Europe and the world are facing. This means bringing together different technologies, sectors, and scientific disciplines to find new solutions to these challenges but also taking on a stronger role at global scale for tackling these challenges. Progress is expected to depend on the typical results of R&I projects (e.g. scientific outputs, innovations) in domains of societal relevance.

As a **continuation to the Science in Society programme** in FP7, a dedicated programme part on "Science with and for society" is also included in Horizon 2020. The overall aim is to build effective cooperation between science and society, to recruit new talent for science and to pair scientific excellence with social awareness and responsibility. In parallel, gender equality, responsible research and innovation, and social sciences and humanities became cross-cutting issues promoted throughout the programme.

Figure 52 provides an overview of the approach used for analysing progress towards the achievement of societal impact. Overall progress of Horizon 2020 towards societal impacts relies on one hand on the scientific and innovation/economic outputs/results/impacts (discussed in the previous sections) in fields related to societal challenges and on more horizontal progress on cross-cutting issues supported across the programme such as sustainable development, climate and biodiversity action, more responsible research and innovation, gender equality, the integration of Social Sciences and Humanities (SSH) in R&I projects and the generation of outputs for policy.

Figure 52 Approach towards analysing progress towards societal impact



Source: European Commission

Summary box: Key findings on the progress towards achieving societal impact

- ✓ Most Horizon 2020 projects, not only from the 'Societal challenges' pillar but also from the 'Excellent science' and 'Industrial leadership' pillars, are expected to generate key discoveries and technologies and cross-cutting societal impacts.
- ✓ The portfolio of Horizon 2020 projects selected under the 'Societal challenges' pillar and their progress are so far in line with the objectives set.

- ✓ Horizon 2020 projects already produce numerous results like publications, patents, prototypes, products, processes and methods in domains of societal relevance.
- ✓ Horizon 2020 has not yet met the targets for expenditure on sustainable development and climate action but it is expected that they will be achieved by the end of the Programme.
- ✓ Stakeholders are less convinced about the role of Horizon 2020 in the resolution of societal challenges than in the achievement of knowledge-related objectives, which seems to call for better involvement of end-users and communication with citizens on the contribution that R&I can make to tackling societal challenges.
- ✓ Progress is made with respect to promoting gender equality under Horizon 2020 but data quality concerns remain.
- ✓ Results are encouraging in terms of the integration of social sciences and humanities and responsible research and innovation in Horizon 2020, even if highly uneven across the programme.

8.3.1. Tackling societal challenges

Horizon 2020 is supporting seven Societal Challenges (SC) as depicted in Figure 52. The Societal Challenges pillar has so far received 36.3% of Horizon 2020 funding (EUR 7.4 billion), with the largest share going to the energy challenge (SC3 - 8.6% of Horizon 2020 funding), followed by the health challenge (SC1 - 7.6%) and the transport challenge (SC4 - 7%), with the security challenge (SC7) receiving the smallest share (2.3% of the overall funding).

The existing monitoring indicators under Horizon 2020 relate to classical outputs from R&I projects (e.g. publications, patents, prototypes) but not to their societal impact in the medium to long term on e.g. decreasing CO2 emissions, improving health of citizen or their security. On these no structured information is collected so far partly because of the difficulty to establish direct links between individual projects' outcomes and long-term impacts, notably given the time needed for the impact to be observable, and the already discussed problems of attribution. However further efforts should be made to identify whether projects under the Societal Challenges pillar are on track towards the delivery of outputs/results/impacts of benefits for society beyond more classical R&I indicators.

Figure 53 KPI for the Societal Challenges Pillar of Horizon 2020

	Publications in peer-reviewed journals	Patent applications and patents awarded	Number of prototypes and testing activities	New products, processes, and methods launched into the market
Health, demographic change and wellbeing (SC1)	280	18 patent application & 11 patents awarded	101	16
Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy (SC2)	172	5 patent application & 1 patents awarded	9	1
Secure, clean and efficient energy (SC3)	132	31 patent application & 4 patents awarded	370	41
Smart, green and integrated transport (SC4)	62	11 patent application & 4 patents awarded	30	13
Climate action, environment, resource efficiency and raw materials (SC5)	115	8 patent application & 3 patents awarded	61	24
Europe in a changing world - inclusive, innovative and reflective societies (SC6)	21	0 patent application & 0 patents awarded	1	2

	Publications in peer-reviewed journals	Patent applications and patents awarded	Number of prototypes and testing activities	New products, processes, and methods launched into the market
Secure societies - protecting freedom and security of Europe and its citizens (SC7)	27	3 patent application & 0 patents awarded	28	9
For all of Societal Challenges	**809**	**76 patent applications & 23 patents awarded**	**600**	**106**

Source: Corda, calls until end 2017, Signed Grants cut-off date by 1/1/2017

From the information available so far, as of 1 January 2017, the 2,941 projects selected under the Societal Challenges pillar already generated **809 peer-reviewed publications, mostly from the health, food / bioeconomy, energy and environment domains.** Out of the **76 patent applications and 23 patents already awarded to Horizon 2020 projects under the Societal Challenges pillar**, the majority is coming from the energy projects, followed by health and transport. Also more than half of **the 600 prototypes and testing activities already developed under Horizon 2020** are coming from the energy projects, which are also the strongest contributor to the **launch of 106 new products, processes and methods into the market**.

According to a survey of Horizon 2020 projects coordinators all projects supported under the Societal Challenges 1-7 are expected to contribute to their specific challenges in the next 10 years (see Figure below). **Projects under certain Societal Challenges (esp. SC1 'Health') are challenge-specific, whereas the projects in other Societal Challenges (e.g. SC3, SC5, SC7) and LEITs (e.g. NMPB, ICT) are expected to generate more cross-cutting impacts.** Survey data indicates particularly strong complementarity of projects between environmental objectives and bioeconomy, energy and transport (SC1 with SC2, SC3, and SC4), as well as between societal objectives and health (SC6 and SC1). The expected contribution of Excellent Science and Industrial Leadership projects to the societal challenges is rather evenly spread but some strong features emerge:

- Many projects under FET are expected to have a wider impact on Societal Challenges related to energy and the environment/climate (SC3 and SC5);
- Research Infrastructures are expected to have particularly impacts on health and food/ bioeconomy (SC1 and SC2);
- LEIT-NMPB projects are expected to have particularly impacts on health and the environment/climate (SC1 and SC5). The Public Private Partnerships under LEIT-NMPB are expected to have particularly impacts on energy and environment/climate (SC3 and SC5, related notably to the cPPP on Energy-efficient Buildings and SPIRE); The enabling nature of the NMBP programme involves support for technologies pointing to the next generation of solutions across societal challenges (addressing health, energy, climate action, the circular economy);
- LEIT-ICT projects are expected to have particularly impacts on health and societies (SC1 and SC6). The thematic assessment also shows that health, inclusion, security, energy and societal aspects play a strong role in LEIT ICT.
- LEIT-Space projects are expected to have particularly impacts on transport (SC4) and security (SC7).

Figure 54 Do you expect in the next 10 years your project to have a wider impact on any of these societal challenges? Share of project coordinators saying YES per Horizon 2020 programme part (representative sample)

Horizon 2020 programme part	SC1	SC2	SC3	SC4	SC5	SC6	SC7
Excellent Science							
Future and Emerging Technologies (n = 16)	33.3%	40.0%	57.1%	20.0%	52.4%	30.0%	25.0%
Research Infrastructures (n = 27)	52.2%	52.4%	23.8%	18.2%	43.5%	40.9%	36.4%
Industrial leadership							
LEIT-NMPB (n = 96)	42.4%	29.0%	52.6%	23.2%	61.9%	18.0%	14.6%
Subtotal within NMPB: PPP projects (n=32)	25.9%	7.0%	69.6%	19.8%	68.3%	23.4%	9.7%
LEIT-ICT (n = 177)	52.0%	21.5%	32.2%	34.5%	30.0%	55.8%	38.5%
LEIT-Space (n = 36)	28.2%	31.4%	33.1%	52.3%	44.0%	29.0%	50.6%
Innovation in SMEs (n = 30)	24.4%	24.3%	26.8%	19.9%	19.9%	26.0%	21.5%
Societal Challenges							
SC1: Health. demographic change and well-being (n = 106)	98.1%	9.8%	1.7%	2.1%	5.3%	35.6%	9.6%
SC2: Food security. sustainable agriculture and forestry. marine. maritime and inland water research. and the Bioeconomy (n = 43)	49.2%	98.6%	21.4%	4.6%	86.4%	25.8%	14.2%
SC3: Secure. clean and efficient energy (n = 124)	21.4%	19.0%	97.5%	34.2%	86.6%	29.4%	17.7%
SC4: Smart. green and integrated transport (n = 96)	26.1%	9.3%	38.5%	96.1%	62.0%	28.9%	23.4%
SC5: Climate action. environment. resource efficiency and raw materials (n = 71)	39.2%	57.9%	57.9%	28.5%	95.7%	34.5%	26.0%
SC6: Inclusive. innovative and reflective societies (n = 32)	53.6%	16.5%	17.5%	20.7%	32.5%	90.2%	35.9%
SC7: Secure & innovative societies: protecting freedom and security of Europe and its citizens (n = 31)	38.6%	33.3%	25.7%	36.2%	30.2%	53.1%	93.3%
SWEP- SWAFS - FTI – Euratom							
Spreading Excellence and Widening Participation (n = 24)	64.0%	44.0%	52.0%	26.9%	44.0%	51.9%	35.7%
Science with and for Society (n = 10)	57.1%	50.0%	50.0%	50.0%	57.1%	87.5%	42.9%
Fast Track to Innovation Pilot (n = 10)	66.7%	33.3%	50.0%	33.3%	66.7%	33.3%	0.0%
Euratom (n = 3)	33.3%	0.0%	100.0%	0.0%	50.0%	33.3%	33.3%
Total	46.9%	29.4%	41.6%	32.8%	50.9%	38.6%	27.2%
Total number of valid responses	920	905	914	906	909	911	902

Source: Survey of representative set of Horizon 2020 project coordinators, PPMI, 2016

Figure 55 also shows more specific areas where impact is expected within the next 10 years within each specific challenge. The survey responses point to a good overall coverage and strong expected impact in many specific areas within the challenges. The relatively large number of "other" responses in SC1 'Health' indicates a broader variety of impact areas than what was outlined in the survey questionnaire.

Figure 55 Could you please indicate a more specific area within this Societal Challenge? Specific areas of expected impact, by Horizon 2020 societal challenge

Horizon 2020 societal challenge	Specific challenges within the Societal Challenges	Share of projects having impact on the specific challenges
SC1: Health, demographic change and wellbeing	Antimicrobial resistance	15.7%
	E-health & large-scale data gathering	52.7%
	Combating European/global health threats (pandemics or biological incidents, infectious diseases)	39.4%
	Other	167 responses
SC2: Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the Bioeconomy	Food waste and eating well	41.9%
	Biodiversity	43.2%
	Food security and sustainability	72.6%
	Freshwater supply	40.7%
	Productive farming	59.6%
	Improving animal health	36.5%
	Other	44 responses
SC3: Secure, clean and efficient energy	Low-energy economy	75.7%
	Increase in competitiveness in energy market	56.7%
	Secure, safe and affordable energy	69.1%
	Reduction in greenhouse gas emissions	83.2%
	Other	29 responses
SC4: Smart, green and integrated transport	Increasing the efficiency of transport	83.4%
	Seamless transport systems	48.9%
	Competitive transport industry	65.7%
	Other	41 responses
SC5: Climate action, environment, resource efficiency and raw materials	Reduction in emissions of greenhouse gasses	80.4%
	Creation and harmonisation of common European/global standards in environmental science and policymaking	44.9%
	More efficient use of raw materials/reduction of waste	67.7%
	Other	41
SC6: Inclusive, innovative and reflective societies	Reducing inequalities and social exclusion in Europe	54.4%
	Europe as a global actor	78.7%
	Transmission of European cultural heritage	37.3%
	Innovation in the public sector or ICT government	69.8%
	Other	27 responses
SC7: Secure & innovative societies: protecting freedom and security of Europe and its citizens	Resilience of society against natural and man-made disasters	55.5%
	Technologies to improve border security and fighting terrorism	46.6%
	Cyber-security technologies	36.8%
	Other	35 responses

Source: Survey of representative set of Horizon 2020 project coordinators, PPMI, 2016

Respondents to the stakeholder consultation suggest that Horizon 2020 is less helping to address major societal challenges compared to its other objectives, like delivering on growth and jobs.[176] In particular, 24% of respondents think Horizon 2020 is not helping at all to address the challenge of securing sufficient supplies of safe, healthy and high quality food and other bio-based products (SC2).

[176] A comparatively lower number of respondents agreed "fully" with the statements that were provided and more respondents expressed their disagreement. Horizon 2020 scored higher when assessed on whether it is helping to fostering a greater understanding of Europe, providing solutions and supporting inclusive, innovative and reflective European societies (SC6) (79% of agreement at least to some extent) and on its capacity to improve the lifelong health and well-being of all (SC1) (78% agree to some extent, but also 18% think the programme is not helping at all). For all the other challenges, around 30% of the respondents do not know, which is not surprising given the early stage of implementation.

Stakeholder position papers: More sophisticated measures are needed to monitor impact.

In their position papers, some stakeholders from different types of organisations commented on the monitoring system and in majority 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 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.

Detailed assessments of progress for each Societal Challenge are provided in the thematic assessments in Annexes Part 3. A quick overview of progress is provided below.

8.3.1.1.Health, demographic change and wellbeing

While is it too early to assess its full impact, Societal Challenge 1 'Health, demographic change and wellbeing' (SC1) is on track to deliver on its objectives, leading to improved health and quality of life for citizens, more sustainable health and care systems and opening up new opportunities for jobs and growth in the sector. The only area where some implementation difficulties are met is that of clinical studies, since some projects have underestimated the undertaking required by major multi-partner international studies. However, as for FP7-Health, the main consequences are generally limited to delays in implementation that can often be solved with the extension of project' durations. SC1 has implemented calls for proposals that were directly structured along its main specific objectives. With each topic published generating high quality proposals, all objectives are being addressed. The biggest share of the funding is allocated to 'Treating and managing disease' (43%), followed by 'Active ageing and self-management of health' (13.5 %), 10.5% to 'Understanding health, wellbeing and disease' (10.5%), 'Preventing disease' (9.5%), 'Methods and data' (7%) and 'Health care provision and integrated care' (3.5%).

Based on the review of projects abstracts, ICT projects under the Excellent Science pillar relating to health issues point out their direct relevance for the development of new medication and tools for diagnosis (e.g. 3D medical imaging, development of new antibiotics, brain diseases and dementia and diagnostic tools), and several projects mention the terms health care and public health. LEIT-ICT projects are more focused on a) the provision of personalised and mobile health services and b) the provision of healthcare systems. Healthcare innovations and cost-effectiveness of health systems and the development of related services play a prominent role. Among the ICT projects placed within the priority Societal Challenges, the majority of keywords are also related to health aspects (patient and care, patient empowerment, healthcare and health monitoring), which also accounts for the highest number of projects. Under LEIT-NMBP healthcare applications have been addressed in a set calls and topics on biomaterials for health and nanomedicine. These activities have direct links to the activities in personalised medicine in the respective societal challenge. The LEIT-Space thematic assessment highlights that there may be room for improvement for supporting space research in developing applications for other sectors like health.

Example box: Immunovia AB, a Horizon 2020 health innovation project on the early diagnosis of pancreatic cancer

Project title: IMMPACT 'Clinical validation of a serum protein biomarker signature for the early diagnosis of pancreatic cancer'; SME Instrument Phase 2; May 2015-May 2017; Total cost: € 4.2 million , EU contribution: € 4.2 million.

In 2014, Immunovia AB, a Swedish health company, received an SC1 SME Instrument Phase 2 grant for a project on early diagnosis of pancreatic cancer. It has developed a method using a blood test to detect and diagnose pancreatic cancer earlier than competing methods, which increases chances to treat it. A world first in pancreatic cancer diagnostics, it could increase the overall 5-year survival rate from 3-4 % to approximately 59 %. Thanks to the EU-funding and new capital injection, the company will be able to commercialise it. In 2015, it had doubled its staff from 9 to 18 and developed enough to be accepted for trading on the Nasdaq First North in Stockholm. Before this, Immunovia carried out a promising share issue that was oversubscribed five times. It provided the company with SEK 60 million before issue costs and about 1,100 new shareholders, including many existing, new and international investors. The CEO, Mats Grahn**,** acknowledged that "*The SME instrument has been a decisive financial and confidence support to convince investors to subscribe to our share issue this year (2015) required to entry in the market in US and EU."*

8.3.1.2. Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy

From the thematic assessment of the Societal Challenge 2 'Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy' (SC2), 75% of the 111 SC2 funded (non-SME) projects are expected to contribute to sustainable and resilient production and consumption systems and rural empowerment, 50% to food security and safety, 29% to empowering rural areas. Additionally, the majority of SME phase I project proposals and reports mention several societal benefits the innovation is expected to bring such as improved welfare for consumers or producers (which generally involve cost reductions and lower prices or higher product quality), improved food quality and food security, greater resource efficiency. The expert group also analysed the impact on society that the innovations undertaken in Phase 2 projects are expected to have if they are successfully commercialised. Most innovations are expected to improve food quality (15 out of 26 projects) and food safety (14), followed by reduction in air and soil pollution (12). Eleven projects envisage their innovations to help increase society-wide water use efficiency. Improved energy efficiency is expected from 8 innovation projects, the same number tackling food waste along the value chain, while 4 expect to reduce food waste at the source. Food security is expected to improve as a result of 7 innovations receiving Phase 2 support. Five projects stated their expected positive effect on preserving wild aquatic (4) and land (1) fauna, the same number expecting to create added value from waste and by-products, improve consumer welfare, and reduce water pollution. Animal welfare will be improved through the implementation of 4 innovation projects, while 3 expect to help improve work productivity.

The bio-economy is also addressed by the biotechnology topics in the LEIT-NMBP programme. In comparison to the Bio-Based Industries initiative (BBI), the biotechnology activities of the LEIT-NMBP programme address more upstream developments (including synergies and some demonstration). Marine-related applications ('Blue Growth') have been addressed by some of the LEIT-NMBP topics in advanced materials. The LEIT-Space thematic assessment highlights that there may be room for improvement for supporting space research in developing applications for other sectors like agriculture.

Example box: COMPARE, a Horizon 2020 food security research and innovation project on the detection of and response to disease outbreaks

Project title: COMPARE 'COllaborative Management Platform for detection and Analyses of (Re-) emerging and foodborne outbreaks in Europe'; Research and Innovation Action; December 2014 – November 2019; Total cost: € 20.85 million, EU Contribution: € 20.82 million; 29 partners.

COMPARE is a large EU project with the intention to speed up the detection of and response to disease outbreaks among humans and animals worldwide through the use of new genome technology (Next Generation Sequencing, Whole Genome Sequencing, Whole Community Sequencing). The project's partners form a multidisciplinary research network that is set up with the common vision to become: (a) the enabling analytical framework and globally linked data and information sharing platform system; (b) for the rapid identification, containment and mitigation of emerging infectious diseases and foodborne outbreaks. The system sets out to integrate state-of-the-art strategies, tools, technologies and methods for collecting, processing and analysing sequence-based pathogen data in combination with associated (clinical, epidemiological and other) data, for the generation of actionable information to relevant authorities and other users in the human health, animal health and food safety domains. Although there are rather high number of partners involved the project is well organised, and managed. This reflects in rather high number (49) of published peer review articles. In parallel to that, the project partners tends to established comprehensive database of protocols, information about reference genomes etc.

8.3.1.3.Secure, clean and efficient energy

The current project portfolio represents only 25% of the total available budget for the Societal Challenge 3 'Secure, clean and efficient energy' (SC3). The project portfolio covers a broad range of aspects within the area, is assessed as in line with the area's scope and objectives specified in the legal base and can be expected to significantly contribute to the specific objectives. The biggest share of the funding goes to 'Low-cost, low-carbon energy supply' (29%), followed by 'Reducing energy consumption and carbon footprint by smart and sustainable use' (28.8%), 'A single, smart European electricity grid' (18.9%); 'Market uptake of energy innovation' (11.8%), 'Alternative fuels and mobile energy sources' (7.7%). 'Robust decision making and public engagement' and 'New knowledge and technologies' receive respectively 2.4% and 1.3% of funding.

Energy-related keywords for ICT actions refer to the objectives of decreasing energy consumption in HPC, energy efficient computing, energy harvesting and overall increase of energy efficiency. Under LEIT-NMBP energy applications have been addressed in topics covering advanced materials and nanotechnology for energy applications. These include renewable energies, as well as storage and distribution. Energy-efficiency is addressed in the cPPPs on energy-efficient buildings (EeB), as well as some of the topics in the cPPPs on sustainable process industries (SPIRE) and Factories of the Future (FoF).

Example box: STEELANOL, a Horizon 2020 energy research and innovation project on the production of bioethanol from steelmaking process emissions

Project title: STEELANOL[177] 'Production of sustainable, advanced bio-ethANOL through an innovative gas-fermentation process using exhaust gases emitted in the STEEL industry'; Innovation Action; May 2015 - October 2018; Total cost: € 14.6 million, EU contribution: € 10.2 million.

The project demonstrates the production of bioethanol from emissions of the steelmaking process which has the potential to significantly reduce greenhouse gas emissions compared to oil-derived fuels. For this purpose, a demonstration plant of approximately 25,000 tons/ethanol per year will be built in Belgium; the first of its kind in Europe, and the largest facility built to date utilizing this technology globally. The project consortium comprises 5 partners from 4 countries. This high-risk/high-impact project is expected to contribute to achieving the targets of the Paris Agreement and advancing the circular economy.

[177] http://www.steelanol.eu/en

8.3.1.4.Smart, green and integrated transport

According to the thematic assessment of the Societal Challenge 4 'Smart, green and integrated transport' (SC4), the programme is on track towards attaining its specific objectives. The analysis of the first two SC4 Work Programmes (without SME instrument and JU), covering the period 2014-2017, shows that all main activity areas are being addressed. The analysis of the funded project portfolio shows that the funded R&I activities are progressing towards providing the required impacts. The activity area "Resource efficient transport that respects the environment" is the one that appears to have been more extensively covered so far (55.9% of funds of the first two WP) - in line with the specific objective of a sustainable transport system. Significant parts of the Specific Programme content are addressed also through other implementation instruments beyond the work programme calls, notably the Joint Undertakings (JUs). Therefore, some topics, which appear to be covered in a rather limited way in the work programmes, are addressed in a significant way through these instruments. Compared to FP7, coordinators of Horizon 2020 projects have higher expectations regarding the ability of their project to address long-term goals in transport. Over 80% of the surveyed Horizon 2020 SC4 projects' coordinators estimate that their projects' results, if implemented, will contribute to the EU transport industry competitiveness, and just below 80% expect to contribute to decarbonising and "greening" the transport system, as well as increasing its efficiency.

Applications in transport have also been addressed under LEIT-NMBP through contributions to the Electric Green Vehicles cPPP (EGVI), covering lightweight materials and next-generation batteries.

Example box: PROSPECT, a Horizon 2020 transport research and innovation project on casualty reduction

Project PROSPECT[178] 'PROactive Safety for PEdestrians and CyclisTs'; Research and Innovation Action; May 2015 – October 2018; Total Cost: € 6.9 million, EC contribution: € 6.9 million.

Even though road safety has improved in recent years, accidents remain a serious problem on European roads, where, on average, 75 people lose their lives every day and 750 are seriously injured. Vulnerable road users (VRUs) such as pedestrians, cyclists, motorbike and moped riders represent a particularly serious safety concern, since they account for a disproportionately high percentage of the total number of road fatalities and serious injuries. By seeking to reduce cyclist and pedestrian casualties, who represent the largest shares of road fatalities, PROSPECT aims at significantly improving the effectiveness of active safety systems on vehicles – and thereby contribute to the 'Better mobility, less congestion, more safety and security' area of activity in the Work Programme.

8.3.1.5.Climate action, environment, resource efficiency and raw materials

Since ongoing projects under Societal Challenge 5 'Climate action, environment, resource efficiency and raw materials' (SC5) are all in their initial phases, there are few available data on outputs. As a consequence it is still too early to assess the actual effectiveness of the SC5 WPs. It is however visible that SC5 made a difference. So far, it changed traditional R&I approaches, making more links between science and innovation through the development of new markets (e.g. climate change services, nature-based solutions) through a systemic approach implying multi-disciplinarity and a challenge-driven, solutions-oriented vision. The biggest share of the funding allocated so far went to 'Protecting the environment, sustainably managing natural resources, water, biodiversity and ecosystems' (23.6%), followed by 'Enabling the transition towards a green economy and society through eco-innovation' (21.7%), 'Ensuring

[178] http://cordis.europa.eu/project/rcn/193275_en.html

the sustainable supply of non-energy and non-agricultural raw materials' (20.9%), 'Fighting and adapting to climate change' (19.9%), 'Developing comprehensive and sustained global environmental observation and information systems' (10.9%). Cultural heritage received 2% of the funding (3 projects).

Under LEIT-NMBP climate action, resource efficiency and the circular economy is addressed in the cPPPs on energy-efficient buildings (EeB) and on sustainable process industries (SPIRE) and on factories of the future (FoF). This involves decarbonisation through energy efficiency, and in the case of SPIRE it involves also direct reductions of greenhouse gas emissions in process industries, the re-use of carbon dioxide and industrial symbiosis. Environmental protection has been fostered in the dedicated activities on nanosafety and the preservation of cultural heritage has been addressed by one topic in advanced materials. Under LEIT-Space topics focussing on EGNSS, Copernicus, earth observation are believed to address the environmental challenge.

Results of **Horizon 2020 expenditure tracking for sustainable development and climate change** show that for the first three years of activity of Horizon 2020 the amounts spent fall behind the expected expenditure for these objectives as of 1 January 2017 - reaching for climate action 27% against the target of 35% applicable to the whole period of Horizon 2020 and for sustainable development 53.3% against a target of 60 %. However, the programme represents a considerable increase in research in those areas as regards FP7. For example, the "Cooperation" part of FP7 is estimated to have contributed EUR 2.4 billion to projects related to climate action, whereas for only the first three years of Horizon 2020 the equivalent figure (i.e. LEIT and Societal challenges together) is EUR 4.2 billion. The responsible EC services identify the main difficulty to reach the expected investments emerging from the bottom-up parts of Horizon 2020, since their content is unpredictable by nature. In addition, the methodology used for this tracking is based on the "Rio Markers" concept from the OECD and its application to diverse research funding tools addressing fundamental research as well as thematic programmes still require further optimisation and fine-tuning. In particular, a better alignment of the climate action and sustainable development tracking methodology with the SDGs would facilitate implementation by clarifying the scope of climate action and sustainable development in relation to globally-recognised goals.

Example box: POWERSTEP, a Horizon 2020 resource efficiency research and innovation project on converting sewage treatment plants into power production facilities

Project title: POWERSTEP 'Full scale demonstration of energy positive sewage treatment plant concepts towards market penetration'; Innovation Action; Total cost: € 5.2 million, EC contribution: € 4 million; 12 partners.

The objective of this project is to convert sewage treatment plants (STEPs) into power production facilities (POWER). For this, the partners will design and demonstrate energy positive wastewater treatment plants with available technologies in 6 full-scale case studies located in four European countries. The estimated benefits are energy savings: 1,7 Mrd €/annum; CO2 – equivalent emission savings: 5,9 million tons; and global market value: 30 Mrd $/annum.

8.3.1.6.Inclusive, innovative and reflective societies

Projects under Societal Challenge 6 'Inclusive, innovative and reflective societies' (SC6) provide a considerable body of informed theoretical and evidence based analysis of Europe's major problems and challenges, even though results are in an early stage. A sample of 56 Horizon 2020 SC6 projects funded under the WP 2014-2015 was analysed for the SC6 thematic

assessment. They are assessed as responding to the Societal Challenge as expected and there are already first publications in high ranked scientific journals. Around 50% of the projects have already developed or expected to develop datasets/ databases. Others will produce simulation tools and other technological devices aimed to foster access to ground information and provide evidences for better policy decision making: 91.3% of the projects are aimed at making political recommendations based on scientific evidence obtained, and 65.2% work in order to have an impact on the formulation of new policies. It has fostered a culture of multidisciplinary collaboration and of societal engagement in Europe and beyond (65.2% engage with end-users during the project, including groups that traditionally have not fully participated in the co-creation of scientific knowledge and agendas, such as the youth). The rise in stakeholder diversity and cross-sectoral collaboration is expected to enable a more diversified social and economic impact, which are however difficult to measure in the lifetime of a project.

A number of ICT projects also mention terms that are related to society and inclusion especially under LEIT-ICT with major keywords mentioned being the participation of citizens and communities, usability, trust, networking, empowering and co-design. Keywords mentioned in some ICT projects under Excellent Science relate to citizen participation, citizen engagement and co-design.

Example box: QUINNE, a Horizon 2020 inclusive societies research and innovation project on the interaction between innovation and employment

Project title: QUINNE - 'Quality of jobs and Innovation generated Employment outcomes'; Research and Innovation Action; April 2015 – March 2018; Total cost: € 2.5 million, EU contribution: € 2.5 million.

QUINNE project also address the topic EURO-2-2014: The European Growth Agenda. The project investigates how job quality and innovation mutually impact each other at the organization level, and what employment outcomes result from this interaction i.e. how more and better jobs are created. The employment outcomes are then tracked in terms of their impact on social inclusion and inequality. QUINNE will produce evidence-based advice on how to boost innovation and economic and employment growth in the EU, along with an awareness of ensuing impacts on social inclusion and inequality. [179]

8.3.1.7. Secure & innovative societies: protecting freedom and security of Europe and its citizens

Based on the assessment of Societal Challenge 7 'Secure & innovative societies: protecting freedom and security of Europe and its citizens' (SC7) two thirds of project coordinators that participated in a dedicated SC7 online survey agreed that this programme part has contributed to increasing the security of Europe's citizens. The majority (75%) indicated that their project has (or will) achieve its aims in full. Only a small minority (3%) of project coordinators have indicated that their project is unlikely to achieve its aims. Most project coordinators have also indicated that end-users are very likely or somewhat likely to use the research results/outputs from their projects. End-users have been included in projects at various stages of the project cycle, including during the inception and design phase, assisting with research and development, testing project outputs (e.g. prototypes) and attending dissemination events and it would appear that some project outputs are already in use by end-users.

The biggest share of funding was allocated so far to 'Improve cyber security' (29.6%), followed by 'Strengthen security through border management' (18.1%), 'Fight crime, illegal trafficking and terrorism, including understanding and tackling terrorist ideas and beliefs' (15%), 'Increase Europe's resilience to crises and disasters' (10.2%), 'Ensure privacy and

[179] Website QUINNE: http://bryder.nu

freedom, including in the Internet, and enhance the societal legal and ethical understanding of all areas of security, risk and management' (9.9%), 'Protect and improve the resilience of critical infrastructures, supply chains and transport modes' (9.4%), 'Enhance standardisation and interoperability of systems, including for emergency purposes' and 'Support the Union's external security policies, including conflict prevention and peace-building' received respectively 4% and 3.8% of funding.

Many ICT projects are also related to security with major keywords being privacy, safety, cybersecurity, resilience and cloud security.

Example box: DARWIN, a Horizon 2020 security research and innovation project on crisis response

Project title: DARWIN[180] 'Expecting the unexpected and know how to respond'; Research and Innovation Action; 1 June 2015 - 31 May 2018; Total cost: € 5 million, EU contribution: € 5 million.

DARWIN is contributing to improve responses to expected and unexpected crises affecting critical societal structures during deliberate man-made disasters (e.g. cyber-attacks) and natural events (e.g. earthquakes). The project is developing European Resilience Management Guidelines (ERMG), which will support the ability of crisis management experts and those responsible for public safety to anticipate, monitor, respond, adapt, learn and evolve, to operate efficiently in the face of crises. After one year, DARWIN achieved promising results: i) definition of the catalogue of resilience concepts and requirements for the development of the ERMG; ii) launched the Community of Resilience and Crisis Practitioners; iii) and presented the initial evaluation plan for the pilots. The guidelines will be user-friendly and presented in formats for easy usage and maintenance. Furthermore, the project is exploring innovative tools such as serious gaming and training packages to facilitate the adoption of the ERMG. The target beneficiaries of DARWIN are infrastructure operators: service providers and related stakeholders who have responsibility for critical infrastructures that might be affected by a crisis as well as the public and media.

8.3.2. Generating science with and for society

Horizon 2020 aims to build effective cooperation between science and society, to recruit new talent for science and to pair scientific excellence with social awareness and responsibility.

The dedicated programme Science with and for Society (SWAFS) implements a set of activities to build effective cooperation between science and society.[181]A review of the projects selected so far indicates that **progress is in line with expectations,** though data on the SWAFS KPI ('number of institutional changes') will only become available when projects end. [182]

The SWAFS thematic assessment highlights however several areas for improvement: **an insufficient focus on areas where the greatest impacts are expected**; the lack of clear SMART objectives defined for all topics and projects, and the under-representation of civil society and private companies in the funded actions overall and in particular in actually 'doing R&I' (for instance in citizen science activities). Also while institutional change is clearly defined for the gender equality lines (as an ERA priority) it should be further operationalised for

[180] http://www.h2020darwin.eu/

[181] The SWAFS eight line of activities are: to make scientific and technological careers attractive to young students, and foster sustainable interactions between schools, research institutions, industry and civil society organisations; promote gender equality; integrate society in science and innovation issues, policies and activities; encourage citizens to engage in science through formal and informal science education; develop the accessibility and use of the results of publicly-funded research; develop governance for the advancement of responsible research and innovation by all stakeholders and promote an ethics framework for research and innovation; take due and proportional precautions in research and innovation activities by anticipating and assessing potential environmental, health and safety impacts; and improve knowledge on science communication.

[182] The questions of public engagement in R&I activities and the coverage of Responsible Research and Innovation in Horizon 2020 are discussed in Section 6.3.3.2.

the other lines and focus should be put on sustainability of these changes. **The thematic assessment points out that SWAFS' relatively low budget means that just a handful of projects are funded per topic/line of activity; this spreads resources thinly and reinforces the need to focus on sustainable institutional changes in the programme.**

Gender equality is implemented as a cross-cutting issue in Horizon 2020. **Gender balance in decision-making is close to being achieved with 53% in advisory groups[183] and 36.7% in evaluation panels.** In addition 6022 experts, 3904 women and 2118 men, declared having a gender expertise in the EC expert database in December 2016.

Concerning the workforce, **women represent 31% of projects' coordinators**, incl. 24.5% of ERC Principal Investigators, 42.2% of MSCA Fellows and 26.9% of scientific coordinators in other Horizon 2020 activities. It represents an increase compared to FP7, where women represented overall 28.5% of projects coordinators, 20% of ERC Principal Investigators, 36.5% of MSCA Fellows and 20% of contact persons for scientific aspects in other FP7 activities.

> *The strict requirement of gender equality and the integration of the gender dimension in science and research is an important added value of H2020. It is giving a strong impetus to many supporting programmes and policies in the Member States. Unfortunately there are till now no strict consequences if these topics are not carefully attended, this means a lack of liability and a lack of sustainability. Integrating of the gender dimension in science and research means improved excellence.*
>
> Belgium, European Platform of Women Scientists

Concerning the integration of gender into R&I content, the gender-flagged topics increased from 99 among 610 topics in Work Programme 2014-2015 to 108 among 568 topics in Work Programme 2016-2017[184]. The wording of topics is often generic. At the level of projects, 32.4 % of them[185] were identified by projects officers[186] as having a gender dimension, however it appeared that **this indicator is not yet reliable as what the gender dimension consists of is not sufficiently understood.** The qualitative analysis of a subset of 111 projects from gender-flagged topics, showed the 53% included the gender dimension well or in part. The notion does not seem to be well understood yet and is often confused with gender balance in research teams, nor is it always well evaluated. Furthermore none of the 111 projects included training on gender knowledge (newly eligible cost in Horizon 2020 funding), indicating that the indications provided are not sufficient to generate take-up.

The approach of integrating the Social Sciences and Humanities (SSH) as a cross-cutting issue has meant that inter-disciplinary cooperation is dealt with in a different way as compared with FP7. A network of SSH liaison officers has been established across all Societal Challenges and LEIT parts of the programme to facilitate the integration of SSH across the programme. It also requires applicants to submit proposals and build consortia that transcend disciplinary and sectorial boundaries, bringing together scholars from SSH and from life and physical sciences, technology, engineering and mathematics (STEM) as well as researchers and practitioners across these fields. Every year a monitoring report of the SSH Integration in Horizon 2020 is carried out by DG RTD[187]. SC6 and its calls and topics attract many of the SSH disciplines. In the 2014-15 Work Programme 37% of the topics have been identified as relevant for SSH researchers, and 41 % in the Work Programme 2016-2017. **The quality of**

[183] In FP7 33% of the members of the advisory groups were women.
[184] At the level of the adoption of the work programmes – not taking into account the possible amendments
[185] The indicator does not include MSCA and ERC.
[186] Who checked at the level of the Description of Activities annexed to the grant agreement when preparing grant agreements.
[187] European Commission, SSH monitoring report 2014 and 2015

SSH integration is highly uneven across projects but almost half of the projects funded under SSH flagged topics show good or fair integration of SSH in terms of share of partners, budget allocated to them, and variety of disciplines involved. Contributions from economics, sociology, political science and public administration are well integrated while many other SSH disciplines are underrepresented, especially geography/ demography and philosophy/anthropology. The low participation of the humanities and the arts remains a challenge. Overall, EUR 433 million went to SSH partners in SSH flagged topics, representing 22% of the estimated total budget for the SSH flagged topics. In terms of countries represented, the SSH partners and coordinators in projects flagged as SSH relevant come predominantly from a group of 5-6 Member States.

70.1% of the stakeholder consultation respondents agreed fully or to a large extent that Horizon 2020 is helping to support science with and for society, 21.4% agree to some extent and 3.3% not at all. The most positive respondents are businesses and research organisations, whereas the least positive are NGO and public authorities.

8.3.3. Generating science for policy

Horizon 2020 aims to provide robust, evidence-based support for Union policies. This shall be driven by customer needs, complemented by forward-looking activities.

The objective of generating science for policy is mainly pursued through the direct research actions of the Joint Research Centre (JRC) but also through projects implemented across Horizon 2020.

The JRC direct research actions play a distinctive role in the EU policy processes by providing scientific knowledge and technological competence for EU policy making.[188] In addition to providing fit-for-purpose scientific and technical support, the JRC has to maintain an anticipatory function, a strategic dialogue with partners and a research base. It aims at fostering excellence through internal quality control and external peer review, evaluation and benchmarking, while striving for quality labels and certifications, where appropriate. It also develops new methods, tools and standards, sharing its expertise with its partners. A strong relationship between the JRC and the Member States is a high priority for the organisation. Hence to the extent possible the direct actions are implemented taking into account relevant initiatives at the level of regions, Members States or the EU, within the perspective of shaping the ERA. The JRC implements the open access policy established under Horizon 2020 and Commission policies.

From the evidence collected, the research results of the JRC have provided support to policy making under the Commission priorities; this included areas of high political activity such as the energy union, sensitive issues such as the regulatory framework for emissions from road vehicles, areas where the EU has taken a global leadership (such as the negotiations on climate change), or pressing issues such as the economic and monetary union. JRC has also started to place increasing focus on pressing issues such as security and migration, and on supporting regional economic development. DG REGIO of the European Commission established jointly with the JRC the S3 Platform[189] to support

[188] The key areas in which the JRC offers support are: energy and transport, environment and climate change, agriculture and food security, health and consumer protection, information society, innovation and growth, economic and monetary union, reference materials and standards, safety and security (including nuclear safety and security in the Euratom programme).
[189] http://s3platform.jrc.ec.europa.eu/

Member States in developing and implementing Smart Specialisation Strategies. It acts as a facilitator for regions and countries in the uptake and incorporation of the smart-specialisation concept and methodology in their R&I strategies. Over 160 regions and the majority of the Member States are registered members in this platform.

In 2013 the Board of Governors commended the JRC's internal review processes in a special report.[190] For the first years of Horizon 2020, a total number of 350 occurrences of tangible specific impacts on European policies is identified in the JRC annual activity report. The number of peer reviewed publications in high-impact journals fluctuates around 700 since JRC scientists publish between 600 and 800 scientific articles in peer-reviewed journals every year.[191] **More than 16% of JRC's peer-reviewed publications are among the world's highly cited publications,[192] confirming that scientific publications of the JRC have an impact in the international scientific community.[193]**

Science for policy is generated also through the Projects for Policy (P4P) initiative, which aims at identifying portfolios of projects linked to different thematic areas in both FP7 and Horizon 2020 in order to develop recommendations rising from the results of funded projects. For instance, a portfolio analysis of 135 projects on efficient and sustainable batteries has shown important impact on strengthening the knowledge base across the batteries supply chain in both the research sector and industry. They have furthered understanding and knowledge of materials sciences and engineering, chemistry, electrochemistry and battery cell design and performance. They have also provided industry with new knowledge and capabilities that can be used to make improvements to existing products and processes.

Similarly, a major investment, close to EUR 900 million, has been made from FP7 and Horizon 2020 to 164 collaborative projects related to rare diseases. The results of the EU-funded projects bring new knowledge on the understanding of the epidemiology, pathophysiology and natural history of rare diseases and bring forward the translation of the results into the development of new diagnostic tools and therapies for rare diseases. Concrete benefits for healthcare have been delivered in terms of clinical guidelines for the diagnosis and treatment for rare diseases. Projects also provide tools for effective and ethical sharing of research and medical data as well as insights into new methodologies for clinical trials in small populations and health technology assessment and thus strengthen the evidence base for future policy decisions regarding the regulatory pathway and access to new interventions.

87% (3018) of the public consultation respondents agreed, at least to some extent, that Horizon 2020 helps developing and implementing EU policies, yet a comparatively low number of respondents (18%) agreed "fully with this statement, which is far less than the number of respondents who did so for the contribution of the programme to support science with and for society. Also **almost all the stakeholder consultation respondents agreed (at least to some extent) that Horizon 2020 is contributing to foster the role of the European Union as a stronger global actor (92%).**

[190] Impact analysis of JRC activities - Special report for the 100th meeting of the Board of Governors, (2013)
[191] Thomson Reuters study on the research performance of the Joint Research Centre of the European Commission during the 7th Framework Programme (2007-2013) + supplement (2014-2016) in preparation.
[192] Thomson Reuters deems papers "relatively highly cited" when they are in the top 10% of the world's most frequently cited papers, taking into account year and field of publication
[193] Ex-post Evaluation of the direct actions of the Joint Research Centre under the Seventh Framework Programmes 2007-2013. The FP7 ex-post evaluation of JRC direct actions (2007-2013) highlighted that this level of scientific productivity is giving the JRC a respectable position amongst its comparators during this period.

Box: Examples of initiatives of Science for policy across Horizon 2020

The **ERC** has supported some of the world's leading economists including the Nobel Prize winners Jean Tirole, Christopher Pissarides, James Heckman as well as Thomas Piketty and Helene Rey.

The **MSCA** have launched a pilot **Society & Entreprise panel** for Individual Fellowships which is open to the participation of governmental organisations. The first call resulted in six researchers taking up their fellowships in public administrations throughout Europe.

LEIT-NMBP funds scientific and regulatory research in the area of nanosafety, contributing to EU regulations as well as to international standards in the OECD context. The NanoSafety cluster addresses policy and risk governance issues related to the use of nanotechnology. The targeted results include predictive models and harmonised standard operating procedures for nanotechnology.

SC1 launched the first European Joint Programme Cofund under Horizon 2020. The HBM4EU initiative represents a novel way of collaborating between several Commission services, EU agencies and national representatives, highlighting how research funding can build bridges between the research and policy worlds. A joint effort of 26 countries and the Commission, its aims to coordinate and advance human biomonitoring in Europe and will thereby provide better evidence of the actual exposure of citizens to chemicals and the possible health effects to support policy making.

SC3 has been supporting projects which influence policy making, notably related to energy issues, at local, national and EU level. For example, the project AURES (CSA) aims at supporting policy makers at EU and Member States level in improving the effectiveness and cost-efficiency of financial support systems for electricity from renewable energy sources, notably through improving the design of auctions. AURES will develop best practices and tailored policy recommendations for future auction designs, making it possible for policy makers and markets participant to make informed decisions when dealing with renewable support policies.

The **SC4** project LOWBRASYS[194] is tackling for the first time the issue of particles emissions from brake pads and discs, starting from the understanding of their generation and effects to methods for their measurement and reduction, thus supporting the work of the Commission DGs involved in road emissions regulation and providing input to the United Nations Particle Measurement Programme Working Group in assessing the situation and developing legislation.

Under **SC6** all the reviewed projects do consider the relevance of their outcomes to provide a basis for evidence-based policies in the diverse fields related to SC6. All projects stated that they will produce policy recommendations, and seven of the on-going projects have already Policy briefs in their webpages. Collaborations with policy makers at both national and EU level are described in most approved projects. For example the Action Plan on the integration of Third Country nationals[195] takes into account recommendations from the migration policy review of projects under FP7 and SC6.

8.4. What is the overall progress of Horizon 2020 towards its general objective?

Summary box: Key findings on the progress of Horizon 2020 towards its general objective

- ✓ Through its focus on scientific, economic and societal impact, Horizon 2020 is on track to contribute to the creation of jobs and growth and the achievement of the priorities of the Juncker Commission.
- ✓ Horizon 2020 is projected to produce large-scale economic impacts.
- ✓ Having marked a definite shift towards innovation, Horizon 2020 is contributing to the Innovation Union flagship of the Europe 2020 strategy, by improving and strengthening the framework conditions and facilitating access to risk finance for R&I.
- ✓ Horizon 2020 contributes to the achievement of a Digital Single Market.
- ✓ Horizon 2020 contributes to improved resource efficiency.
- ✓ Horizon 2020 reinforces the European Research Area.

[194] http://www.lowbrasys.eu/
[195] COM(2016) 377 final

By pursuing its general objective of building a society and an economy based on knowledge and innovation - and based on its early progress towards achieving scientific, economic and societal impact - Horizon 2020 is on track to contribute to the creation of jobs and growth and the achievement of the priorities of the Juncker Commission.

As already highlighted in the previous sections, it is difficult to assess the extent to which Horizon 2020 - which only represents a small proportion of total public R&D spending in the EU - is contributing to key performance indicators set to measure progress against the general objective (the target of 3% of GDP invested in R&D, the evolution of the innovation output indicator and the share of researchers as part of the active population).

However an external study using a macro-econometric model (NEMESIS) estimated the contribution of Horizon 2020 to growth and jobs.[196] Macro-econometric simulations were carried out using partially real data on the actual allocation of Horizon 2020 funds during the first years and partially projections on the basis of the budget available for the remaining years of its implementation. The economic impact of Horizon 2020 on EU GDP is reported in the graph below, which assesses the difference between Horizon 2020 economic performance and the reference scenario. In the context of this study, the reference scenario is based on the assumption that, at the end of FP7 in 2013, Horizon 2020 would have not been implemented. The impact follows three main phases. In the first phase (maturation) up to 2023 there are only few innovations and the increase in GDP is mainly the result of the demand induced by the investments in R&D through Horizon 2020. The recruitment of research personal increases real wages as well as final consumption. The inflationary pressures deteriorate competitiveness and the increase in demand raises imports. After 2020, the reduction of the EU contribution pushes down the GDP gains. During the second phase (innovation) up to 2030, the arrival of process and product innovations increases the internal and external demand. The external demand becomes gradually the main driver of the GDP gains. It is at the end of this second phase (around 2030) that the maximum impacts of Horizon 2020 are reached.

Compared to the reference scenario in which – after FP7 – Horizon 2020 would not have been implemented, at its peak in 2030, Horizon 2020 is estimated to bring a GDP gain of between 0.27% and 0.34% compared to the GDP of the reference scenario in 2030. During the third phase (Maturity and obsolescence), the gradual obsolescence of new knowledge progressively cancels GDP gains.

On average, the GDP gain is estimated to amount to between EUR 24 billion and EUR 35 billion per year (in 2014 prices) during 2014-2030. Over the same period of 17 years, the total GDP gain is between EUR 400 billion and EUR 600 billion: each EUR of Horizon 2020 investment brings a GDP increase of between EUR 6 and 8.5. This high economic return is justified by the assumptions that investing in R&I at EU level has a higher economic performance justified by its added values (between 15 and 21%[197]) and is better in terms of attracting additional funding (direct leverage of up to EUR 0.40 for each EUR in-

[196] The analysis has consisted in simulating different scenarios comparing the situation of the EU economy in the short (during the execution of the research programme), medium (2030) and long term (2050), to a reference scenario where, by assumption, the Framework Programme would have ceased in 2014, after the end of FP7.For all the assumptions of the model please refer to the specific study (contract n° 2012/S 144-240132): PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming. It should be bear in mind that the benefits arising from Horizon 2020 are numerous and go much beyond a strict quantification in monetary terms.

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

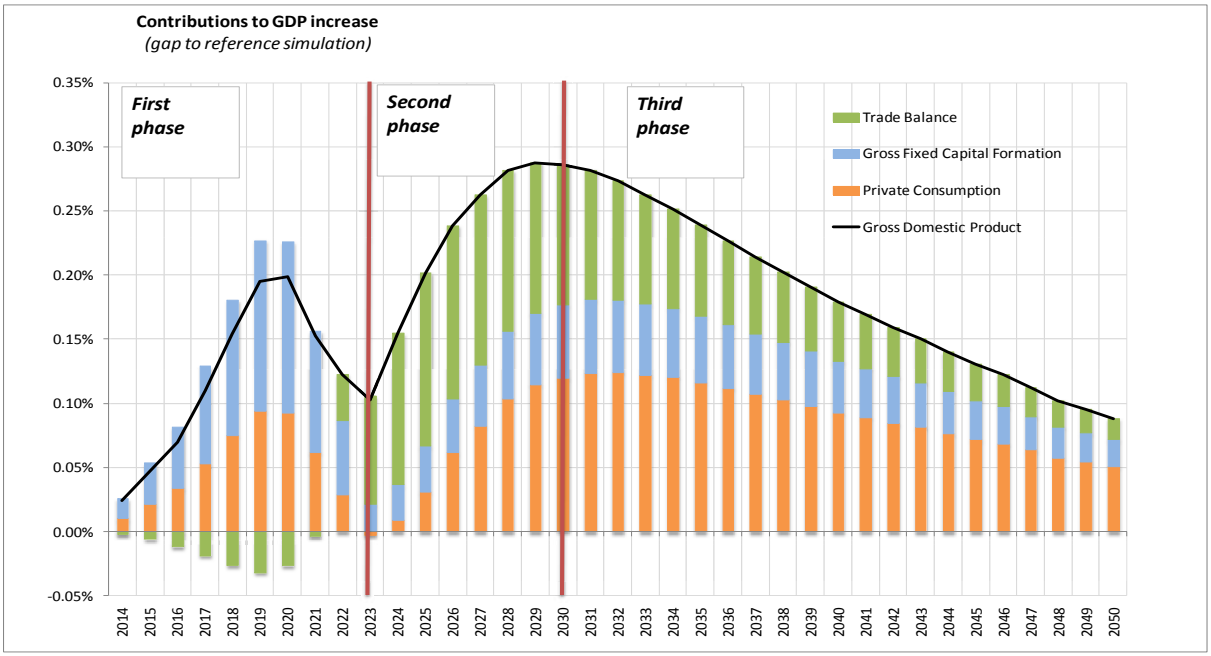
vested)[198] compared to national programmes. These ranges are, nontheless based on sensitivity analysis considering both a pessimistic and optimistic scenarios: in the pessimistic scenario, it is assumed that there is no better economic performance compared to national programmes while the direct leverage effect is the lowest (EUR 0.16 for each EUR invested); in the optimistic scenario, it is assumed that the economic performance of Horizon 2020 is 21% higher than national programmes and its direct leverage effect is EUR 0.40 for each EUR invested.

Box: Strengths and limitations of the NEMESIS model

NEMESIS is a macro-econometric model that does not rely on a general equilibrium framework. Three types of innovation activities are captured in NEMESIS: investments in R&D, investments in ICT and in other intangibles. For this reason, Di Comite and Kancs (2015)[199] consider that NEMESIS is the richest model in terms of innovation types when compared with other standard macro-economic models for R&D and innovation policies (QUEST, RHOMOLO, GEM-E3). Innovations that are generated in each sector are process and product innovations, and distinct impacts on economic growth and employment are calibrated for each type of innovation from the results of previous studies. Endogenous growth comes from the increasing returns of the accumulation of three knowledge stocks reflecting knowledge externalities that are specific to countries and sectors and to the type of investment: R&D, ICT or other intangibles. Private and public R&D is also differentiated in terms of impact. Due to its econometric nature and its departure from general equilibrium framework, the specification of NEMESIS can ensure a high level of fit with observed data.

While the strengths of NEMESIS justify its relevance for measuring the impact of R&I policies, the specificities and approach of the model also imply a number of limitations that have to be taken into account when interpreting the results of the model. First, it relies on the empirical observation of relationships and allows for flexibility in behavioural functions, which may generate inconsistencies with most recent developments in macro-economic theory. Furthermore, it does not use forward looking expectations but adaptive ones. Regarding the use of human capital in the model, NEMESIS does not link it with investments in the educational system.

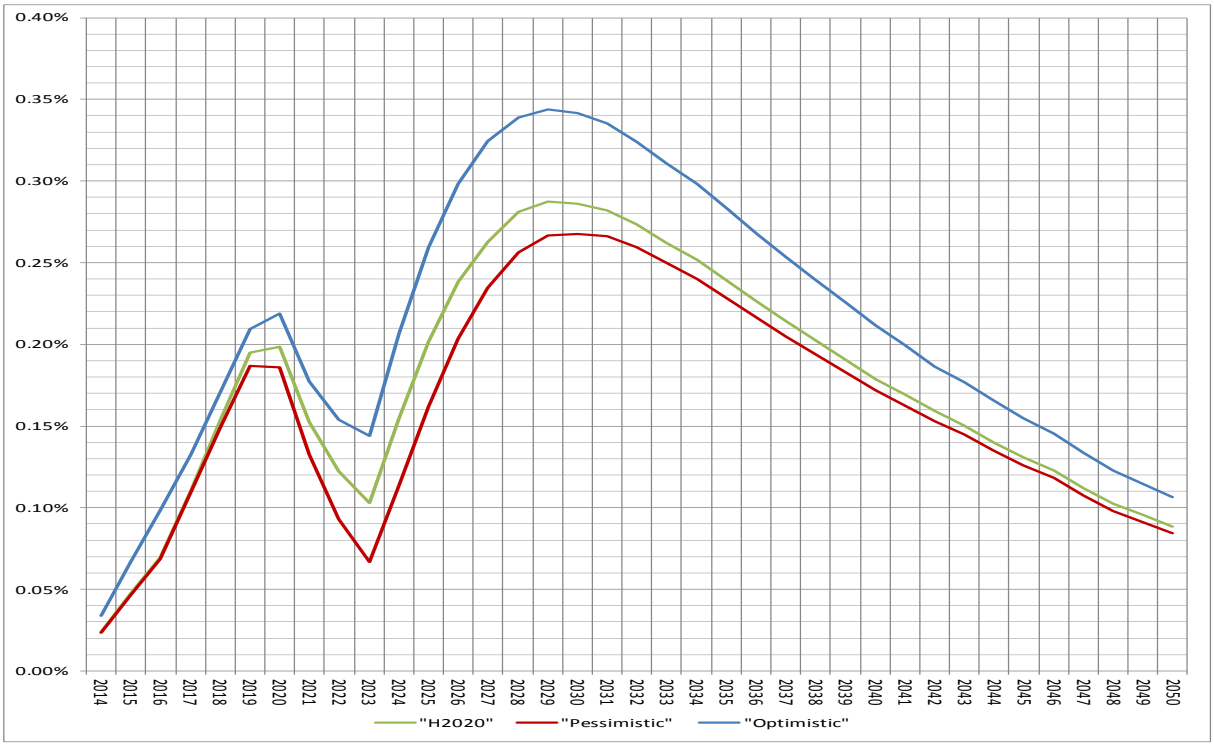
Figure 56 The economic impact of the Horizon 2020 funding for research on EU28 GDP (in % deviation from reference scenario)



Source: PPMI based on NEMESIS model results

[198] Calculated on estimations of total costs of Horizon 2020 projects, based on real data from Corda combined with a methodology for the estimation of real indirect costs.
[199] F Di Comite and D Kancs, Macro-Economic Models for R&D and Innovation Policies (2015), IPTS Working Papers on Corporate R&D and Innovation – No 03/2015

Figure 57 Sensitivity analysis of EU GDP gains from Horizon 2020 (in % deviation from reference scenario)



Source: PPMI based on NEMESIS model results

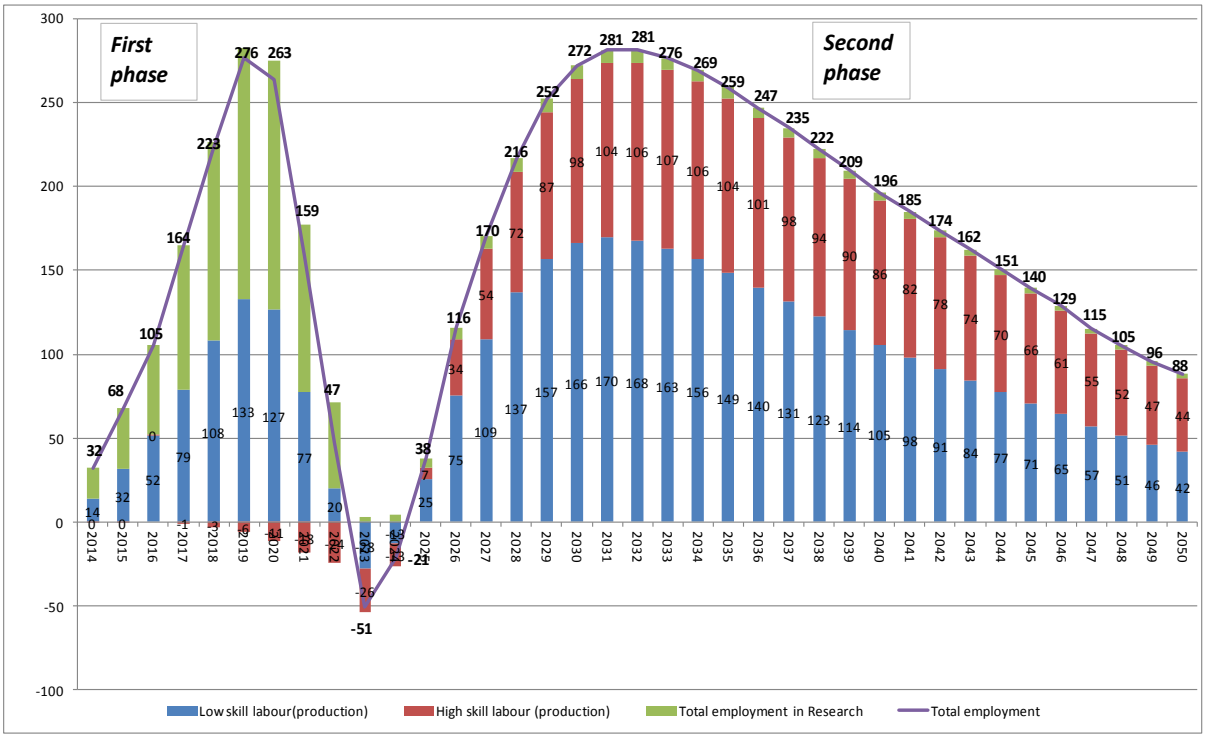
In terms of employment, two phases can be distinguished, as shown in the figure below. In the first phase, up to 2022, the EU contribution increases significantly employment in research activities, where most of the jobs are created. Job creation peaks in 2019 when the number of job is 276 000 more than in the reference scenario in the same year (150 000 of them are in research sector). Once the Horizon 2020 funding starts decreasing – i.e. beyond 2020 – employment in research comes close to zero. Innovations are not yet numerous enough to push up vigorously the demand of goods and services, while the inflationary pressures of the first period continue to lower exports: the consequence is a decrease of total employment even below the reference scenario (-51 000 in 2023). In the second phase, innovation enters into the market and pushes up the employment creation. In 2030, employment would amount to 272 000 jobs more than in the reference scenario, including 8000 jobs in research. **Taking into account the sensitivity analysis, during the period 2014-2030, the EU contribution through Horizon 2020 is forecasted to have increased the level of employment compared to the reference scenario by between 110 000 and 179 000 units, including between 29 000 and 35 000 jobs in research.**

The study brings many additional findings: **in 2030, the internal rate of return[200] of the Horizon 2020 contribution would amount to between 26% and 37%; the investments in research provoked by Horizon 2020 would increase labour productivity by between 0.16**

[200] The internal rate of return was calculated as the actualisation rate that equalizes the actualized sum of GDP gains to the actualized sum of the Horizon 2020 contribution. It increases slightly in time as annual GDP gains stay positive in most countries up to 2050 while EC contribution stops after 2022. This 30% rate of return is in line with the econometric literature results (cf. Hall, Mairesse and Mohnen, 2011). According to most studies, the overall value generated by public research is between three and eight times the initial investment, which in rates of return represents a median value between 20% and 50% (cf. Georghiu, 2015).

and 0.20%; the Horizon 2020 impact on EU external competitiveness would increment net exports by between EUR 18 and 23 billion; the final energy consumption by unit of GDP and the energy-related CO2 emissions would be reduced by 0.2%. Under similar conditions, the estimated GDP gains and the estimated job creation in 2030 are respectively 34% lower and 35% lower compared to those predicted in the ex-ante impact assessment[201]. These discrepancies seem mainly related to the size of the budget inputted in the NEMESIS model[202] and to the assumptions made for the direct crowding-in.[203]

Figure 58 Impact of Horizon 2020 on total employment in thousands (difference from reference scenario)



Source: PPMI based on NEMESIS model results

The same study included a survey of beneficiaries on this issue, and found that they expect to generate an estimated EUR 57 billion from their main innovation in the next three years. While this revenue is not factual and likely to be revised downwards in the future, it illustrates the strong confidence in the technologies developed. It is likely that very substantial revenue is yet to be accrued from the R&I activities performed.

[201] In order to make this comparison feasible, some basic assumptions were modified: notably, it was assumed that Horizon 2020 would continue beyond 2020 and its budget would increase per year by EUR 450 million after 2020.

[202] The NEMESIS calculations for the ex-ante Impact Assessment of Horizon 2020 were based on a budget of EUR 84.9 billion, while for the Interim Evaluation the budget considered was EUR 69.3 billion. Cumulating the investments beyond 2020, the total budget introduced in the model varies from 246 billion for the ex-ante Impact Assessment to 217 billion for the Interim Evaluation – a difference of 12% in the size of the budget.

[203] In the ex-ante impact assessment, the crowding-in effect was assumed to be equal on average to EUR 0.86 (each EUR of Commission contribution leading to an additional R&D expenditure of EUR 0.86 from other public and private actors), while in the interim evaluation this was estimated on conservative figures from CORDA and it was set at EUR 0.24.

Figure 59 Estimated revenue generated from the main innovations of FP-funded research teams

	Revenue generated from the main innovation in 2015			Expected revenue during the next 3 years
	Share of projects whose main innovation has this revenue	Total revenue generated	Of which: exports	Expected revenue in the next three years
No revenue	81%	n/a	n/a	n/a
Up to EUR 100k revenue/value	6.5%	1.37 billion	0.59 billion	14.8 billion
Between EUR 100k and EUR 0.5 M revenue/value	6.1%	1.28 billion	0.47 billion	17.2 billion
More than EUR 0.5 M revenue/value	6.6%	1.39 billion	0.73 billion	24.8 billion
Total	**100%**	**4 billion**	**1.78 billion**	**57 billion**

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

Almost all the stakeholder consultation respondents agreed (at least to some extent) that Horizon 2020 is contributing to support jobs, growth and investments (94.5%).

62% of the stakeholder consultation respondents think that Horizon 2020 is helping fully or to a large extent to 'implement the Europe 2020 strategy, the EU's strategy for jobs and smart, sustainable and inclusive growth'. Only 2.2% do not share this view at all. In addition, 71.5% of the respondents think that Horizon 2020 is helping fully or to a large extent to build a society and an economy based on knowledge and innovation. For both options, the least positive respondents are umbrella organisations representing research organisations and NGOs. **74% agree (at least to some extent) that Horizon 2020 is contributing to achieve a deeper and fairer internal market with a strengthen industrial base**, **72% to promoting an Energy union with a forward looking climate policy** (25.3% do not share this vision at all, which is the priority with the highest share of full disagreement), and **66% to help to create a Digital Single Market** (29.4% of respondents not to know).

8.5. Key conclusions on the effectiveness of Horizon 2020

In terms of effectiveness even if at a very early stage of implementation and the lack of indicators to track progress across all objectives, Horizon 2020 is on track to achieve its specific objectives – strengthening the science base, tackling the insufficient technological leadership and innovation capability in the private sector, and addressing the insufficient contribution of R&I to tackling societal challenges – thereby contributing to the achievement of its **general objective** – building a society and economy based on knowledge and innovation across the Union while playing a role in the reinforcement of the European Research Area and the implementation of the Europe 2020 Strategy.

It already strengthens the science base by involving the EU's and world's best research institutions and researchers; by training large numbers of EU-based researchers; by producing large numbers of world class open access scientific publications and data; by producing scientific breakthroughs; and by building cross-sectoral, inter-disciplinary, intra- and extra-European research and innovation networks. It is so far difficult to assess the extent to which Horizon 2020 - which only represents a small proportion of total public R&D spending in the EU - is contributing to key performance indicators set to measure progress against the general objective (the 3% GDP target, innovation output indicator and share of researchers as part of the

active population). Nevertheless, Horizon 2020 is expected to have a significant socio-economic impact in the medium to the long term, which are projected to peak towards the end of the next decade, when new product and process innovations enter into the market.

More specifically Horizon 2020 with its focus on excellence is on track towards achieving **scientific impact** through the reinforcement of R&I capacities, the integration of R&I efforts and its contribution to the achievement and reinforcement of the European Research Area. There are early indications of the quality of the knowledge created and circulated, making Europe an attractive destination for excellent researchers worldwide and generating scientific breakthroughs. Research infrastructures are contributing to increase the knowledge base with shared distribution and access to data, materials and tools that are accessible across the EU. Horizon 2020 is also making progress, albeit slowly, on spreading excellence across Europe. The dedicated SEWP actions have mobilised stakeholders at the political level and have shown early signs of structuring effects (notably in preparation for the Teaming actions) but further efforts can still be made.

Horizon 2020 is putting more emphasis than FP7 on supporting closer to market applications and innovation, and there is early evidence of progress towards **innovation and economic impact**. It fosters industrial leadership by successfully involving the private sector and SMEs; by creating networks between the business sector, universities and research institutions; by providing businesses and SMEs with risk finance to carry out their research and innovation projects; by investing in demand-driven innovation; by producing high quality, commercially valuable patents and other intellectual property rights; by generating proofs of concept and demonstrators and supporting the deployment of innovation solutions; by producing new knowledge, strengthening capabilities, and generating a wide range of innovation outputs including new technologies, products and services; and by increasing the competitiveness of beneficiaries. Most of the targeted outputs relate to products and processes, and to a lesser extent to services, although these are becoming increasingly linked to manufacturing. Single-beneficiary projects have been quicker than collaborative projects in applying for IPR. However, a number of potential factors impeding full effectiveness in terms of market uptake have been identified and relate to the capacity of innovation systems to address a range of issues, particularly for SMEs: technological, regulatory, standards, technical and access to finance, as well as lack of customer acceptance of new solutions. The programme has yet to make a significant outreach to young and fast growing innovative companies. On balance, despite positive progress made in coupling research with innovation, it is too early to point to a major impact in terms of breakthrough innovations entering the market.

Whereas FP7 was focused on specific domains, Horizon 2020 puts more emphasis on **societal impact** and aims at contributing through research and innovation to tackling the major societal challenges Europe and the world are facing. The Societal Challenges pillar is already generating publications, patents, prototypes, products, process and methods in domains of relevance for society. The portfolio of projects selected and their progress are in line with the objectives set. Noticeably most Horizon 2020 projects are expected to generate cross-cutting impacts, including from the Excellent Science and Industrial Leadership pillar generating key discoveries and technologies. In terms of achieving the objectives set, stakeholders believe Horizon 2020 is helping relatively less to address societal challenges than other objectives, while the internal framework for systematically identifying impact is lacking. Moreover, results of expenditure tracking for sustainable development and climate change show that the programme falls behind the expenditure target, which is mainly due to the bottom-up (hence unpredictable) parts of Horizon 2020 and methodological problems, which are being addressed. It is still expected that the target will be achieved by the end of the Programme.

A review of the projects selected so far indicates that the progress Horizon 2020 is making in generating science with and for society is in line with expectations. Results are encouraging in terms of the integration of Responsible Research and Innovation, Gender in research content and Social Sciences and Humanities in Horizon 2020, although some data quality concerns exist. Apart from the relatively low budget, the limited lifetime of funding, and the fact that just a handful of projects are funded per topic, which spreads resources rather thinly, factors impeding full effectiveness of projects supporting science with and for society include the lack of clear objectives defined for all topics, the fact that not all lines work clearly towards the SWAFS key performance indicator (number of institutional changes), and the under-representation of some parts of society (particularly private companies and other types of organisations) in the funded actions.