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2013/743/EU: Council Decision of 3 December 2013 establishing the specific programme implementing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020) and repealing Decisions 2006/971/EC, 2006/972/EC, 2006/973/EC, 2006/974/EC and 2006/975/EC

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COUNCIL DECISION

of 3 December 2013

establishing the specific programme implementing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020) and repealing Decisions 2006/971/EC, 2006/972/EC, 2006/973/EC, 2006/974/EC and 2006/975/EC

(Text with EEA relevance)

(2013/743/EU)

THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty on the Functioning of the European Union, and in particular Article 182(4) thereof,

Having regard to the proposal from the European Commission,

After transmission of the draft legislative act to the national parliaments,

Having regard to the opinion of the European Parliament,

Having regard to the opinion of the European Economic and Social Committee ([1]),

Having regard to the opinion of the Committee of the Regions ([2]),

Acting in accordance with a special legislative procedure,

Whereas:

(1) In accordance with Article 182(3) of the Treaty on the Functioning of the European Union (TFEU), the Framework Programme for Research and Innovation 2014-2020 ("Horizon 2020"), established by Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 ([3]), is to be implemented through a specific programme which determines the specific objectives and rules for their implementation, fixes its duration and provides for the means deemed necessary.

(2) The general objective of Horizon 2020 should be pursued through three priorities dedicated to generating excellent science ("Excellent science"), creating industrial leadership ("Industrial leadership") and tackling societal challenges ("Societal challenges"). The general objective should also be pursued through the specific objectives "Spreading excellence and widening participation" and "Science with and for society". Those priorities and specific objectives should be implemented by means of a specific programme setting out one Part for each of the three priorities, one Part for the specific objective "Spreading excellence and widening participation", one Part for the specific objective "Science with and for society" and one Part for the non-nuclear direct actions of the Joint Research Centre (JRC).

(3) All Horizon 2020 priorities and specific objectives should include an international dimension. International cooperation activities should be maintained at least at the level of the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007-2013) ("Seventh Framework Programme"), adopted by Decision No 1982/2006/EC of the European Parliament and of the Council [4].

(4) While Regulation (EU) No 1291/2013 sets out the general objective of Horizon 2020, the priorities and the broad lines of the specific objectives and activities to be carried out, the specific programme should define the specific objectives and the broad lines of the activities which are specific to each of the Parts. The provisions on implementation set out in Regulation (EU) No 1291/2013 apply fully to the specific programme, including those relating to ethical principles.

(5) Each Part should be complementary to and implemented in a coherent way with the other Parts of the specific programme.

(6) There is a critical need to reinforce, widen and extend the excellence of the Union's science base and to ensure a supply of world-class research and talent to secure Europe's long term competitiveness and well-being. The priority "Excellent science" should support the activities of the European Research Council (ERC) on frontier research, future and emerging technologies, Marie Skłodowska-Curie actions and European research infrastructures. These activities should aim at building competence in the long term, focusing strongly on the next generation of science, systems and researchers, and providing support for emerging talent from across the Union and from associated countries. Union activities to support excellent science should help consolidate the European Research Area (ERA) and make the science system of the Union more competitive and attractive on a global scale.

(7) Research actions carried out under the priority "Excellent science" should be determined according to the needs and opportunities of science. The research agenda should be set in close liaison with the scientific community. Research should be funded on the basis of excellence.

(8) The ERC should replace and succeed the ERC established by Commission Decision 2007/134/EC [5]. It should operate according to the established principles of scientific excellence, autonomy, efficiency and transparency.

(9) In order to maintain and increase the Union's industrial leadership there is an urgent need to stimulate private sector research and development and innovation investment, promote research and innovation with a business driven agenda and accelerate the development of new technologies which will underpin future businesses and economic growth. The priority "Industrial leadership" should support investments in excellent research and innovation in key enabling technologies and other industrial technologies, facilitate access to risk finance for innovative companies and projects, and provide Union-wide support for innovation in micro, small and medium-sized enterprises (SMEs).

(10) Space research and innovation, which is a shared competence of the Union, should be included as a coherent element in the priority "Industrial leadership" in order to maximise the scientific, economic and societal impact and to ensure an efficient and cost-effective implementation.

(11) Addressing the major societal challenges identified in the Europe 2020 strategy for smart, sustainable and inclusive growth ("Europe 2020 strategy") requires major investments in research and innovation to develop and deploy novel and breakthrough solutions that have the necessary scale and scope. These challenges also represent major economic opportunities for innovative companies and therefore contribute to the Union's competitiveness and employment.

(12) The priority "Societal challenges" should increase the effectiveness of research and innovation in responding to key societal challenges by supporting excellent research and innovation activities. Those activities should be implemented using a challenge-based approach which brings together resources and knowledge across different fields, technologies and disciplines. Social sciences and humanities research is an important element for addressing all of the challenges. The activities should cover the full range of research and innovation, including innovation-related activities such as piloting, demonstration, test-beds, and support for public procurement, pre-normative research and standard setting, and market uptake of innovations. The activities should support directly the corresponding sectoral policy competences at Union level, where appropiate. All challenges should contribute to the overarching objective of sustainable development.

(13) There should be an appropriate balance between small and large projects within the priority "Societal challenges" and the specific objective "Leadership in enabling and industrial technologies".

(14) The specific objective "Spreading excellence and widening participation" should fully exploit the potential of Europe's talent pool and 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.

(15) The specific objective "Science with and for society" should build effective cooperation between science and society, foster the recruitment of new talent for science, and pair scientific excellence with social awareness and responsibility.

(16) As an integral part of Horizon 2020, the JRC should continue to provide independent customer-driven scientific and technical support for the formulation, development, implementation and monitoring of Union policies. In order to achieve its mission the JRC should carry out research of the highest quality. In carrying out the direct actions in accordance with its mission, the JRC should place particular emphasis on areas of key concern for the Union, namely smart, inclusive and sustainable growth, and the headings "Security and citizenship" and "Global Europe" of the Multiannual Financial Framework for 2014-2020.

(17) The direct actions of the JRC should be implemented in a flexible, efficient and transparent manner, taking into account the relevant needs of the users of the JRC and the needs of Union policies, and respecting the objective of protecting the financial interests of the Union. Those research actions should be adapted, where appropriate, to those needs and to scientific and technological developments and should aim to achieve scientific excellence.

(18) The JRC should continue to generate additional resources through competitive activities, including participation in the indirect actions of Horizon 2020, third party work and, to a lesser extent, the exploitation of intellectual property.

(19) The specific programme should complement the actions carried out in the Member States as well as other Union actions which are necessary for the overall strategic effort for the implementation of the Europe 2020 strategy.

(20) Pursuant to Council Decision 2001/822/EC ([6]), legal entities of the overseas countries and territories are eligible to participate in Horizon 2020 subject to the specific conditions laid down in the latter.

(21) In order to ensure that the specific conditions for the use of the finance facilities reflect market conditions, the power to adopt acts in accordance with Article 290 TFEU should be delegated to the Commission to adapt or define further the specific conditions for use of the finance facilities. It is of particular importance that the Commission carry out appropriate consultations during its preparatory work, including at expert level. The Commission, when preparing and drawing up delegated acts, should ensure a timely and appropriate transmission of relevant documents to the Council.

(22) In order to ensure uniform conditions for the implementation of the specific programme, implementing powers should be conferred on the Commission to adopt work programmes for the implementation of the specific programme.

(23) The implementing powers relating to the work programmes for the priorities "Excellent science", "Industrial leadership" and "Societal challenges" and for the specific objectives "Spreading excellence and widening participation" and "Science with and for society" should be exercised in accordance with Regulation (EU) No 182/2011 of the European Parliament and of the Council ([7]).

(24) The Board of Governors of the JRC, set up by Commission Decision 96/282/Euratom ([8]), has been consulted on the scientific and technological content of the specific programme on the non-nuclear direct actions of the JRC.

(25) For reasons of legal certainty and clarity, Council Decision 2006/971/EC ([9]), Council Decision 2006/972/EC ([10]), Council Decision 2006/973/EC ([11]), Council Decision 2006/974/EC ([12]) and Council Decision 2006/975/EC ([13]) should be repealed,

HAS ADOPTED THIS DECISION:

TITLE I

GENERAL PROVISIONS

Article 1

Subject matter

This Decision establishes the specific programme implementing Regulation (EU) No 1291/2013 and determines the specific objectives for Union support to the research and innovation activities set out in Article 1 of that Regulation as well as the rules for implementation.

Article 2

Establishment of the specific programme

1. The specific programme implementing Horizon 2020 – the Framework Programme for Research and Innovation (2014-2020) (the 'specific programme') is hereby established for the period from 1 January 2014 to 31 December 2020.

2. In accordance with Article 5(2), (3) and (4) of Regulation (EU) No 1291/2013, the specific programme shall consist of the following Parts:

(a) Part I 'Excellent science';

(b) Part II 'Industrial leadership';

(c) Part III 'Societal challenges';

(d) Part IV 'Spreading excellence and widening participation';

(e) Part V 'Science with and for society';

(f) Part VI 'Non-nuclear direct actions of the Joint Research Centre (JRC)'.

Article 3

Specific objectives

1. Part I 'Excellent science' shall strengthen the excellence of European research in accordance with the priority "Excellent science" set out in point (a) of Article 5(2) of Regulation (EU) No 1291/2013 by pursuing the following specific objectives:

(a) strengthening frontier research, through the activities of the European Research Council (ERC) ("The European Research Council (ERC)");

(b) strengthening research in future and emerging technologies ("Future and Emerging Technologies (FET)");

(c) strengthening skills, training and career development, through the Marie Skłodowska-Curie actions ("Marie Skłodowska-Curie actions");

(d) strengthening European research infrastructures, including e-infrastructures ("Research infrastructures").

The broad lines of the activities for those specific objectives are set out in Part I of Annex I.

2. Part II 'Industrial leadership' shall strengthen industrial leadership and competitiveness in accordance with the priority 'Industrial leadership' set out in point (b) of Article 5(2) of Regulation (EU) No 1291/2013 by pursuing the following specific objectives:

(a) boosting Europe's industrial leadership through research, technological development, demonstration and innovation in the following enabling and industrial technologies ("Leadership in enabling and industrial technologies"):

(i) information and communication technologies ("ICT");

(ii) nanotechnologies;

(iii) advanced materials;

(iv) biotechnology;

(v) advanced manufacturing and processing;

(vi) space;

(b) enhancing access to risk finance for investing in research and innovation ("Access to risk finance");

(c) increasing innovation in SMEs ("Innovation in SMEs").

The broad lines of the activities for those specific objectives are set out in Part II of Annex I.

There shall be specific conditions for use of finance facilities under the specific objective in point (b) of the first subparagraph. Those conditions are set out in section 2 of Part II of Annex I.

The Commission shall be empowered to adopt delegated acts in accordance with Article 11 concerning the modifications of the share of investment from the Equity facility of Horizon 2020 of the total Union investment in expansion and growth-stage investments regarding the financial instruments referred to in section 2 of Part II of Annex I.

3. Part III 'Societal challenges' shall contribute to the priority 'Societal challenges' set out in point (c) of Article 5(2) of Regulation (EU) No 1291/2013 by pursuing research, technological development, demonstration and innovation actions which contribute to the following specific objectives:

(a) improving the lifelong health and well-being of all ("Health, demographic change and well-being");

(b) securing sufficient supplies of safe, healthy and high quality food and other bio-based products, by developing productive, sustainable and resource-efficient primary production systems, fostering related ecosystem services and the recovery of biological diversity, alongside competitive and low-carbon supply, processing and marketing chains ("Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy");

(c) making the transition to a reliable, affordable, publicly accepted, sustainable and competitive energy system, aiming at reducing fossil fuel dependancy in the face of increasingly scarce resources, increasing energy needs and climate change ("Secure, clean and efficient energy");

(d) achieving a European transport system that is resource-efficient, climate- and environmentally-friendly, safe and seamless for the benefit of all citizens, the economy and society ("Smart, green and integrated transport");

(e) achieving a resource- and water-efficient and climate change resilient economy and society, protection and sustainable management of natural resources and ecosystems and a sustainable supply and use of raw materials, in order to meet the needs of a growing global population within the sustainable limits of the planet's natural resources and ecosystems ("Climate action, environment, resource efficiency and raw materials");

(f) fostering a greater understanding of Europe, providing solutions and supporting inclusive, innovative and reflective European societies in a context of unprecedented transformations and growing global interdependencies ("Europe in a changing world – Inclusive, innovative and reflective societies");

(g) fostering secure European societies in a context of unprecedented transformations and growing global interdependencies and threats, while strengthening the European culture of freedom and justice ("Secure societies – Protecting freedom and security of Europe and its citizens").

The broad lines of the activities for those specific objectives are set out in Part III of Annex I.

4. Part IV 'Spreading excellence and widening participation' shall contribute to the specific objective "Spreading excellence and widening participation" set out in Article 5(3) of Regulation (EU) No 1291/2013 by fully exploiting the potential of Europe's talent pool and ensuring 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 broad lines of the activities for this specific objective are set out in Part IV of Annex I.

5. Part V 'Science with and for society' shall contribute to the specific objective "Science with and for society" set out in Article 5(3) of Regulation (EU) No 1291/2013 by building effective cooperation between science and society, recruiting new talent for science and pairing scientific excellence with social awareness and responsibility.

The broad lines of the activities for this specific objective are set out in Part V of Annex I.

6. Part VI 'Non-nuclear direct actions of the Joint Research Centre (JRC)' shall contribute to all of the priorities set out in Article 5(2) of Regulation (EU) No 1291/2013 with the specific objective of providing customer-driven scientific and technical support to Union policies.

The broad lines of the activities for this specific objective are set out in Part VI of Annex I.

7. The specific programme shall be assessed in relation to results and impact as measured against performance indicators.

Further details on the key performance indicators are set out in Annex II.

Article 4

Budget

1. In accordance with Article 6(1) of Regulation (EU) No 1291/2013, the financial envelope for the implementation of the specific programme shall be EUR 74 316,9 million.

2. The amount referred to in paragraph 1 of this Article shall be distributed among the six Parts set out in Article 2(2) of this Decision in accordance with Article 6(2) of Regulation (EU) No 1291/2013. The indicative budgetary breakdown for the specific objectives set out in Article 3 of this Decision and the maximum overall amount of the contribution to the actions of the JRC are set out in Annex II to Regulation (EU) No 1291/2013.

3. No more than 5 % of the amounts referred to in Article 6(2) of Regulation (EU) No 1291/2013 for Parts I to V of the specific programme shall be for the Commission's administrative expenditure. The Commission shall ensure that during the programme its administrative expenditure will decrease and it will endeavour to reach a target of 4,6 % or less in 2020. These figures shall be subject to review as part of the Horizon 2020 interim evaluation as laid down in Article 32(3) of Regulation (EU) No 1291/2013.

4. Where necessary, appropriations may be entered in the budget beyond 2020 to cover technical and administrative expenses, in order to enable the management of activities not yet completed by 31 December 2020.

TITLE II

IMPLEMENTATION

Article 5

Work programmes

1. The specific programme shall be implemented by work programmes.

2. The Commission shall adopt common or separate work programmes for the implementation of Parts I to V of the specific programme referred to in points (a) to (e) of Article 2(2), except for the implementation of the actions under the specific objective "The European Research Council (ERC)", referred to in point (a) of Article 3(1). Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 10(4).

3. The work programmes for the implementation of the actions under the specific objective "The European Research Council (ERC)" referred to in point (a) of Article 3(1), as established by the Scientific Council under point (b) of Article 7(2), shall be adopted by the Commission, by means of an implementing act, in accordance with the advisory procedure referred to in Article 10(3). The Commission shall depart from the work programme established by the Scientific Council only when it considers that it is not in accordance with the provisions of this Decision. In that case, the Commission shall adopt the work programme by means of an implementing act in in accordance with the examination procedure referred to in Article 10(4). The Commission shall duly motivate this measure.

4. The Commission shall adopt a separate multi-annual work programme, by means of an implementing act, for Part VI of the specific programme referred to in point (f) of Article 2(2).

This work programme shall take into account the opinion provided by the Board of Governors of the JRC referred to in Decision 96/282/Euratom.

5. The work programmes shall take account of the state of science, technology and innovation at national, Union and international level and of relevant policy, market and societal developments. They shall contain, where appropriate, information on coordination with research and innovation activities carried out by Member States (including their regions), including in areas where there are joint programming initiatives. They shall be updated where appropriate.

6. The work programmes for the implementation of Parts I to V referred to in points (a) to (e) of Article 2(2) of this Decision shall set out the objectives pursued, the expected results, the method of implementation and their total amount, including indicative information on the amount of climate-related expenditure, where appropriate. They shall also contain a description of the actions to be financed, an indication of the amount allocated to each action, an indicative implementation timetable, as well as a multi-annual approach and strategic orientations for the following years of implementation. They shall include for grants the priorities, the selection and award

criteria and the relative weight of the different award criteria and the maximum rate of funding of the total eligible costs. They shall also indicate any additional exploitation and dissemination obligations for participants, in accordance with Article 43 of Regulation (EU) No 1290/2013 ([14]) of the European Parliament and of the Council. They shall allow for strategic top-down as well as bottom-up approaches, as appropriate, that address the objectives in innovative ways.

In addition, those work programmes shall contain a section which identifies the cross-cutting issues as referred to in Article 14 and under the subtitle "Cross-cutting issues and support measures in Horizon 2020" in Annex I to Regulation (EU) No 1291/2013, across two or more specific objectives both within the same priority or across two or more priorities. Those actions shall be implemented in an integrated manner.

7. The Commission shall adopt, by means of implementing acts, in accordance with the examination procedure referred to in Article 10(4) the following measures:

(a) the decision on the approval of the funding of indirect actions, where the estimated amount of the Union contribution under the specific programme is equal to or more than EUR 2,5 million, with the exception of actions under the specific objective "European Research Council (ERC)" referred to in point (a) of Article 3(1) of this Decision and with the exception of actions funded under the "Fast Track to Innovation" pilot, referred to in Article 24 of Regulation (EU) No 1291/2013;

(b) the decision on the approval of the funding of actions involving the use of human embryos and human embryonic stem cells and of actions under the specific objective "Secure societies – Protecting freedom and security of Europe and its citizens" referred to in point (g) of Article 3(3);

(c) the decision on the approval of the funding of actions, where the estimated amount of the Union contribution under the specific programme is equal to or more than EUR 0,6 million for actions under the specific objective "Europe in a changing world – Inclusive, innovative and reflective societies" referred to in point (f) of Article 3(3) and for actions under the specific objectives "Spreading excellence and widening participation" and "Science with and for society" referred to in Article 3(4) and (5) respectively;

(d) the drawing up of the terms of reference for the evaluations provided for in Article 32 of Regulation (EU) No 1291/2013.

Article 6

European Research Council

1. The Commission shall establish a European Research Council ("ERC"), which shall be the means of implementing the actions under Part I 'Excellent science' which relate to the specific objective "The European Research Council (ERC)", referred to in point (a) of Article 3(1) of this Decision. The ERC shall succeed the ERC set up by Decision 2007/134/EC.

2. The ERC shall be composed of the independent Scientific Council provided for in Article 7 and the dedicated implementation structure provided for in Article 8.

3. The ERC shall have a President who shall be chosen from among senior and internationally respected scientists.

The President shall be appointed by the Commission following a transparent recruitment process involving an independent dedicated search committee, for a term of office limited to four years, renewable once. The recruitment process and the candidate selected shall have the approval of the Scientific Council.

The President shall chair the Scientific Council and shall ensure its leadership and liaison with the dedicated implementation structure, and represent it in the world of science.

4. The ERC shall operate according to the principles of scientific excellence, autonomy, efficiency, effectiveness, transparency and accountability. It shall ensure continuity with ERC actions conducted under Decision 2006/972/EC.

5. The activities of the ERC shall support research carried out across all fields by individual and transnational teams in competition at the European level. ERC frontier research grants shall be awarded on the sole criterion of excellence.

6. The Commission shall act as the guarantor of the autonomy and integrity of the ERC and shall ensure the proper execution of the tasks entrusted to it.

The Commission shall ensure that the implementation of the ERC actions is in accordance with the principles set out in paragraph 4 of this Article as well as with the overall strategy for the ERC, referred to in point (a) of Article 7(2), established by the Scientific Council.

Article 7

Scientific Council

1. The Scientific Council shall be composed of scientists, engineers and scholars of the highest repute and appropriate expertise, of both women and men in different age groups, ensuring a diversity of research areas and acting in their personal capacity, independent of extraneous interests.

The members of the Scientific Council shall be appointed by the Commission, following an independent and transparent procedure for their identification agreed with the Scientific Council, including a consultation of the scientific community and a report to the European Parliament and the Council.

Their term of office shall be limited to four years, renewable once, on the basis of a rotating system which shall ensure the continuity of the work of the Scientific Council.

2. The Scientific Council shall establish:

(a) the overall strategy for the ERC;

(b) the work programme for the implementation of the ERC activities;

(c) the methods and procedures for peer review and proposal evaluation on the basis of which the proposals to be funded are determined;

(d) its position on any matter which from a scientific perspective may enhance achievements and impact of the ERC and the quality of the research carried out;

(e) a code of conduct addressing, inter alia, the avoidance of conflict of interests.

The Commission shall depart from the positions established by the Scientific Council in accordance with points (a), (c), (d), and (e) of the first subparagraph only when it considers that the provisions of this Decision have not been respected. In that case, the Commission shall adopt measures to maintain continuity in the implementation of the specific programme and the achievements of its objectives, setting out the points of departure from the Scientific Council positions and duly motivating them.

3. The Scientific Council shall act in accordance with the mandate set out in section 1.1 of Part I of Annex I.

4. The Scientific Council shall act exclusively in the interest of achieving the specific objective "The European Research Council (ERC)", referred to in point (a) of Article 3(1), according to the principles set out in Article

6(4). It shall act with integrity and probity and carry out its work efficiently and with the greatest possible transparency.

Article 8

Dedicated implementation structure

1. The dedicated implementation structure shall be responsible for the administrative implementation and programme execution, as described in section 1.2 of Part I of Annex I. It shall support the Scientific Council in the conduct of all of its tasks.

2. The Commission shall ensure that the dedicated implementation structure follows strictly, efficiently and with the necessary flexibility the objectives and requirements of the ERC alone.

TITLE III

FINAL PROVISIONS

Article 9

Monitoring and information on implementation

1. The Commission shall annually monitor and report on the implementation of Horizon 2020 in accordance with Article 31 of Regulation (EU) No 1291/2013 and Annex III to this Decision.

2. The Commission shall regularly inform the Committee referred to in Article 10 of the overall progress of the implementation of the indirect actions of the specific programme to allow the Committee to provide early appropriate input on the preparation of the work programmes, in particular the multi-annual approach and strategic orientations, and shall provide it with timely information on all actions proposed or funded under Horizon 2020 as specified in Annex IV.

Article 10

Committee procedure

1. The Commission shall be assisted by a committee (the Programme Committee). That committee shall be a committee within the meaning of Regulation (EU) No 182/2011.

2. The committee shall meet in different configurations as set out in Annex V, having regard to the subject matter to be discussed.

3. Where reference is made to this paragraph, Article 4 of Regulation (EU) No 182/2011 shall apply.

4. Where reference is made to this paragraph, Article 5 of Regulation (EU) No 182/2011 shall apply.

5. Where the opinion of the committee is to be obtained by written procedure, that procedure shall be terminated without result when, within the time-limit for delivery of the opinion, the chair of the committee so decides or a simple majority of committee members so request.

Article 11

Exercise of the delegation

1. The power to adopt delegated acts is conferred on the Commission subject to the conditions laid down in this Article.

2. The power to adopt delegated acts referred to in Article 3(2) shall be conferred on the Commission for the duration of Horizon 2020.

3. The delegation of power referred to in Article 3(2) may be revoked at any time by the Council. A decision to revoke shall put an end to the delegation of the power specified in that decision. It shall take effect the day following the publication of the decision in the *Official Journal of the European Union* or at a later date specified therein. It shall not affect the validity of any delegated acts already in force.

4. As soon as it adopts a delegated act, the Commission shall notify it to the Council.

5. A delegated act adopted pursuant to Article 3(2) shall enter into force only if no objection has been expressed by the Council within a period of two months of notification of that act to the Council or if, before the expiry of that period, the Council has informed the Commission that it will not object. That period shall be extended by one month at the initiative of the Council.

6. The European Parliament shall be informed of the adoption of delegated acts by the Commission, or any objection formulated to them, or of the revocation of the delegation of powers by the Council.

Article 12

Repeal and transitional provisions

1. Decisions 2006/971/EC, 2006/972/EC, 2006/973/EC, 2006/974/EC and 2006/975/EC are repealed with effect from 1 January 2014.

2. However, actions initiated under the Decisions referred to in paragraph 1 of this Article and financial obligations related to actions pursued under those Decisions shall continue to be governed by those Decisions until their completion. Where necessary, any remaining tasks of the Committees established by the Decisions referred to in paragraph 1 of this Article shall be undertaken by the Committee referred to in Article 10.

3. The financial allocation for the specific programme may also cover technical and administrative assistance expenses necessary to ensure the transition between the specific programme and the measures covered by Decisions 2006/971/EC, 2006/972/EC, 2006/973/EC, 2006/974/EC and 2006/975/EC.

Article 13

Entry into force

This Decision shall enter into force on the third day following that of its publication in the *Official Journal of the European Union*.

Article 14

Addressees

This Decision is addressed to the Member States.

Done at Brussels, 3 December 2013.

For the Council

The President

E. GUSTAS

([1]) OJ C 181, 21.6.2012, p. 111.

([2]) OJ C 277, 13.9.2012, p. 143.

([3]) Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020) and repealing Decision No 1982/2006/EC (See page 104 of this Official Journal).

([4]) Decision No 1982/2006/EC of the European Parliament and of the Council of 18 December 2006 concerning the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007-2013) (OJ L 412, 30.12.2006, p. 1).

([5]) Commission Decision 2007/134/EC of 2 February 2007 establishing the European Research Council (OJ L 57, 24.2.2007, p. 14).

([6]) Council Decision 2001/822/EC of 27 November 2001 on the association of the overseas countries and territories with the European Community ("Overseas Association Decision") (OJ L 314, 30.11.2001, p. 1).

(7) Regulation (EU) No 182/2011 of the European Parliament and of the Council of 16 February 2011 laying down the rules and general principles concerning mechanisms for control by Member States of the Commission's exercise of implementing powers (OJ L 55, 28.2.2011, p. 13).

(8) Commission Decision 96/282/Euratom of 10 April 1996 on the reorganization of the Joint Research Centre (OJ L 107, 30.4.1996, p. 12).

(9) Council Decision 2006/971/EC of 19 December 2006 concerning the specific programme: 'Cooperation' implementing the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007 to 2013) (OJ L 400, 30.12.2006, p. 86).

(10) Council Decision 2006/972/EC of 19 December 2006 concerning the specific programme: 'Ideas' implementing the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007 to 2013) (OJ L 400, 30.12.2006, p. 243).

(11) Council Decision 2006/973/EC of 19 December 2006 concerning the specific programme 'People' implementing the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007 to 2013) (OJ L 400, 30.12.2006, p. 272).

(12) Council Decision 2006/974/EC of 19 December 2006 on the specific programme: 'Capacities' implementing the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007 to 2013) (OJ L 400, 30.12.2006, p. 299).

(13) Council Decision 2006/975/EC of 19 December 2006 concerning the specific programme to be carried out by means of direct actions by the Joint Research Centre under the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007 to 2013) (OJ L 400, 30.12.2006, p. 368).

(14) Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for participation and dissemination in 'Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)' and repealing Regulation (EC) No 1906/2006 (See page 81 of this Official Journal).

ANNEX I

BROAD LINES OF THE ACTIVITIES

Common elements for the indirect actions

1. PROGRAMMING

1.1. *General*

Regulation (EU) No 1291/2013 provides a set of principles in order to foster a programmatic approach whereby activities contribute in a strategic and integrated way to its objectives and in order to ensure strong complementarities with other related policies and programmes across the Union.

The indirect actions of Horizon 2020 will be implemented through the forms of funding provided for in Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council (1), in particular grants, prizes, procurement and financial instruments. All forms of funding will be used in a flexible manner across all general and specific objectives of Horizon 2020, with their use being determined on the basis of the needs and the specificities of the particular specific objective.

Particular attention will be paid to ensuring a balanced approach to research and innovation, which is not only limited to the development of new products and services on the basis of scientific and technological breakthroughs, but which also incorporates aspects such as the use of existing technologies in novel applications, continuous improvement and non-technological and social innovation. Only a holistic approach to innovation can at the same time tackle societal challenges and give rise to new competitive businesses and industries.

In particular for the priority "Societal challenges" and the specific objective "Leadership in enabling and industrial technologies", there will be a particular emphasis on research and innovation activities complemented with activities which operate close to the end-users and the market, such as demonstration, piloting or proof-of-concept. This will also include, where appropriate, activities in support of social innovation, and support to demand side approaches such as pre-standardisation or pre-commercial procurement, procurement of innovative

solutions, standardisation and other user-centered measures to help accelerate the deployment and diffusion of innovative products and services into the market. In addition, there will be sufficient room for bottom-up approaches to call for proposals, and activities in work programmes will be defined in broad terms. There will be open, light and fast schemes under each of the challenges and technologies to provide Europe's best researchers, entrepreneurs and enterprises with the opportunity to put forward breakthrough solutions of their choice.

Detailed priority setting during the implementation of Horizon 2020 will entail a strategic approach to programming of research, using modes of governance aligning closely with policy development yet cutting across the boundaries of traditional sectoral policies. This will be based on sound evidence, analysis and foresight, with progress measured against a robust set of performance indicators. This cross-cutting approach to programming and governance will allow effective coordination between all specific objectives of Horizon 2020 and will allow to address challenges which cut across them, such as sustainability, climate change, social sciences and humanities or marine sciences and technologies.

Priority setting will equally be based on a wide range of inputs and advice. It will include, where appropriate, groups of independent experts set up specifically to advise on the implementation of Horizon 2020 or any of its specific objectives. These expert groups shall show the appropriate level of expertise and knowledge in the covered areas and a variety of professional backgrounds, including academia, industry and civil society involvement. Advice on the identification and design of strategic priorities by the European Research Area and Innovation Committee (ERAC), other ERA-related Groups and the Enterprise Policy Group (EPG) shall, where appropriate, also be taken into consideration.

Priority setting may also take into account the strategic research agendas of European Technology Platforms, Joint Programming Initiatives or inputs from the European Innovation Partnerships. Where appropriate, public-public partnerships and public-private partnerships supported through Horizon 2020 will also contribute to the priority setting process and to the implementation, in line with Regulation (EU) No 1291/2013. Regular interactions with end-users, citizens and civil society organisations, through appropriate methodologies such as consensus conferences, participatory technology assessments or direct engagement in research and innovation processes, will also be a cornerstone of the priority setting process.

As Horizon 2020 is a programme for seven years, the economic, societal and policy context in which it will operate may change significantly during its life-time. Horizon 2020 needs to be able to adapt to these changes. Under each of the specific objectives, there will therefore be the possibility to include support for activities beyond the descriptions set out below, where this is duly justified to address major developments, policy needs or unforeseen events.

Activities supported under the different Parts and their specific objectives should be implemented in a way that ensures complementarity and consistency among them, as appropriate.

1.2. *Access to risk finance*

Horizon 2020 will help companies and other types of entities gain access to loans, guarantees and equity finance via two facilities.

The Debt facility will provide loans to single beneficiaries for investment in research and innovation; guarantees to financial intermediaries making loans to beneficiaries; combinations of loans and guarantees, and guarantees or counter-guarantees for national, regional and local debt-financing schemes. It will include a SME window targeting research and innovation (R&I) driven SMEs with loan amounts that complement finance to SMEs by the Loan Guarantee Facility under the Programme for the Competitiveness of Enterprises and small and medium-sized enterprises (COSME) (2014-2020).

The Equity facility will provide venture and/or mezzanine capital to individual enterprises in the early stage (start-up window). The facility will also have the possibility to make expansion and growth-stage investments in conjunction with the Equity Facility for Growth under COSME, including in funds-of-funds.

These facilities will be central to the specific objective 'Access to risk finance' but may, where relevant, also be used across all other specific objectives of Horizon 2020.

The Equity facility and the SME window of the Debt facility will be implemented as part of two Union financial instruments that provide equity and debt to support R&I and growth of SMEs, in conjunction with the equity and debt facilities under COSME.

1.3. *Communication, exploitation and dissemination*

A key added value of research and innovation funded at the Union level is the possibility to disseminate, exploit and communicate results on a continent-wide scale to enhance their impact. Horizon 2020 will therefore include, under all of its specific objectives, dedicated support to dissemination (including through open access to scientific publications), communication and dialogue actions, with a strong emphasis on communicating results to end-users, citizens, academia, civil society organisations, industry and policy makers. To this extent, Horizon 2020 may make use of networks for information transfer. Communication activities undertaken in the context of Horizon 2020 will promote the fact that the results were obtained with the support of Union funding and will also seek to raise public awareness on the importance of research and innovation by means of publications, events, knowledge repositories, databases, websites or a targeted use of social media.

2. COMPLEMENTARITIES, CROSS-CUTTING ISSUES AND SUPPORT MEASURES

Horizon 2020 is structured around the objectives defined for its three priorities: "Excellent science", "Industrial leadership" and "Societal challenges". Particular attention will be paid to ensuring adequate coordination between these priorities and fully exploiting the synergies generated between all specific objectives to maximise their combined impact on the higher level policy objectives of the Union. The objectives of Horizon 2020 will therefore be addressed through a strong emphasis on finding efficient solutions, going well beyond an approach based simply on traditional scientific and technological disciplines and economic sectors.

Cross-cutting actions will be promoted across Part I 'Excellent Science', Part II 'Industrial Leadership', Part III 'Societal Challenges', Part IV 'Spreading excellence and widening participation' and Part V 'Science with and for society' to develop jointly new knowledge, future and emerging technologies, research infrastructures and key competences. Research infrastructures will also be leveraged for broader usage in society, for example in public services, promotion of science, civil security and culture. Furthermore, priority setting during implementation for the direct actions of the JRC and the activities of the European Institute of Innovation and Technology (EIT) will be adequately coordinated with the other parts of Horizon 2020.

Furthermore, in many cases, contributing effectively to the objectives of Europe 2020 and the flagship initiative "Innovation Union" will require solutions to be developed which are interdisciplinary in nature and therefore cut across multiple specific objectives of Horizon 2020. Horizon 2020 includes specific provisions to incentivise such cross-cutting actions, including by an efficient bundling of budgets. This includes also for instance the possibility for the priority "Societal challenges" and the specific objective "Leadership in enabling and industrial technologies" to make use of the provisions for financial instruments and the dedicated SME instrument.

Cross-cutting actions will also be vital in stimulating the interactions between the priority "Societal challenges" and the specific objective "Leadership in enabling and industrial technologies", needed to generate major technological breakthroughs. Examples of where such interactions may be developed are: the domain of eHealth, smart grids, intelligent transport systems, mainstreaming of climate actions, nanomedicine, advanced materials for lightweight vehicles or the development of bio-based industrial processes and products. Strong synergies will therefore be fostered between the priority "Societal challenges" and the development of generic enabling and industrial technologies. This will be explicitly taken into account in developing the multi-annual strategies and the priority setting for each of these specific objectives. It will require that stakeholders representing the different perspectives are fully involved in the implementation, and in many cases it will also require actions which bring together funding from the specific objective "Leadership in enabling and industrial technologies" and the relevant specific objectives of the priority "Societal challenges".

Particular attention will also be paid to the coordination of activities funded through Horizon 2020 with those supported under other Union funding programmes, such as the Common Agricultural Policy, the Common Fisheries Policy, the Life Programme, the Erasmus+ programme or the Health for Growth Programme and the Union's external and development funding programmes. This includes an appropriate articulation with the

cohesion policy in the context of national and regional R&I strategies for smart specialisation, where support to capacity-building for research and innovation at regional level may act as a 'stairway to excellence', the establishment of regional centres of ex cellence may help close the innovation divide in Europe, or support to large-scale demonstration and pilot line projects may aid in achieving the objective of generating industrial leadership in Europe.

A. *Social sciences and humanities*

Social sciences and humanities research will be fully integrated into each of the specific objectives of Horizon 2020. This will include ample opportunities for supporting such research through the specific objectives "The European Research Council (ERC)", "Marie Skłodowska-Curie actions" or "Research infrastructures".

To this end, social sciences and humanities will also be mainstreamed as an essential element of the activities needed to enhance industrial leadership and to tackle each of the societal challenges. For the latter, this includes: understanding the determinants of health and optimising the effectiveness of healthcare provision; supporting policies empowering rural areas; researching and preserving Europe's cultural heritage and richness; promoting informed consumer choices; creating an inclusive digital ecosystem based on knowledge and information; robust decision making on energy policy and in ensuring a consumer-friendly European electricity grid and a transition to a sustainable energy system; supporting evidence-based transport policy and foresight; supporting climate change mitigation and adaptation strategies, resource efficiency initiatives and measures towards a green and sustainable economy; and understanding cultural and socio-economic aspects of security, risk and management issues (including legal and human rights aspects).

In addition, the specific objective 'Europe in a changing world - Inclusive, innovative and reflective societies' will support social sciences and humanities research into issues of a horizontal nature such as the creation of smart and sustainable growth, social, cultural and behavioural transformations in European societies, social innovation, innovation in the public sector or the position of Europe as a global actor.

B. *Science and society*

The relationship and interaction between science and society as well as the promotion of responsible research and innovation, science education, science communication and culture shall be deepened and public confidence in science and innovation reinforced by activities of Horizon 2020 favouring the informed engagement of and a dialogue with citizens and civil society in research and innovation.

C. *Gender*

Promoting gender equality in science and innovation is a commitment of the Union. In Horizon 2020, gender will be addressed as a cross-cutting issue in order to rectify imbalances between women and men and to integrate a gender dimension in research and innovation programming and content.

D. *SMEs*

Horizon 2020 will encourage and support the increased participation of SMEs in an integrated way across all specific objectives.

In addition to the establishment of better conditions for SMEs to participate in Horizon 2020, in accordance with Article 22 of Regulation (EU) No 1291/2013, dedicated measures set out under the specific objective 'Innovation in SMEs' (dedicated SME instrument) shall be applied in the specific objective 'Leadership in enabling and industrial technologies' and in the priority 'Societal challenges'. This integrated approach should lead to a minimum of 20 % of their total combined budgets going to SMEs.

Particular attention shall be paid to the adequate representation of SMEs in public-private partnerships referred to in Article 25 of Regulation (EU) No 1291/2013.

E. *Fast Track to Innovation (FTI)*

FTI will reduce the time from idea to market significantly and is expected to increase the participation of industry and first-time applicants in Horizon 2020.

FTI, as set out in Article 24 of Regulation (EU) No 1291/2013, will support innovation actions under the specific objective "Leadership in enabling and industrial technologies" and under the priority "Societal challenges", with a bottom-up-driven logic on the basis of a continuously open call, and "time to grant" not exceeding six months. FTI will contribute to innovation in Europe, underpinning the Union's competitiveness.

F. *Widening participation*

The research and innovation potential of the Member States, despite some recent convergence, remains very different, with large gaps between "innovation leaders" and "modest innovators". Activities shall help close the research and innovation divide in Europe by promoting synergies with the European Structural and Investment Funds (ESI Funds) and also by specific measures to unlock excellence in low performing research, development and innovation (RDI) regions, thereby widening participation in Horizon 2020 and contributing to the realisation of the ERA.

G. *International cooperation*

International cooperation with partners in third countries is necessary to address effectively many specific objectives defined in Horizon 2020, in particular those relating to Union external and development policies and international commitments. This is the case for all the societal challenges addressed by Horizon 2020, which are common in nature. International cooperation is also essential for frontier and basic research in order to capture the benefits from emerging science and technology opportunities. Promoting R&I staff mobility at an international scale is therefore crucial to enhance this global cooperation. Activities at international level are equally important to enhance the competitiveness of European industry by promoting the take-up and trade of novel technologies, for instance through the development of worldwide standards and interoperability guidelines, and by promoting the acceptance and deployment of European solutions outside Europe. All international activities should be supported by an efficient and fair knowledge transfer framework which is critical for innovation and growth.

The focus of international cooperation in Horizon 2020 will be on cooperation with three major country groupings:

(1) industrialised and emerging economies;

(2) enlargement and neighbourhood countries; and

(3) developing countries.

Where appropriate, Horizon 2020 will promote cooperation at bi-regional or multilateral level. International cooperation in research and innovation is a key aspect of the Union's global commitments and has an important role to play in the Union's partnership with developing countries, such as progressing towards the achievement of the United Nations' Millennium Development Goals.

Article 27 of Regulation (EU) No 1291/2013 sets out the general principles for participation of legal entities from third countries and of international organisations. As research and innovation in general benefit largely from an openness towards third countries, Horizon 2020 will continue with the principle of general openness while encouraging reciprocal access to third country programmes. Where appropriate, and in particular to safeguard European interest as regards intellectual property, a more cautious approach may be adopted.

In addition, a range of targeted actions will be implemented taking a strategic approach to international cooperation on the basis of common interest, priorities and mutual benefit and promoting coordination and synergies with Member States' activities. This will include a mechanism for supporting joint calls and the possibility of co-funding programmes together with third countries or international organisations. Synergies with other Union policies will be sought.

Strategic advice from the Strategic Forum for International Scientific and Technological Cooperation (SFIC) will continue to be sought.

Without prejudice to other collaboration opportunities, examples of areas where such strategic international cooperation may be developed are:

(a) the continuation of the European & Developing Countries Clinical Trials Partnership (EDCTP2) on clinical trials for medical interventions against HIV, malaria, tuberculosis and neglected diseases;

(b) support by way of an annual subscription to the Human Frontier Science Programme (HFSP) to allow non-G7 Member States to fully benefit from the funding provided by the HFSP;

(c) international consortium on rare diseases, with a number of Member States and third countries. The aim of this initiative is to develop by 2020 diagnostic tests for most rare diseases and 200 new therapies for rare diseases;

(d) support to the activities of the International Knowledge-Based Bio-Economy Forum and the EU-US Task Force on Biotechnology Research as well as collaborative links with relevant international organisations and initiatives, such as global research alliances on agricultural greenhouse gases and on animal health;

(e) contribution to multilateral processes and initiatives, such as the Intergovernmental Panel on Climate Change (IPCC), the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), and the Group on Earth Observations (GEO);

(f) the Space Dialogues between the Union and the United States and Russia, the two major space faring nations, is an extremely valuable one and forms the basis for the establishment of strategic cooperation in space partnerships;

(g) the implementing arrangement between the Union and the United States for cooperative activities in the field of Homeland Security/Civil Security/Research, signed on 18 November 2010;

(h) cooperation with developing countries, including from Sub-Saharan Africa, in the field of decentralised energy production for poverty alleviation;

(i) continuation of research collaboration with Brazil on new generation of biofuels and other uses of biomass.

In addition, dedicated horizontal activities will be supported in order to ensure the coherent and effective development of international cooperation across Horizon 2020.

H. *Sustainable development and climate change*

Horizon 2020 will encourage and support activities towards exploiting Europe's leadership in the race to develop new processes and technologies promoting sustainable development, in a broad sense, and combating climate change. Such a horizontal approach, fully integrated in all Horizon 2020 priorities, will help the Union to prosper in a low-carbon, resource-constrained world while building a resource-efficient, sustainable and competitive economy.

I. *Bridging from discovery to market application*

Bridging actions throughout Horizon 2020 are aimed at bringing discovery to market application, leading to exploitation and commercialisation of ideas whenever appropriate. The actions should be based on a broad innovation concept and stimulate cross-sectoral innovation.

J. *Cross-cutting support measures*

The cross-cutting issues will be supported by a number of horizontal support measures, including support to: enhancing the attractiveness of the research profession, including the general principles of the European Charter for Researchers, as set out in the Commission Recommendation of 11 March 2005 ([2]); strengthening the evidence base and the development of and support for ERA (including the five ERA initiatives) and the flagship initiative "Innovation Union"; recognising top performing Horizon 2020 beneficiaries and projects in the different fields through symbolic awards; improving framework conditions in support of the flagship initiative "Innovation Union", including the principles of the Commission Recommendation on the management of intellectual property ([3]), and exploring the possibility of setting up an European Intellectual Property Rights valorisation instrument; and administration and coordination of international networks for excellent researchers and innovators, such as European Cooperation in Science and Technology (COST).

3. PARTNERING

For achieving sustainable growth in Europe, the contribution of public and private players must be optimised. This is essential for consolidating the ERA and for delivering on the "Innovation Union", "the Digital Agenda for Europe", and other Europe 2020 flagship initiatives. Furthermore, responsible research and innovation requires that best solutions be derived from interactions between partners having various perspectives but common interests.

Horizon 2020 includes scope and a clear set of criteria for setting up public-public and public-private partnerships. Public-private partnerships can be based on a contractual arrangement between public and private actors and can in limited cases be institutionalised public-private partnerships, such as Joint Technology Initiatives (JTIs) and other joint undertakings.

Existing public-public and public-private partnerships may receive support from Horizon 2020, provided they address Horizon 2020 objectives, contribute to realising the ERA, meet the criteria laid down in Horizon 2020 and have shown to make significant progress under the Seventh Framework Programme.

Initiatives under Article 185 TFEU supported under the Sixth Framework Programme of the European Community for research, technological development and demonstration activities ("the Sixth Framework Programme"), adopted by Decision No 1513/2002/EC of the European Parliament and of the Council ([4]), and/or under the Seventh Framework Programme for which further support may be provided under the above conditions include: the European & Developing Countries Clinical Trials Partnership (EDCTP), Ambient Assisted Living Joint Programme (AAL), Baltic Sea Research and Development Programme (BONUS), the Eurostars Programme and the European Metrology Research Programme (EMRP). Further support may also be provided to the European Energy Research Alliance (EERA) established under the European Strategic Energy Technology Plan (SET Plan). Joint Programming Initiatives may be supported by Horizon 2020 through the instruments referred to in Article 26 of Regulation (EU) No 1291/2013, including through initiatives under Article 185 TFEU.

Joint Undertakings established in the Seventh Framework Programme under Article 187 TFEU for which further support may be provided under the above conditions are: the Innovative Medicines Initiative (IMI), Clean Sky, Single European Sky ATM Research (SESAR), the Fuel Cells and Hydrogen Joint Undertaking (FCH) and the Electronic Components and Systems for European Leadership Joint Technology Initiative (ECSEL).

Other public-private partnerships supported under the Seventh Framework Programme for which further support may be provided under the above conditions are: Factories of the Future, Energy-efficient Buildings (EeB), European Green Cars Initiative and Future Internet. Further support may also be provided to the European Industrial Initiatives (EIIs) established under the SET Plan.

Further public-public partnerships and public-private partnerships may be launched under Horizon 2020 where they meet the defined criteria.

PART I

EXCELLENT SCIENCE

1. EUROPEAN RESEARCH COUNCIL (ERC)

The ERC will promote world-class frontier research. Research at and beyond the frontiers of current understanding is both of critical importance to economic and social welfare, and an intrinsically risky venture, progressing on new and most challenging research areas and characterised by an absence of disciplinary boundaries.

In order to stimulate substantial advances at the frontiers of knowledge, the ERC will support individual teams to carry out research in any field of basic scientific and technological research which falls within the scope of Horizon 2020, including engineering, social sciences and the humanities. As appropriate, specific target groups (e.g. starting researchers/emerging teams) may be taken into account, following the objectives of the ERC and needs for efficient implementation. Particular attention will be paid to emerging and fast-growing areas at the frontier of knowledge and at the interface between disciplines.

Independent researchers of any age and gender, including starting researchers making the transition to being independent research leaders in their own right, from any country in the world will be supported to carry out their research in Europe.

The ERC shall give particular priority to assisting the best starting researchers with excellent ideas to make the transition to independence by providing adequate support at the critical stage when they are setting up or consolidating their own research team or programme. The ERC will also continue to provide appropriate levels of support for established researchers.

An "investigator-driven" approach will be followed. This means that the ERC will support projects carried out by researchers on subjects of their choice within the scope of calls for proposals. Proposals will be evaluated on the sole criterion of excellence as judged by peer review, taking account of excellence in new groups, starting researchers, as well as established teams, and paying particular attention to proposals which are highly pioneering and involve correspondingly high scientific risks.

The ERC will operate as an autonomous science-led funding body consisting of an independent Scientific Council, supported by a lean and cost-effective dedicated implementation structure.

The Scientific Council will establish the overall scientific strategy and will have full authority over decisions on the type of research to be funded.

The Scientific Council will establish the work programme to meet the ERC's objectives based on its scientific strategy as set out below. It will establish the necessary international cooperation initiatives in line with its scientific strategy, including outreach activities to increase the visibility of the ERC for the best researchers from the rest of the world.

The Scientific Council will continuously monitor the operation of the ERC and its evaluation procedures and consider how best to achieve its broader objectives. It will develop the ERC's mix of support measures as necessary to respond to emerging needs.

The ERC will aim for excellence in its own operations. The administrative and staff costs for the ERC relating to the Scientific Council and the dedicated implementation structure will be consistent with lean and cost-effective management. Administrative expenditure will be kept to a minimum, consistent with ensuring the resources necessary for world-class implementation, in order to maximise funding for frontier research.

ERC awards will be made and grants operated according to simple, transparent procedures that maintain the focus on excellence, encourage initiative and combine flexibility with accountability. The ERC will continuously look for further ways to simplify and improve its procedures in order to ensure that these principles are met.

Given the unique structure and role of the ERC as a science-led funding body the implementation and management of the activities of the ERC will be reviewed and evaluated on an ongoing basis with the full involvement of the Scientific Council to assess its achievements and to adjust and improve procedures and structures on the basis of experience.

1.1. *The Scientific Council*

In order to carry out its tasks, as set out in Article 7, the Scientific Council will:

(1) Scientific strategy:

— establish the overall scientific strategy for the ERC, in the light of scientific opportunities and European scientific needs;

— on a permanent basis, in accordance with the scientific strategy, ensure the establishment of the work programme and necessary modifications, including calls for proposals and criteria and, as may be required, the definition of specific target groups (e.g. starting/emerging teams);

(2) Scientific management, monitoring and quality control:

— as appropriate, from a scientific perspective, establish positions on implementation and management of calls for proposals, evaluation criteria, peer review processes including the selection of experts, the methods for peer review and proposal evaluation and the necessary implementing rules and guidelines, on the basis of which the proposal to be funded will be determined under the supervision of the Scientific Council, and establish positions on any other matter affecting the achievements and impact of the ERC's activities and the quality of the research carried out, including the principal provisions of the ERC Model Grant Agreement;

— monitor quality of operations and evaluate implementation and achievements and make recommendations for corrective or future actions.

(3) Communication and dissemination:

— assure transparency in communication with the scientific community, key stakeholders and the general public on the ERC's activities and achievements;

— regularly report to the Commission on its own activities.

The Scientific Council has full authority over decisions on the type of research to be funded and is the guarantor of the quality of the activity from the scientific perspective.

Where appropriate, the Scientific Council shall consult with the scientific, engineering and scholarly community, regional and national research funding agencies and other stakeholders.

The members of the Scientific Council shall be compensated for the tasks they perform by means of an honorarium and, where appropriate, reimbursement of travel and subsistence expenses.

The President of the ERC will reside in Brussels for the duration of the appointment and devote most of his/her working time ([5]) to ERC business. He/she will be remunerated at a level commensurate with the Commission's top management.

The Scientific Council shall elect from amongst its members three Vice-Chairs who shall assist the President in its representation and the organisation of its work. They may also hold the title of Vice-President of the ERC.

Support will be provided to the three Vice-Chairs to ensure adequate local administrative assistance at their home institutes.

1.2. *Dedicated implementation structure*

The dedicated implementation structure will be responsible for all aspects of administrative implementation and programme execution, as provided for in the work programme. It will, in particular, implement the evaluation procedures, peer review and selection process in accordance with the strategy established by the Scientific Council and will ensure the financial and scientific management of the grants.

The dedicated implementation structure will support the Scientific Council in the conduct of all of its tasks as set out above, provide access to the necessary documents and data in its possession, and keep the Scientific Council informed of its activities.

In order to ensure an effective liaison with the dedicated implementation structure on strategy and operational matters, the leadership of the Scientific Council and the Director of the dedicated implementation structure will hold regular coordination meetings.

The management of the ERC will be carried out by staff recruited for that purpose, including, where necessary, officials from the Union institutions, and will cover only the real administrative needs in order to assure the stability and continuity necessary for an effective administration.

1.3. *Role of the Commission*

In order to fulfil its responsibilities as set out in Articles 6, 7 and 8 the Commission will:

— ensure the continuity and renewal of the Scientific Council and provide support for a standing Identification Committee for the identification of future Scientific Council members;

— ensure the continuity of the dedicated implementation structure and the delegation of tasks and responsibilities to it taking into account the views of the Scientific Council;

— appoint the Director and the Senior Staff of the dedicated implementation structure taking into account the views of the Scientific Council;

— ensure the timely adoption of the work programme, the positions regarding implementing methodology and the necessary implementing rules as provided by the ERC Rules of Submission and the ERC Model Grant Agreement, taking into account the positions of the Scientific Council;

— regularly inform and consult the Programme Committee on the implementation of the ERC activities.

2. FUTURE AND EMERGING TECHNOLOGIES

Future and Emerging Technologies (FET) activities will concretise different logics of intervention, from completely open to varying degrees of structuring of topics, communities and funding, structured around three strands - FET Open, FET Proactive and FET Flagships.

2.1. *FET Open: fostering novel ideas*

Supporting a large set of early stage, high-risk visionary science and technology collaborative research projects is necessary for the successful exploration of new foundations for radically new future scientific knowledge and technologies. By being explicitly non-topical and non-prescriptive, this activity allows for new ideas, whenever

they arise and wherever they come from, within the broadest spectrum of themes and disciplines, and it actively stimulates creative out-of-the-box thinking. Nurturing such fragile ideas requires an agile, risk-friendly and highly interdisciplinary research approach, going well beyond the strictly technological realms. Attracting and stimulating the participation of new high-potential actors in research and innovation, such as young researchers and high-tech SMEs, is also important for nurturing the scientific and industrial leaders of the future.

2.2. *FET Proactive: nurturing emerging themes and communities*

Novel areas and themes need to be matured, by working towards structuring emerging communities and supporting the design and development of transformative research themes. The main benefits of this structuring yet explorative approach are emerging novel areas that are not yet ready for inclusion in industry research roadmaps, and building up and structuring of research communities around them. It makes the step from collaborations between a small number of researchers, to a cluster of projects that each address aspects of a research theme and exchange results. This will be done in close association with the priorities "Industrial leadership" and "Societal challenges".

2.3. *FET Flagships: pursuing grand interdisciplinary scientific and technological challenges*

Research initiatives within this strand are science- and technology-driven, large-scale, multidisciplinary and built around a visionary unifying goal. They tackle grand science and technology challenges requiring cooperation among a range of disciplines, communities and programmes. The scientific and technological advance should provide a strong and broad basis for future innovation and economic exploitation, as well as novel benefits for society of a potential high impact. The overarching nature and magnitude implies that they can only be realised through a collaborative long-term and sustained effort.

2.4. *Specific implementation aspects*

A FET Advisory Board, including scientists and engineers of the highest repute and expertise, will provide stakeholder input on the overall scientific and technological strategy, including advice on the definition of the work programme.

FET will continue to be science- and technology-led, supported by a light and efficient implementation structure. Simple administrative procedures will be adopted to maintain the focus on excellence in science-driven technological innovation, encourage initiative and combine speed in decision-making and flexibility with accountability. The most appropriate approaches will be used for probing the FET research landscape (e.g. portfolio analysis) and for involving communities of stakeholders (e.g. consultations). The aim will be for continuous improvement and for the search for further ways to simplify and improve procedures in order to ensure that these principles are met. Assessments of the effectiveness and impact of the FET activities will be carried out, complementing those at programme level.

Given its mission of fostering science-driven research towards future technologies, FET strives to bring together actors from science, technology and innovation, including, where appropriate, users, and to the extent possible from both public and private sectors. FET should therefore play an active and catalytic role in stimulating new thinking, new practices and new collaborations.

FET Open groups activities for an entirely bottom-up search for promising new ideas. The high risk implied by each such idea is countered by exploring many of them. Efficiency in terms of time and resources, low opportunity cost for the proposers, and undisputable openness to non-conventional and interdisciplinary ideas are the key characteristics for these activities. Light and fast continuously open submission schemes will seek for promising new high-risk research ideas and will include tracks for new and high-potential innovation actors such as young researchers and high-tech SMEs. To complement FET Open activities, activities under the priorities "Industrial Leadership" and "Societal Challenges" may foster radically new use of knowledge and technologies.

FET Proactive will regularly open calls on several high-risk, high-potential innovative themes, funded at such a level that several projects can be selected. These projects will be supported by community building actions that foster activities such as joint events, development of new curricula and research roadmaps. The selection of

themes will take into account excellence in science-driven research towards future technologies, potential for creating a critical mass and impact on science and technology.

A number of large-scale focused initiatives (FET Flagships) could be implemented subject to the positive outcome of FET preparatory projects. They should be based on open partnerships that enable the voluntary combination of Union, national and private contributions, with a balanced governance that allows programme owners to have appropriate influence, as well as a large degree of autonomy and flexibility in the implementation, enabling the Flagship to follow closely a broadly supported research roadmap. The selection of topics to be implemented as Flagships will be based on scientific and technologial excellence and will take into account the unifying goal, the potential impact, the integration of stakeholders and resources under a cohesive research roadmap and, where appropriate, the support from stakeholders and national/regional research programmes. These activities shall be realised using the existing funding instruments.

Activities in the three FET strands are complemented by networking and community-based activities for creating a fertile and vibrant European base for science-driven research towards future technologies. They will support the future developments of the FET activities, foster the debate on implications of new technologies, and accelerate impact.

3. MARIE SKŁODOWSKA-CURIE ACTIONS

3.1. *Fostering new skills by means of excellent initial training of researchers*

Europe needs a strong and creative human resource base, mobile across countries and sectors, with the right combination of skills to innovate and to convert knowledge and ideas into products and services for economic and social benefit.

This will be achieved in particular by structuring and raising excellence in a substantial share of the high-quality initial training of early stage researchers and doctoral candidates throughout Member States and associated countries including, where appropriate, participation from third countries. By equipping early stage researchers with a diversity of skills that will allow them to face current and future challenges, the next generation of researchers will benefit from enhanced career perspectives in both public and private sectors, thereby enhancing also the attraction of young people to research careers.

The action will be implemented through support to Union-wide competitively selected research training programmes implemented by partnerships of universities, research institutions, research infrastructures, businesses, SMEs and other socio-economic actors from different countries across Europe and beyond. Single institutions able to provide the same enriching environment will also be supported. Flexibility in the implementation of the objectives will have to be ensured in order to address the different needs. Typically, successful partnerships will take the form of research training networks that may offer innovative types of training such as joint or multiple doctoral degrees or industrial doctorates, while single institutions will usually be involved in innovative doctoral programmes. Industrial doctorates are an important element to foster an innovative spirit among researchers and create closer links between industry and academia. In this frame, support is foreseen for the best early stage researchers from any country to join these excellent programmes, which may include, inter alia, mentoring to transfer knowledge and experience.

These training programmes will address the development and broadening of core research competences, while equipping researchers with a creative mind, an entrepreneurial outlook and innovation skills that will match the future needs of the labour market. The programmes will also provide training in transferable competences such as team-work, risk-taking, project management, standardisation, entrepreneurship, ethics, intellectual property rights (IPR), communication and societal outreach which are essential for the generation, development, commercialisation and diffusion of innovation.

3.2. *Nurturing excellence by means of cross-border and cross-sector mobility*

Europe has to be attractive for the best researchers, European and non-European alike. This will be achieved in particular by supporting attractive career opportunities for experienced researchers in both public and private

sectors and by encouraging them to move between countries, sectors and disciplines to enhance their creative and innovative potential.

Funding will be given to the best or most promising experienced researchers, regardless of their nationality, who want to develop their skills through a transnational or international mobility experience. They can be supported along all the different stages of their career, including the most junior ones just after their doctoral degree or equivalent experience. These researchers will receive funding on the condition that they move from one country to another to broaden or deepen their competences in universities, research institutions, research infrastructures, businesses, SMEs or other socio-economic actors of their choice (e.g. civil society organisations), working on research and innovation projects fitting their personal needs and interests. They will be encouraged to move from public to private sector or vice versa through the support of temporary postings. This should enhance the innovativeness of the private sector and promote cross-sector mobility. Part-time opportunities allowing combined positions in both public and private sectors will also be supported to enhance the transfer of knowledge between sectors and also to encourage the creation of start-ups. Such tailor-made research opportunities will help promising researchers to become fully independent and to facilitate career moves between public and private sectors.

In order to fully exploit the existing potential of researchers, possibilities to be trained and to acquire new knowledge in a third-country high-level research institution, to restart a research career after a break and to (re)integrate researchers into a longer term research position in Europe, including their country of origin, after a transnational/international mobility experience covering return and reintegration aspects will also be supported.

3.3. *Stimulating innovation by means of cross-fertilisation of knowledge*

Societal challenges are becoming more and more global and cross-border and cross-sector collaborations are crucial to successfully face them. Sharing of knowledge and ideas from research to market (and vice versa) is therefore vital and can only be achieved through the connection of people. This will be promoted through the support of flexible exchanges of highly skilled R&I staff between sectors, countries and disciplines.

European funding will support exchanges of R&I staff within partnerships of universities, research institutions, research infrastructures, businesses, SMEs and other socio-economic actors among Europe, as well as between Europe and third countries to reinforce international cooperation. It will be open to R&I staff at all career levels, from the most junior (post-graduate) to the most senior (management), including also administrative and technical staff.

3.4. *Increasing structural impact by co-funding the activities*

Stimulating regional, national or international programmes to foster excellence and to spread best practices of the Marie Skłodowska-Curie Actions in terms of European-wide mobility possibilities for researchers' training, career development and staff exchange will increase the numerical and structural impact of the Marie Skłodowska-Curie Actions. This will also enhance the attractiveness of the centres of excellence across Europe.

This will be achieved by co-funding new or existing regional, national and international programmes, both public and private, to open up to and provide for international, intersectoral and interdicisplinary research training, as well as cross-border and cross-sector mobility of R&I staff at all stages of their career.

This will allow the exploitation of synergies between Union actions and those at regional and national level, combating fragmentation in terms of objectives, evaluation methods and working conditions of researchers. In the framework of co-funding activities, use of employment contracts will be strongly promoted.

3.5. *Specific support and policy actions*

To meet the challenge efficiently it will be essential to monitor progress. The Marie Skłodowska-Curie actions will support the development of indicators and the analysis of data related to researchers' mobility, skills, careers and gender equality with a view to identifying gaps and barriers in these actions and to increasing their impact. These activities will be implemented by seeking synergies and close coordination with the policy support actions on researchers, their employers and funders carried out under the specific objective 'Europe in a changing world

- Inclusive, innovative and reflective societies'. Specific actions will be funded to support initiatives to raise awareness on the importance of the research career and to disseminate research and innovation results emanating from work supported by the Marie Skłodowska-Curie actions.

To further increase the impact of the Marie Skłodowska-Curie actions, the networking between Marie Skłodowska-Curie researchers (current and past) will be enhanced through a strategy of alumni services. These will range from supporting a forum for contact and exchange between the researchers, providing possibilities for exploring collaborations and job opportunities, to the organisation of joint events and the involvement of the fellows in outreach activities as ambassadors for the Marie Skłodowska-Curie actions and for the ERA.

3.6. *Specific implementation aspects*

The Marie Skłodowska-Curie actions will be open to training and career development activities within all domains of research and innovation addressed under the TFEU, from basic research up to market take-up and innovation services. Research and innovation fields as well as sectors will be chosen freely by the applicants.

To benefit from the worldwide knowledge base, the Marie Skłodowska-Curie actions will be open to R&I staff, as well as to universities, research institutions, research infrastructures, businesses and other socio-economic actors from all countries, including third countries, under the conditions defined in Regulation (EU) No 1290/2013.

Throughout all the activities described above, attention will be paid to encourage a strong participation of enterprises, in particular SMEs, as well as of other socio-economic actors in the successful implementation and impact of the Marie Skłodowska-Curie actions. A long-term collaboration between higher education, research organisations and the public and private sectors, taking into account the protection of intellectual property rights, is promoted throughout all Marie Skłodowska-Curie actions.

The Marie Skłodowska-Curie actions will be developed in close synergy with other programmes supporting these policy objectives, including the Erasmus+ programme and the Knowledge and Innovation Communities (KICs) of the EIT.

The possibility is retained, if specific needs arise, to target certain activities under the Marie Skłodowska-Curie actions regarding specific societal challenges, types of research and innovation institutions, or geographical locations in order to respond to the evolution of Europe's requirements in terms of skills, research training, career development and knowledge sharing.

In order to be open to all sources of talent, general measures to overcome any distortions in the access to the grants will be ensured, for example by encouraging equal opportunities for male and female researchers in all Marie Skłodowska-Curie actions and by benchmarking gender participation. In addition, the Marie Skłodowska-Curie actions will support researchers to get established on a more stable career path and to ensure that they can achieve an appropriate work/life balance, taking into account their family situation, and to facilitate resuming a research career after a break. The principles of the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers promoting open recruitment and attractive working conditions are recommended to be endorsed and applied by all funded participants.

To further enhance dissemination and public engagement, beneficiaries of the Marie Skłodowska-Curie actions may be required to plan suitable outreach activities to the general public. This plan will be assessed during the evaluation process as well as during the project follow-up.

4. RESEARCH INFRASTRUCTURES

The activities will aim at developing excellent European research infrastructures for 2020 and beyond, fostering their innovation potential and human resources and reinforcing European policy. Coordination with the cohesion funding sources will be pursued to ensure synergies and a coherent approach for the development of the research infrastructures. Synergies with the Marie Sklodowska-Curie actions will be encouraged.

4.1. *Developing the European research infrastructures for 2020 and beyond*

4.1.1. Developing new world-class research infrastructures

The aim is to facilitate and support the preparation, implementation, long-term sustainability and efficient operation of the research infrastructures identified by the European Strategy Forum on Research Infrastructures (ESFRI) and of other world-class research infrastructures, which will help Europe to respond to grand challenges in science, industry and society. This objective will address specifically those infrastructures that are planning to set up, are setting up or have set up their governance, e.g. on the basis of the European Research Infrastructure Consortium (ERIC) or any equivalent structure at European or international level.

The Union funding will contribute to, as appropriate:

(a) he preparatory phase of future infrastructures (e.g. detailed construction plans, legal arrangements, multiannual planning, and early engagement of industry);

(b) the implementation phase (e.g. research and development (R&D) and engineering work jointly with industry and users, and development of Regional Partner Facilities ([6]) aiming at a more balanced development of the ERA); and/or

(c) the operation phase (e.g. access, data handling, outreach, training and international cooperation activities).

This activity will also support design studies for new research infrastructures through a bottom-up approach.

4.1.2. Integrating and opening existing national and regional research infrastructures of European interest

The aim is to open up, where appropriate, key national and regional research infrastructures to all European researchers, from both academia and industry, and to ensure the optimal use and joint development of these infrastructures.

The Union will support networks and clusters that bring together and integrate, on European scale, key national research infrastructures. Funding will be provided to support, in particular, the transnational and virtual access of researchers and the harmonisation and improvement of the services that the infrastructures provide.

4.1.3. Development, deployment and operation of ICT-based e-infrastructures ([7])

The aim is to achieve by 2020 a world-leading capability in networking, computing and scientific data in a single and open European space for online research where researchers enjoy leading-edge, ubiquitous and reliable services for networking and computing, and seamless and open access to e-Science environments and global data resources.

To achieve this goal, support will be given to: global research and education networks providing advanced, standardised and scalable inter-domain services on-demand; grid and cloud infrastructures providing virtually unlimited computational and data processing capacity; an ecosystem of supercomputing facilities, advancing towards exascale; a software and service infrastructure, e.g. for simulation and visualisation; real-time collaborative tools; and an interoperable, open and trusted scientific data infrastructure.

4.2. *Fostering the innovation potential of research infrastructures and their human resources*

4.2.1. Exploiting the innovation potential of research infrastructures

The goal is to stimulate innovation both in the infrastructures themselves and in industries, such as the supplier and user industry.

To this end, support will be provided to:

(a) R&D partnerships with industry to develop Union capacities and industrial supply in high-tech areas such as scientific instrumentation or ICT;

(b) pre-commercial procurement by research infrastructure actors to drive forward innovation and act as early adopters or developers of cutting-edge technologies;

(c) stimulate the use of research infrastructures by industry, e.g. as experimental test facilities or knowledge-based centres; and

(d) encourage the integration of research infrastructures into local, regional and global innovation ecosystems.

The Union actions will also leverage the use of research infrastructures, in particular e-infrastructures, for public services, social innovation, culture, education and training.

4.2.2. Strengthening the human capital of research infrastructures

The complexity of research infrastructures and the exploitation of their full potential require adequate skills for their managers, engineers and technicians, as well as users.

The Union funding will support the training of staff managing and operating research infrastructures of pan-European interest, the exchange of staff and best practices between facilities, and the adequate supply of human resources in key disciplines, including the emergence of specific education curricula. Synergies with the Marie Skłodowska-Curie actions will be encouraged.

4.3. *Reinforcing European research infrastructure policy and international cooperation*

4.3.1. Reinforcing European policy for research infrastructures

The aims are to exploit synergies between national and Union initiatives by setting up partnerships between relevant policy makers, funding bodies or advisory groups (e.g. ESFRI, e-Infrastructure Reflection Group (e-IRG), EIROforum organisations, and national public authorities), to develop complementarities and cooperation between research infrastructures and activities implementing other Union policies (such as regional, cohesion, industrial, health, environment, employment, or development policy), and to ensure coordination between different Union funding sources. Union actions will also support survey, monitoring and assessment of research infrastructures at Union level, as well as relevant policy studies and communication tasks.

Horizon 2020 will facilitate the efforts of the Member States to optimise their research facilities by supporting an up-to-date Union-wide database on openly accessible research infrastructures in Europe.

4.3.2. Facilitating strategic international cooperation

The aim is to facilitate the development of global research infrastructures, i.e. research infrastructures that require funding and agreements on a global scale. The aim is also to facilitate the cooperation of European research infrastructures with their non-European counterparts, ensuring their global interoperability and reach, and to pursue international agreements on the reciprocal use, openness or co-financing of infrastructures. In this respect due account will be taken of the recommendations of the Carnegie Group of Senior Officials on Global Research Infrastructures. Attention will also be given to ensure adequate Union participation in coordination with international bodies such as the United Nations (UN) or the Organisation for Economic Cooperation and Development (OECD).

4.4. *Specific implementation aspects*

During implementation independent expert groups will be consulted, as well as stakeholders and advisory bodies, such as ESFRI and the e-IRG.

The implementation will follow a three-pronged approach: bottom-up where the exact content and partnership of projects are not known; targeted where the specific research infrastructures and/or communities addressed are well-defined; and named beneficiaries, for example where a contribution to operational costs is provided to (a consortium of) infrastructure operator(s).

The aims of the activity lines set out under sections 4.2 and 4.3 shall be pursued by dedicated actions, as well as within the actions developed under section 4.1, when appropriate.

PART II

INDUSTRIAL LEADERSHIP

1. LEADERSHIP IN ENABLING AND INDUSTRIAL TECHNOLOGIES

General

The successful mastering, integration and deployment of enabling technologies by European industry is a key factor in strengthening Europe's productivity and innovation capacity and ensuring Europe has an advanced, sustainable and competitive economy, global leadership in high-tech application sectors and the ability to develop effective and sustainable solutions for societal challenges taking into account, inter alia, user needs. Innovation activities will be combined with R&D, as an integral part of the funding.

An integrated approach to Key Enabling Technologies

A major component of the specific objective 'Leadership in Enabling and Industrial Technologies' are Key Enabling Technologies (KETs), defined as micro- and nanoelectronics, photonics, nanotechnology, biotechnology, advanced materials and advanced manufacturing systems. Many innovative products incorporate several of these technologies simultaneously, as single or integrated parts. While each technology offers technological innovation, the accumulated benefit from the numerous interactions of KETs and other industrial enabling technologies and their combinations can also lead to technological leaps. Tapping into cross-cutting key enabling technologies will enhance product competitiveness and impact, stimulate growth and jobs and provide new opportunities to tackle societal challenges. The numerous interactions of these technologies will therefore be exploited. Dedicated support will be provided for larger-scale pilot line and demonstrator projects to be implemented in various environments and conditions.

This will include KETs and cross-cutting KET (multi KETs) activities that bring together and integrate various individual technologies, resulting in technology validation in an industrial environment to a complete and qualified system, ready or close to enter the market. Strong private sector involvement in such activities and the demonstration of how project results will contribute to market value for the Union will be a prerequisite, and implementation could therefore take the form of public-private partnerships. To this extent and through the Horizon 2020 implementation structure, a joint work programme for cross-cutting KET activities will be developed. Taking into account market needs and the requirements of the societal challenges, it will aim at providing generic KETs and multi KETs building blocks for different application areas, including societal challenges. In addition, synergies will be sought, where appropriate, between KET activities and the activities under the cohesion policy framework in the context of national and regional R&I strategies for smart specialisation, as well as with the EIT, the European Investment Bank (EIB) and, where appropriate, with the Member States driven activities under the Joint Programming Initiatives.

Specific implementation aspects

Innovation activities will include the integration of individual technologies; demonstrations of capacities to make and deliver innovative products, systems, processes and services; user and customer pilots to prove feasibility and added value; and large-scale demonstrators to facilitate market take-up of the research results. Adequate focus will be given to small and medium scale projects. Furthermore, implementation under this Part will encourage the involvement of small and medium-sized research teams, also contributing to a more active participation of SMEs.

Various individual technologies will be integrated, resulting in technology validation in an industrial environment to a complete and qualified system, ready for the market. Strong private sector involvement in such activities will be a prerequisite, including public-private partnerships.

Demand-side actions will complement the technology push of the research and innovation initiatives. These include making the best use of public procurement of innovation; developing appropriate technical standards and technical activities in support of standardisation and regulation; private demand and engaging users to create more innovation-friendly markets.

For nanotechnology and biotechnology in particular engagement with stakeholders and the general public will aim to raise the awareness of benefits and risks. Safety assessment and the management of overall risks in the deployment of these technologies will be systematically addressed. Where appropriate, social sciences and humanities will contribute to taking into account user needs preferences and acceptance as well as ensuring societal engagement and informed consumers' choice.

The activities supported under this specific objective will complement support for research and innovation in enabling technologies, which may be provided by national or regional authorities under the Cohesion Policy Funds, within the framework of smart specialisation strategies.

This specific objective shall, as part of the funding of actions, also support technology transfer activities (both at national and regional level), including the development of international and regional innovation clusters, to promote more effective linkages between universities and the industry.

Strategic international cooperation initiatives will be pursued in areas of mutual interest and benefit with leading partner countries. Of particular, but not exclusive, interest for enabling and industrial technologies are:

— access to world-leading scientific and technological expertise;

— the development of global standards;

— the removal of bottlenecks in industrial exploitation, R&D collaboration and conditions for trade;

— the safety of nanotechnology-based and biotechnology-based products and the long-term impact of their use;

— the development of materials and methods to reduce energy and resource consumption;

— industry-led, collaborative international initiatives within the manufacturing community; and

— the interoperability of systems.

1.1. *Information and Communication Technologies (ICT)*

A number of activity lines will target ICT industrial and technological leadership challenges along the whole value chain and cover generic ICT research and innovation agendas, including notably:

1.1.1. A new generation of components and systems: Engineering of advanced, embedded and energy- and resource-efficient components and systems

The objective is to maintain and reinforce European leadership in technologies related to advanced, embedded, energy-and resource-efficient and robust components and systems. It also includes micro-nano-bio systems, organic electronics, large area integration, underlying technologies for the Internet of Things (IoT) ([8]), including platforms to support the delivery of advanced services, sensors, smart integrated systems, embedded and distributed systems, systems of systems and complex systems engineering.

1.1.2. Next generation computing: Advanced and secure computing systems and technologies, including cloud computing

The objective is to leverage European assets in processor and system architecture, interconnect and data localisation technologies, cloud computing, parallel computing, modelling and simulation software for all market segments, including engineering applications (such as uncertainty quantification, risk analysis and decision in engineering).

1.1.3. Future Internet: Software, hardware, infrastructures, technologies and services

The objective is to reinforce the competitiveness of European industry in developing, mastering and shaping the next generation Internet that will gradually replace and surpass the current Web, fixed and mobile networks and service infrastructures, and enable the interconnection of trillions of devices (IoT) across multiple operators and domains that will change the way we communicate, access and use knowledge. This includes R&I on networks, software, processes and services, cyber security, privacy, reliability and trust, wireless ([9]) communication and all optical networks, immersive interactive multimedia and the connected enterprise of the future.

1.1.4. Content technologies and information management: ICT for digital content and for cultural and creative industries

The objective is to strengthen Europe's position as provider of products and services based on individual and business creativity. It will do so by providing professionals and citizens with new tools to create, access, exploit, preserve and re-use all forms of digital content in any language and to model, analyse and visualise vast amounts of data (big data), including linked data. This includes new technologies for arts, language, learning, interaction, digital preservation, web design, content access, analytics and media; and intelligent and adaptive information management systems based on advanced data mining, machine learning, statistical analysis and visual computing technologies.

1.1.5. Advanced interfaces and robots: Robotics and smart spaces

The objective is to reinforce European scientific and industrial leadership in industrial and service robotics, cognitive and communicative systems, advanced interfaces and smart spaces, and sentient machines, building on increases in computing and networking performance and progress in the ability to design and build systems that can learn, self-assemble, adapt and react or that optimise human-machine interactions. Where appropriate, the systems developed and advancements in the state of the art should be validated in real-world environments.

1.1.6. Micro- and nanoelectronics and photonics: Key enabling technologies related to micro- and nanoelectronics and to photonics, covering also quantum technologies

The objective is to take advantage of the excellence of Europe in these key enabling technologies and support and further enhance the competitiveness and market leadership of its industry. Activities will also include research and innovation on design, advanced processes, pilot lines for fabrication, related production technologies and demonstration actions to validate technology developments and innovative business models as well as underlying next generation technologies exploiting advances in quantum physics.

These six major activity lines are expected to cover the full range of needs taking into account the competitiveness of European industry on a global scale. These would include industrial leadership in generic ICT-based solutions, products and services needed to tackle major societal challenges as well as application-driven ICT research and innovation agendas which will be supported together with the relevant societal challenge. In view of the ever increasing advancement of technology in all areas of life, the interaction between humans and technology will be important in this respect, and part of the application-driven ICT research mentioned above. Research with a user-centred perspective will contribute to the development of competitive solutions.

Included under each of these six major activity lines are also ICT-specific research infrastructures, such as living labs for experimentation, and infrastructures for underlying key enabling technologies and their integration in advanced products and innovative smart systems, including equipment, tools, support services, clean rooms and access to foundries for prototyping.

This should be implemented in a way that ensures complementarity and consistency with the specific objective "Research infrastructures" under the priority "Excellent Science".

Activities will support research and development of ICT systems in full respect of the fundamental rights and freedoms of natural persons and in particular their right to privacy.

1.2. *Nanotechnologies*

1.2.1. Developing next generation nanomaterials, nanodevices and nanosystems

Development and integration of knowledge of nanoscale phenomena at the cross-roads of different scientific disciplines, aiming at fundamentally new products and systems enabling sustainable solutions in a wide range of sectors.

1.2.2. Ensuring the safe and sustainable development and application of nanotechnologies

Advancing scientific knowledge of the potential impact of nanotechnologies on health or on the environment for pro-active, science-based governance of nanotechnologies, and providing validated scientific tools, methods and platforms for hazard, exposure and risk assessment and management along the entire life cycle of nanomaterials and nanosystems, including standardisation issues.

1.2.3. Developing the societal dimension of nanotechnology

Addressing the human and physical needs of nanotechnology deployment and focusing on governance of nanotechnology for societal and environmental benefit, including communication strategies to ensure social engagement.

1.2.4. Efficient and sustainable synthesis and manufacturing of nanomaterials, components and systems

Focusing on new flexible, scalable and repeatable unit operations, smart integration of new and existing processes, including technology convergence such as nanobiotechnology, as well as up-scaling to enable sustainable high precision large-scale production of products and flexible and multi-purpose plants that ensure the efficient transfer of knowledge into industrial innovation.

1.2.5. Developing and standardisation of capacity-enhancing techniques, measuring methods and equipment

Focusing on the underpinning technologies, supporting the development and market introduction of safe complex nanomaterials and nanosystems, including nanometrology, characterisation and manipulation of matter at the nano-scale, modelling, computational design and advanced engineering at the atomic level.

1.3. *Advanced materials*

1.3.1. Cross-cutting and enabling materials technologies

Research on materials by design, functional materials, multifunctional materials with higher knowledge content, new functionalities and improved performance, such as self-repairing or biocompatible materials, self-assembling materials, novel magnetic materials and structural materials, for innovation in all industrial sectors, particularly for high value markets, and including the creative industries.

1.3.2. Materials development and transformation

Research and development to ensure efficient, safe and sustainable development and scale-up to enable industrial manufacturing of future design-based products towards a "no-waste" management of materials in Europe, e.g. in the metal, chemical or biotechnological industries, and to improve the understanding of material degradation mechanisms (wear, corrosion and mechanical reliability).

1.3.3. Management of materials components

Research and development for new and innovative techniques for materials, components and systems, joining, adhesion, separation, assembly, self-assembly and the disassembling, decomposition and deconstruction of

material components, and management of life-cycle costs and environmental impacts through novel use of advanced materials technology.

1.3.4. Materials for a sustainable, resource-efficient and low-emission industry

Developing new products and applications, business models and responsible consumer behaviour that increase the use of the renewable resources for sustainable applications, reduce energy demand in the product's entire life cycle and facilitate low-emission production, as well as process intensification, recycling, depollution, materials for energy storage and materials with potential for high added value from waste and remanufacture.

1.3.5. Materials for creative industries, including heritage

Applying design and the development of converging technologies to create new business opportunities, including the preservation and restoration of Europe's heritage and materials with historical or cultural value, as well as novel materials.

1.3.6. Metrology, characterisation, standardisation and quality control

Promoting technologies such as characterisation, non-destructive evaluation, continuous assessing and monitoring and predictive modelling of performance for progress and impact in materials science and engineering.

1.3.7. Optimisation of the use of materials

Research and development to investigate substitution and alternatives to the use of materials, including addressing the challenge of raw materials through tailor-made materials or the substitution of scarce, critical or dangerous materials, and innovative business model approaches and identification of critical resources.

1.4. *Biotechnology*

1.4.1. Boosting cutting-edge biotechnologies as a future innovation driver

The objective is to lay the foundations for the European industry to stay at the front line of innovation, also in the medium and long term. It encompasses the development of emerging technology areas such as synthetic biology, bioinformatics and systems biology, as well as exploiting the convergence with other enabling technologies such as nanotechnology (e.g. bionanotechnology), ICT (e.g. bioelectronics) and engineering technology. These and other cutting-edge fields deserve appropriate measures in terms of research and development to facilitate effective transfer and implementation into new applications.

1.4.2. Biotechnology-based industrial products and processes

The objective is twofold: on the one hand, enabling the European industry (e.g. chemical, health, mining, energy, pulp and paper, fibre-based products and wood, textile, starch, and food processing industries) to develop new products and processes meeting industrial and societal demands using preferably environmentally friendly and sustainable production methods and competitive and enhanced biotechnology-based alternatives to replace established ones; on the other hand, harnessing the potential of biotechnology for detecting, monitoring, preventing and removing pollution. It includes R&I on novel enzymes with optimised biocatalyst functions, enzymatic and metabolic pathways, industrial scale bio-process design, integration of bio-processes in industrial production processes, advanced fermentation, up- and down-stream processing, and gaining insight on the dynamics of microbial communities. It will also encompass the development of prototypes for assessing the techno-economic feasibility as well as the sustainability of the developed products and processes.

1.4.3. Innovative and competitive platform technologies

The objective is to develop platform technologies (e.g. genomics, meta-genomics, proteomics, metabolomics, molecular tools, expression systems, phenotyping platforms and cell-based platforms) triggering leadership and competitive advantage on a wide number of economic sectors having econonomic impact. It includes aspects such as underpinning the development of bio-resources with optimised properties and applications beyond conventional alternatives; enabling exploration, understanding and exploitation in a sustainable manner of

terrestrial and marine biodiversity for novel applications, bio-based products and processes; and sustaining the development of biotechnology-based healthcare solutions (e.g. diagnostics, biologicals, and bio-medical devices).

1.5. *Advanced Manufacturing and Processing*

1.5.1. Technologies for Factories of the Future

Promoting sustainable industrial growth by facilitating a strategic shift in Europe from cost-based manufacturing to an approach based on the creation of high added value products and ICT-enabled intelligent and high performance manufacturing in an integrated system. This requires addressing the challenge of producing more, while consuming less material, using less energy and generating less waste and pollution aiming at high ecological efficiency. The focus will be on the development and integration of the adaptive production systems of the future, with particular emphasis on the needs of European SMEs, in order to achieve advanced and sustainable manufacturing systems and processes. Focus shall also be on methodologies for enhancing flexible, safe and smart production where adequate levels of automation are applied in worker-friendly environments.

1.5.2. Technologies enabling energy-efficient systems and energy-efficient buildings with a low enviromental impact

Reducing energy consumption and CO2 emissions by the development and deployment of sustainable construction technologies and systems and by the implementation and replication of measures for an increased uptake of energy-efficient systems and materials in new, renovated and retrofitted buildings. Life-cycle considerations and the growing importance of design-build-operate concepts will be key factors in addressing the challenge of a transition to near-zero-energy buildings in Europe by 2020 and the realisation of energy-efficient districts through the engagement of the wide stakeholder community.

1.5.3. Sustainable, resource-efficient and low-carbon technologies in energy-intensive process industries

Increasing the competitiveness of process industries, such as chemical, cement, pulp and paper, glass, minerals or non-ferrous metals and steel industries, by drastically improving resource and energy efficiencies and reducing the environmental impact of such industrial activities. Focus will be on the development and validation of enabling technologies for innovative substances, materials and technological solutions for low-carbon products and less energy-intensive processes and services along the value chain, as well as on the adoption of ultra-low carbon production technologies and techniques, to achieve specific greenhouse gas emission intensity reductions.

1.5.4. New sustainable business models

Cross-sectoral cooperation in concepts and methodologies for knowledge-based, specialised production can boost learning in organisations, creativity and innovation with a focus on business models in customised approaches that can adapt to the requirements of globalised value chains and networks, changing markets, and emerging and future industries. This includes addressing sustainable business models by covering the whole lifecycle of the product and process.

1.6. *Space*

In the field of space research, action at Union level will be carried out in conjunction with the space research activities of the Member States and the European Space Agency (ESA), aiming at building up complementarity among different actors.

1.6.1. Enabling European competitiveness, non-dependence and innovation of the European space sector

The objective is to maintain a globally leading role in space by safeguarding and further developing a cost-effective, competitive and innovative space industry (including SMEs) and research community and by fostering space-based innovation.

1.6.1.1. Safeguard and further develop a competitive, sustainable and entrepreneurial space industry and research community and strenghten European non-dependance in space systems

Europe is playing a leading role in space research and in the development of space technologies and is continually developing its own operational space infrastructures (e.g. the Galileo programme and the Copernicus programme). In fact, European industry has established itself as an exporter of first class satellites and other space-related technologies. Nevertheless, this position is challenged by competition from other major space powers. The objective of this measure is the development of a research base by providing continuity in space research and innovation programmes, for example by a sequence of smaller and more frequent in-space demonstration projects. This will allow Europe to develop its industrial base and space research and technological development (RTD) community, thereby contributing to advancing beyond the current state of the art and to its non-dependence from imports of critical technologies.

Standardisation should be supported in order to optimise the investments and to develop access to market.

1.6.1.2. Boost innovation between space and non-space sectors

A number of challenges in space technologies have parallels to terrestrial challenges, for example in the fields of aeronautics, energy, environment, telecommunications and ICT, natural resource exploration, sensors, robotics, advanced materials, security and health. These commonalities offer opportunities for early co-development, in particular by SMEs, of technologies across space and non-space communities, including non-space industries, potentially resulting in breakthrough innovations more rapidly than achieved in spin-offs at a later stage. Exploitation of existing European space infrastructure should be stimulated by promoting the development of innovative products and services based on remote sensing, geo-positioning or other types of satellite enabled data. Europe should furthermore reinforce the incipient development of an entrepreneurial space sector, where appropriate, by well targeted measures, including support for space technology transfer initiatives.

1.6.2. Enabling advances in space technologies

The objective is to develop advanced and enabling space technologies and operational concepts from idea to demonstration in space.

The ability to access space and to develop, maintain and operate space systems in Earth orbit and beyond are vital to the future of European society. The necessary capabilities require research and innovation investments in a multitude of space technologies (e.g. for launchers and other vehicles, satellites, robotics, instruments and sensors) and in operational concepts from idea to demonstration in space. Europe is currently one of the three leading space powers mainly driven by investments by Member States through ESA and national programmes, but compared to the level of investment in space R&D in the United States (e.g. about 20 % of the total NASA budget) the European focus in future space technologies and applications needs to be strengthened along the entire chain:

(a) low technology readiness level (TRL) research, often relying heavily on key enabling technologies, with the potential of generating breakthrough technologies with terrestrial applications;

(b) improvement of existing technologies, e.g. through miniaturisation, higher energy efficiency, and higher sensor sensitivity;

(c) demonstration and validation of new technologies and concepts in the space and terrestrial analogue environments;

(d) mission context, e.g. analysis of the space environment, ground stations, protecting space systems and infrastructure against damage or destruction from collision with debris or other space objects, as well as the effects of space weather events including solar flares (Space Situational Awareness, SSA), fostering innovative data gathering and transmission and sample archiving infrastructure;

(e) satellite communication, advanced navigation and remote sensing technologies, covering the research essential for future generations of Union space systems (e.g. Galileo and Copernicus).

1.6.3. Enabling exploitation of space data

The objective is to ensure more extensive utilisation of space data from existing, archived and future European missions in the scientific, public and commercial domain.

Space systems produce information which often cannot be acquired in any other way. Despite world-class European missions, publication figures show that data from European missions are not as likely to be used as data from US missions. A considerably increased exploitation of data from European satellites (scientific, public or commercial) can be achieved if further effort is made for the processing, archiving, validation, standardisation and sustainable availability of space data from European missions as well as to support the development of new information products and services resulting from those data and, where appropriate, in combination with data from ground-based observations. Innovations in data acquisition and processing, data fusion, and data dissemination and interoperability, in particular promotion of access to and exchange of earth science data and metadata, utilising also innovative ICT-enabled forms of collaboration, can ensure a higher return on investment of space infrastructure and contribute to tackling societal challenges. Calibration and validation of space data (for individual instruments, between instruments and missions, and with respect to in-situ objects) are key factors in the efficient use of space data in all domains, and there is a need to enhance the standardisation of space-derived data and reference frames.

Data access and exploitation of space missions is a matter that requires global coordination. For Earth observation data, harmonised approaches and best practices are partly achieved in coordination with the intergovernmental organisation Group on Earth Observation (GEO), aiming to sustain a Global Earth Observation System of Systems (GEOSS), in which the Union participates, namely by fully exploiting the Copernicus programme. A fast introduction of these innovations into the relevant application and decision making processes will be supported. This includes as well the exploitation of data for further scientific investigation.

1.6.4. Enabling European research in support of international space partnerships

The objective is to support the European research and innovation contribution to long term international space partnerships.

Although space information provides great local benefits, space undertakings have a fundamentally global character. This is particularly clear for the cosmic threat to Earth and space systems. The loss of satellites due to space weather and space debris is estimated to cost around EUR 100 million a year. Equally global are many space science and exploration projects. The development of cutting-edge space technology is increasingly taking place within such international partnerships, making access to such international projects an important success factor for European researchers and industry. The Union contribution to such global space endeavours needs to be defined in long-term strategic roadmaps (10 years and more), aligning with the Union's space policy priorities, and in coordination with the Member States and internal European partners, such as ESA and National Space Agencies, and, when relevant, with international partners and with the space agencies of space-faring nations.

1.6.5. Specific implementation aspects

The implementation priorities of space research and innovation under Horizon 2020 are in line with the Union's space policy priorities as defined by the Space Council and in the Commission Communication of 4 April 2011 entitled "Towards a space strategy for the European Union that benefits its citizens". The implementation will, where appropriate, be based on strategic research agendas developed in consultation with the Member States and National Space Agencies, ESA, stakeholders from European space industry (including SMEs), academia, technology institutes and the Space Advisory Group. As regards the participation in international undertakings,

the research and innovation agenda will be defined in collaboration with European stakeholders and international partners (e.g. NASA, ROSCOSMOS and JAXA).

The application of space technologies shall be supported through the respective specific objectives of the priority "Societal challenges", where appropriate.

2. ACCESS TO RISK FINANCE

Horizon 2020 will set up two facilities (the 'Equity facility' and the 'Debt facility'), composed of various windows. The Equity facility and the SME window of the Debt facility will be implemented in interdependence with COSME, as part of two Union Financial Instruments that provide equity and debt to support R&I and growth of SMEs.

The Equity facility and the Debt facility may, where appropriate, allow pooling of financial resources with Member States or regions willing to contribute part of the ESI Funds allocated to them, in accordance with Regulation (EU) No 1303/2013 of the European Parliament and of the Council ([10]).

Instead of providing for instance loans, guarantees or equity directly to final beneficiaries, the Commission will delegate to financial institutions the provision of support via, in particular, risk-sharing, guarantee schemes and equity and quasi-equity investments.

2.1. *Debt facility*

The Debt facility will provide loans to single beneficiaries for investment in R&I; (counter-) guarantees to financial intermediaries providing loans to beneficiaries; combinations of loans and (counter-) guarantees; and guarantees and/or counter-guarantees for national or regional debt-financing schemes. The Debt facility will undertake maturity enhancement activities, and it will support the dedicated SME Instrument, subject to the level of demand (see section 3 'Innovation in SMEs' of Part II). Provisions from the Debt facility may be combined, with the possible addition of grants (including lump sums), with provisions from the Equity facility in one or more integrated schemes. Soft loans, convertible loans, subordinated loans, participating loans, leasing loans and securitisation may also be possible.

As well as providing loans and guarantees on a market-driven, first-come, first-served basis, the Debt facility will target, under a series of compartments, particular policies and sectors. Ring-fenced budgetary contributions for this purpose may, where appropriate, come from:

(a) other parts of Horizon 2020, notably Part III 'Societal challenges';

(b) other frameworks, programmes and budget lines in the general budget of the Union;

(c) particular regions and Member States that wish to contribute with resources available from the Cohesion Policy Funds; and

(d) specific entities (such as Joint Technology Initiatives) or initiatives.

Such budgetary contributions may be made or topped up at any time during the course of Horizon 2020.

Risk-sharing and other parameters may vary within policy or sector compartments, provided their values or states comply with the common rules for debt instruments. Furthermore, compartments may have specific communications strategies within the overall promotional campaign for the Debt facility. In addition, specialist intermediaries at national level may be used if specific expertise is needed to assess prospective loans in the domain of a particular compartment.

The SME window under the Debt facility shall target R&I-driven SMEs and small mid-caps with loan amounts exceeding EUR 150 000, thus complementing finance to SMEs by the Loan Guarantee Facility under COSME.

The SME window of the Debt facility shall also cover loans below EUR 150 000 for R&I-driven SMEs and small mid-caps.

The leverage of the Debt facility - defined as the total funding (i.e. Union funding plus contribution from other financial institutions) divided by the Union financial contribution - is expected to range from an average 1,5 to 6,5, depending on the type of operations involved (level of risk, target beneficiaries, and the particular debt financial instrument facility concerned). The multiplier effect - defined as the total of investments made by supported beneficiaries divided by the Union financial contribution - is expected to be 5 to 20, again depending on the type of operations involved.

2.2. *Equity facility*

The Equity facility will focus on early-stage venture capital funds and public and private funds-of-funds providing venture capital and/or mezzanine capital to individual portfolio enterprises. These enterprises may, in addition, seek debt financing from financial intermediaries implementing the Debt facility. Furthermore, the Equity facility will also explore possibilities to support business angels and other potential sources of equity finance. This could also include support at the phase 3 stage of the SME instrument subject to the level of demand, as well as to technology transfer (including the transfer of research results and inventions stemming from the sphere of public research to the productive sector, for example through proof-of-concept).

The Equity facility will also have the possibility to make expansion and growth-stage investments in conjunction with the Equity Facility for Growth (EFG) under COSME (this includes investments in funds-of-funds with a broad investor base and includes private institutional and strategic investors as well as national public and semi-public financial institutions). In the latter case, the investment from the Equity facility of Horizon 2020 shall not exceed 20 % of the total Union investment except in cases of multi-stage funds, where funding from EFG and the Equity facility of Horizon 2020 will be provided on a pro rata basis, based on the funds' investment policy. Like the EFG, the Equity facility shall avoid buy-out or replacement capital intended for the dismantling of an acquired enterprise. The Commission may decide to amend the 20 % threshold in light of changing market conditions.

The Union Equity Financial Instrument for SMEs' R&I and growth referred to in the first paragraph of section 2 should be of an appropriate size and scale to back innovative companies from the earliest stage through to growth and expansion, in an integrated approach.

Investment parameters will be set in such a way that specific policy objectives, including the targeting of particular groups of potential beneficiaries, can be achieved while still preserving the market-oriented, demand-driven approach of this instrument.

The Equity facility may be supported by budgetary contributions from:

(a) other parts of Horizon 2020;

(b) other frameworks, programmes and budget lines in the general budget of the Union;

(c) particular regions and Member States; and

(d) specific entities or initiatives.

The leverage of the Equity facility - defined as the total funding (i.e. Union funding plus contribution from other financial institutions) divided by the Union financial contribution - is expected to be around 6, depending on market specificities, with an expected multiplier effect - defined as the total of investments made by supported beneficiaries divided by the Union financial contribution - of, on average, 18.

2.3. *Specific implementation aspects*

The implementation of the two facilities will be delegated to the European Investment Bank Group (EIB and the European Investment Fund (EIF)) and/or to other financial institutions that may be entrusted with the implementation of financial instruments in compliance with Regulation (EU, Euratom) No 966/2012. Their design and implementation will be aligned with the general provisions for financial instruments set out in that Regulation and with more specific operational requirements to be set out in Commission guidance. The use of financial instruments must have a clear European added value and should provide leverage and function as a complement to national instruments.

Financial intermediaries, selected by entrusted entities for the implementation of financial instruments pursuant to Article 139(4) of Regulation (EU, Euratom) No 966/2012 on the basis of open, transparent, proportionate and non-discriminatory procedures, may include private financial institutions as well as governmental and semi-governmental financial institutions, national and regional public banks as well as national and regional investment banks.

Their elements may be combined, with the possible addition of grants (including lump sums), in one or more integrated schemes supporting particular categories of beneficiary or special-purpose projects, such as SMEs and mid-caps with growth potential, or the large-scale demonstration of innovative technologies.

Their implementation will be supported by a set of accompanying measures. These may include technical assistance for financial intermediaries involved in assessing the eligibility of loan applications or the value of knowledge assets; investment-readiness schemes covering incubating, coaching and mentoring SMEs and fostering their interaction with potential investors; measures to raise the awareness of venture capital firms and business angels of the growth potential of innovative SMEs involved in Union funding programmes; schemes to attract private investors to support the growth of innovative SMEs and mid-caps; actions to improve cross-border and multi-country debt and equity financing; schemes for encouraging philanthropic foundations and individuals to support R&I; and schemes to foster corporate venturing and encourage the activities of family offices and business angels.

Bodies such as regional authorities, SMEs associations, chambers of commerce and relevant financial intermediaries may be consulted, as appropriate, in relation to the preparation and implementation of these activities.

Complementarity will be ensured with the facilities of COSME.

3. INNOVATION IN SMES

3.1. *Mainstreaming SME support, especially through a dedicated instrument*

SMEs will be supported across Horizon 2020. For this purpose, to participate in Horizon 2020, better conditions for SMEs shall be established. In addition, a dedicated SME instrument is targeted at all types of innovative SMEs showing a strong ambition to develop, grow and internationalise. It will be provided for all types of innovation, including non-technological, social and service innovations, given each activity has a clear European added value. The objective is to help fill the gap in funding for early stage high-risk research and innovation, stimulate breakthrough innovations and increase private-sector commercialisation of research results.

All specific objectives of the priority "Societal challenges" and the specific objective "Leadership in enabling and industrial technologies" shall apply the dedicated SME instrument and allocate an appropriate amount to it, to reach the minimum goal of 20 % of total combined budgets for all specific objectives of the priority "Societal challenges" and the specific objective 'Leadership in enabling and industrial technologies' being devoted to SMEs.

Only SMEs will be allowed to apply for funding and support. They can form collaborations according to their needs, including for subcontracting research and development work. Projects must be of clear interest and potential benefit to SMEs and have a clear European dimension.

The SME instrument will cover all fields of science, technology and innovation in a bottom-up approach within a given societal challenge or enabling technology so as to leave sufficient room for all kinds of promising ideas,

notably cross-sector and interdisciplinary projects, to be funded.

The SME instrument will operate under a single centralised management system, light administrative regime and a single entry point. It shall be implemented primarily in a bottom-up manner through a continuously open call.

The SME instrument will provide simplified and staged support. Its three phases will cover the whole innovation cycle. Transition from one phase to the next will be seamless, provided that the SME project has proven to be worth further funding during a previous phase. There is no obligation for applicants to sequentially cover all three phases. At the same time each phase will be open to all SMEs:

— Phase 1: Concept and feasibility assessment:

  SMEs will receive funding to explore the scientific or technical feasibility and the commercial potential of a new idea (proof of concept) in order to develop an innovation project. A positive outcome of this assessment, in which the linkage between project-topic and potential user/buyer needs is an important issue, will allow for funding under the following phase(s).

— Phase 2: R&D, demonstration, market replication:

  With due attention to the innovation voucher concept, research and development will be supported with a particular focus on demonstration activities (testing, prototype, scale-up studies, design, piloting innovative processes, products and services, validation, performance verification etc.) and market replication encouraging the involvement of end users or potential clients. Innovation Vouchers will promote the participation of young entrepreneurs.

— Phase 3: Commercialisation:

  This phase will not provide direct funding other than support activities, but aims to facilitate access to private capital and innovation enabling environments. Links to the financial instruments (see section 2 'Access to Risk Finance' of Part II) are foreseen, for example by giving SMEs that have successfully completed phases 1 and/or 2 priority within a ring-fenced volume of financial resources. SMEs will also benefit from support measures such as networking, training, coaching and advice. In addition, this phase may connect to measures promoting pre-commercial procurement and procurement of innovative solutions.

Uniform promotion, implementation and monitoring of the SME instrument across Horizon 2020 will ensure easy access for SMEs. Relying on existing SME support networks, such as the Europe Enterprise Network and other innovation service providers, a mentoring scheme for the beneficiary SMEs shall be established to accelerate impact from the support provided. In addition, links will be explored with relevant national and/or regional intermediaries to ensure an efficient implementation of the mentoring scheme.

A dedicated body of stakeholders and experts in SME research and innovation will be set up with view to promoting and accompanying the specific SME measures of Horizon 2020.

3.2. *Specific support*

3.2.1. Support for research-intensive SMEs

A specific action will promote transnational market-oriented innovation of R&D performing SMEs. It targets research-intensive SMEs in any sectors that also need to demonstrate their capability to commercially exploit the project results.

The action will cover the entire field of science and technology with a bottom-up approach to fit the needs of R&D performing SMEs.

The action will be implemented by an Article 185 TFEU initiative building on the Eurostars Programme and reorienting it along the lines stated in its interim evaluation.

3.2.2. Enhancing the innovation capacity of SMEs

Transnational activities assisting the implementation of and complementing the SME specific measures across Horizon 2020 will be supported, notably to enhance the innovation capacity of SMEs. Activities may include awareness raising, information and dissemination, training and mobility activities, networking and exchange of best practices, developing high quality innovation support mechanisms and services with strong Union added value for SMEs (e.g. intellectual property and innovation management, knowledge transfer, innovative use of ICT and e-skills in SMEs), as well as assisting SMEs to connect to research and innovation partners across the Union, allowing them to spin in technology and develop their innovation capacity. Intermediary organisations representing groups of innovative SMEs shall be invited to conduct cross-sectoral and cross-regional innovation activities with SMEs having mutually reinforcing competences, in order to develop new industrial value chains.

These activities shall be coordinated with similar national measures when appropriate. Close cooperation with the National Contact Point (NCP) Network is envisaged. Synergies with Union cohesion policy will be sought in the context of national and regional innovation strategies for smart specialisation.

A reinforced link with the Enterprise Europe Network (EEN) (under COSME) is envisaged ensuring its coordination with the National Contact Points. The support could range from improved information and advisory services through mentoring, coaching and partner search activities for SMEs wishing to develop cross-border innovation projects, to providing innovation support services. This will consolidate the 'one stop shop' approach of the Enterprise Europe Network to supporting SMEs, together with a strong regional and local presence of the network.

3.2.3. Supporting market-driven innovation

These activities will support transnational market-driven innovation in view of enhancing the innovation capacity of SMEs by improving the framework conditions for innovation as well as tackling the specific barriers preventing the growth of innovative SMEs with potential for fast growth. Specialised innovation support (on e.g. exploitation of intellectual property, networks of procurers, support to technology transfer offices, and strategic design) and reviews of public policies in relation to innovation will be supported.

PART III

SOCIETAL CHALLENGES

1. HEALTH, DEMOGRAPHIC CHANGE AND WELL-BEING

Effective health promotion, supported by a robust evidence base, prevents disease, contributes to well-being and is cost-effective. Promotion of health, active ageing, well-being and disease prevention also depend on an understanding of the determinants of health, on effective preventive tools, such as vaccines, on effective health and disease surveillance and preparedness, and on effective screening programmes.

Successful efforts to prevent, detect early, manage, treat and cure disease, disability, frailty and reduced functionality are underpinned by the fundamental understanding of their causes, processes and impacts, as well as factors underlying good health and well-being. Improved understanding of health and disease will demand close linkage between fundamental, clinical, epidemiological and socio-economic research. Effective sharing of data and the linkage of these data with real-world large-scale cohort studies is also essential, as is the translation of research findings into the clinic, in particular through the conduct of clinical trials.

It is a societal challenge to adjust to the further demands on health and care sectors due to the ageing population. If effective health and care is to be maintained for all ages, efforts are required to improve and speed up decision making in prevention and treatment provision, to identify and support the dissemination of best practice in the health and care sector, to raise awareness and to support integrated care. A better understanding of ageing processes and the prevention of age-related illnesses are the basis for keeping European citizens healthy and active throughout the course of their lives. Similarly important is the wide uptake of technological,

organisational and social innovations empowering older persons, persons with chronic diseases as well as disabled persons, to remain active and independent. Doing so will contribute to increasing their physical, social, and mental well-being and lengthening the duration thereof.

This specific objective should address in the relevant activities chronic conditions and diseases including but not limited to: cardiovascular disease, cancer, metabolic diseases and risk factors including diabetes, chronic pain, neurological, neurodegenerative, mental health and substance use disorders, rare diseases, overweight and obesity, autoimmune diseases, rheumatic and musculo-skeletal disorders and various diseases affecting different organs as well as acute conditions and various functional limitations. Likewise infectious diseases, including but not limited to HIV/AIDS, tuberculosis and malaria, neglected and poverty related diseases and animal-borne diseases, emerging epidemics, re-emerging infectious diseases (including water-related diseases) as well as the threat of increasing anti-microbial resistance and occupational diseases and work related disorders should be addressed.

Personalised medicine should be developed in order to suit preventive and therapeutic approaches to patient requirements, and must be underpinned by the early detection of disease.

All of these activities will be undertaken in such a way as to provide support throughout the research and innovation cycle, strengthening the competitiveness of the European based industries and development of new market opportunities. Support will be given to translational approaches that integrate several steps of the innovation process in the health care industry.

Specific activities are described below.

1.1. *Understanding health, well-being and disease*

1.1.1. Understanding the determinants of health, improving health promotion and disease prevention

A better understanding of the determinants of health is required in order to provide evidence for effective health promotion and disease prevention, and will also allow the development of comprehensive health and well-being indicators in the Union based on existing data sources and indicator systems. Environmental, behavioural (including life-style), psychological, organisational, cultural, socio-economic, biological and genetic factors, in their broadest senses, will be studied. Approaches will include the long term study of cohorts and their linkage with data derived from "omics" research, systems bio-medicine including relevant applications of systems biology and other methods.

In particular, a better understanding of the environment as a determinant of health will require an interdisciplinary approach integrating amongst others human-relevant molecular biological, epidemiological and toxicological approaches and resultant data to study the modes of action of various chemicals, combined exposures to pollutants and other environmental and climate-related stressors, to perform integrated toxicological testing and to seek alternatives to animal testing. Innovative approaches to exposure assessment are needed using new-generation biomarkers based on 'omics' and epigenetics, human biomonitoring, personal exposure assessments and modelling to understand combined, cumulative and emerging exposures, integrating socio-economic, cultural, occupational, psychological and behavioural factors. Improved links with environmental data using advanced information systems will be supported.

In this way, existing and planned policies and programmes can be assessed and policy support provided. Similarly, improved behavioural interventions, prevention and education programmes can be developed, including those pertaining to health literacy in nutrition, physical activity, vaccination and other primary care interventions.

1.1.2. Understanding disease

There is a need for an improved understanding of health and disease, throughout the human life cycle, so that new and better prevention measures, diagnosis, treatments and rehabilitation measures can be developed. Interdisciplinary, basic and translational research on the patho-physiology of disease is essential to improve the

understanding of all aspects of disease processes, including a re-classification of normal variation and disease based on molecular data, and to validate and use research results in clinical applications.

Underpinning research will encompass and encourage development and use of new tools and approaches for the generation of biomedical data and will include bio-imaging, "omics", high throughput and systems medicine approaches. These activities will demand close linkage between fundamental and clinical research and with long term cohort studies (and the corresponding research domains) as described above. Close links with research and medical infrastructures (databases, bio-banks etc.) will also be required for standardisation, storage, sharing and access to data, which are all essential for maximising data utility and for stimulating more innovative and effective ways of analysing and combining datasets.

1.1.3. Improving surveillance and preparedness

Human populations are under threat from new and emerging infections, including of zoonotic origin, as well as from those which result from drug resistance to existing pathogens and from other direct and indirect consequences of climate change and from the international movement of people. New or improved methods for surveillance, diagnosis, early warning networks, health service organisation and preparedness campaigns are needed for the modelling of epidemics and for effective pandemic response. Efforts to maintain and enhance capabilities to combat drug-resistant infectious diseases are also needed.

1.2. *Preventing disease*

1.2.1. Developing effective prevention and screening programmes and improving the assessment of disease susceptibility

The development of prevention and screening programmes depends on the identification of early biomarkers (including functional and behavioural) of risk and of disease onset, and their design should be informed by internationally accepted criteria. Their deployment depends on the testing and validation of screening methods and programmes. Knowledge should be generated and methods developed for identifying individuals and populations at a clinically relevant increased risk of disease. Identifying individuals and populations at high risk of disease will allow personalised, stratified and collective strategies for efficacious and cost-effective disease prevention to be developed.

1.2.2. Improving diagnosis and prognosis

An improved understanding of health, disease and disease processes throughout the life cycle is needed to develop new and more effective diagnostics and theranostics. Innovative and existing methods, technologies and tools will be developed with the goal of significantly improving disease outcomes through earlier, more accurate diagnosis and prognosis and by allowing for accessible, more patient-adapted, treatment.

1.2.3. Developing better preventive and therapeutic vaccines

There is a need for more effective preventive and therapeutic interventions and vaccines and evidence-based vaccination schemes for an expanded range of diseases, including poverty-related diseases such as HIV/AIDS, tuberculosis, malaria and neglected infectious diseases and also for other major diseases. This relies on a better understanding of disease and disease processes and their consequent epidemics and on clinical trials and associated studies being undertaken.

1.3. *Treating and managing disease*

1.3.1. Treating disease, including developing regenerative medicine

There is a need to support the improvement of cross-cutting support technologies for drugs, biotherapies, vaccines and other therapeutic approaches, including transplantation, surgery, gene and cell therapy and nuclear medicine; to increase success in the drug and vaccine development process (including alternative methods to replace classical safety and effectiveness testing, e.g. the development of new methods); to develop regenerative medicine approaches, including approaches based on stem cells; to develop new biopharmaceuticals, including therapeutic vaccines; to develop improved medical and assistive devices and systems; to improve palliative

therapies; to maintain and enhance the ability to combat disease and undertake medical interventions that depend on the availability of effective and safe antimicrobial drugs; and to develop comprehensive approaches to treat co-morbidities at all ages and avoid poly-pharmacy. These improvements will facilitate the development of new, more efficient, effective, sustainable and personalised treatments for disease and for the management of disability and frailty, including advanced therapies and cellular therapies for the treatment of chronic diseases.

1.3.2. Transferring knowledge to clinical practice and scalable innovation actions

Clinical trials are an important means to transfer biomedical knowledge to application in patients, and support for these will be provided, as well as for the improvement of their practice. Examples include the development of better methodologies to allow trials to focus on relevant population groups, including those suffering from other concomitant diseases and/or already undergoing treatment; the determination of comparative effectiveness of interventions and solutions; and enhancing the use of databases and electronic health records as data sources for trials and knowledge transfer. Pre-clinical and/or clinical development of designated orphan drugs will be supported. Similarly, support for the transfer of other types of interventions, such as those related to independent living, into real world environments will be provided.

1.4. *Active ageing and self-management of health*

1.4.1. Active ageing and independent and assisted living

Multidisciplinary advanced and applied research and innovation with socioeconomic, behavioural, gerontological, digital and other sciences is needed for cost-effective user-friendly solutions for active, independent and assisted daily living (in the home, the workplace, public spaces, etc.) for the ageing population and people with disabilities taking into account gender differences. This applies in a variety of settings and for technologies and systems and services enhancing quality of life and human functionality including mobility, smart personalised assistive technologies, service and social robotics, and ambient assistive environments. Research and innovation pilots to assess implementation and wide uptake of solutions will be supported. Involvement of end-users, user communities and formal/informal carers will be emphasised.

1.4.2. Individual awareness and empowerment for self-management of health

Empowering individuals to improve and manage their health throughout life will result in more cost-effective health and care systems by enabling the management of chronic disease outside institutions and improving health outcomes. This requires research into socio-economic factors and cultural values, behavioural and social models, attitudes and aspirations in relation to personalised health technologies, mobile and/or portable tools, new diagnostics, sensors and devices for monitoring and personalised services including but not limited to nanomedicine-based tools which promote a healthy lifestyle, well-being, mental health, self-care, improved citizen/healthcare professional interaction, personalised programmes for disease and disability management to, inter alia, enhance patients' autonomy, as well as support for knowledge infrastructures. Solutions will be developed and tested with the use of open innovation platforms such as large-scale demonstrators for social and service innovation.

1.5. *Methods and data*

1.5.1. Improving health information and better use of health data

The integration of infrastructures and information structures and sources (including those derived from cohort studies, protocols, data collections, indicators, health examination surveys etc.) as well as the standardisation, interoperability, storage, sharing of and access to data, will be supported to enable such data to be sustainable in the long-term and properly exploited. Attention should be given to data processing, knowledge management, modelling, visualisation, ICT-security and privacy-related issues. In particular, availability of information and data on negative results and adverse effects of treatment need to be improved.

1.5.2. Improving scientific tools and methods to support policy making and regulatory needs

There is a need to support research, development, integration and use of scientific tools, methods and statistics for rapid, accurate and predictive assessment of the safety, efficacy and quality of health interventions and

technologies including new drugs, biologics, advanced therapies and medical devices. This is particularly relevant for new developments in domains concerning biopharmaceuticals, vaccines, antimicrobials, cell/tissue and gene therapies, organs and transplantation, specialist manufacturing, biobanks, new medical devices, combination products, diagnostic/treatment procedures, genetic testing, interoperability and e-health, including privacy aspects. Similarly, support for improved risk assessment methodologies, compliance frameworks, testing approaches and strategies relating to environment and health is required. There is also a need to support the development of relevant methods for assisting the assessment of ethical aspects of the above-mentioned domains.

1.5.3. Using in-silico medicine for improving disease management and prediction

Computer simulation-based medical systems using patient-specific data and building on systems medicine approaches and physiological modelling can be used to predict susceptibility to disease, disease evolution and the likely success of medical treatments. Model-based simulation can be used to support clinical trials, predictability of treatment response, and the personalisation and optimisation of treatment.

1.6. *Health care provision and integrated care*

1.6.1. Promoting integrated care

Supporting the management of chronic disease, including patients with disabilities, outside institutions also depends on improved cooperation between the providers of health and social or informal care. Research and innovative applications will be supported for decision making based on distributed information addressing both physical and mental health, including psychosocial aspects, and for providing evidence for large-scale deployments and market exploitation of novel solutions, including interoperable tele-health and tele-care services. Particularly in the context of demographic change, research and innovation to improve the organisation of long-term care delivery as well as policy and management innovation will also be supported. Implementing new and integrated care solutions shall aim at personal empowerment and enhancement of existing capabilities as well as concentrate on compensation of deficits.

1.6.2. Optimising the efficiency and effectiveness of healthcare provision and reducing inequalities by evidence-based decision making and dissemination of best practice, and innovative technologies and approaches

There is a need to support the development of a systemic approach to health technology assessment and health economics, as well as the gathering of evidence and dissemination of best practice and innovative technologies and approaches in the health and care sector, including ICT and e-health applications. Comparative analyses of the reform of public health systems in Europe and in third countries and assessments of their mid- to long-term economic and social impacts will be supported. Analyses of future health workforce needs both in terms of numbers and required skills in relation to new patterns of care will be supported. Research on the evolution of health inequalities, on their interplay with other economic and social inequalities and on the effectiveness of policies aiming to reduce them in Europe and beyond will be supported. Finally, there is a need to support the assessment of patient safety solutions and quality assurance systems, including the role of patients.

1.7. *Specific implementation aspects*

Implementation of this specific objective will include support for knowledge and technology transfer and other forms of dissemination, for large-scale piloting and demonstration actions, and for standardisation. In this way, market deployment of products and services will be accelerated, and scalable solutions for Europe and beyond will be validated. Such actions will not only support European industrial competitiveness and the involvement of innovative SMEs but will require the active involvement of all stakeholders. Synergies with other relevant programmes and activities, both public and private, at Union, national and international levels will be sought. In particular, synergies with activities developed in the context of the Health for Growth Programme will be sought.

The Scientific Panel for Health will be a science-led stakeholder platform which elaborates scientific input concerning this societal challenge. It will provide a coherent scientific focused analysis of research and innovation bottlenecks and opportunities related to this societal challenge, contribute to the definition of its research and innovation priorities, and encourage Union-wide scientific participation in it. Through active

cooperation with stakeholders, it will help to build capabilities and to foster knowledge sharing and stronger collaboration across the Union in this field.

Consideration may be given to support relevant Joint Programming Initiatives (JPIs) and relevant public-public and public-private partnerships.

Appropriate links with the actions of relevant European Innovation Partnerships and the relevant aspects of the research and innovation agendas of European Technology Platforms will also be established.

2. FOOD SECURITY, SUSTAINABLE AGRICULTURE AND FORESTRY, MARINE, MARITIME AND INLAND WATER RESEARCH, AND THE BIOECONOMY

2.1. *Sustainable agriculture and forestry*

Appropriate knowledge, tools, services and innovations are necessary to support more productive, environmentally friendly resource-efficient and resilient agriculture and forestry systems that supply sufficient food, feed, biomass and other raw materials and deliver ecosystems services while at the same time protecting biodiversity and supporting the development of thriving rural livelihoods. Research and innovation will provide options for integrating agronomic and environmental goals into sustainable production, thus: increasing productivity and resource efficiency, including water use efficiency, of agriculture; increasing the safety of animal and plant production; reducing agricultural greenhouse gas emissions; reducing the production of waste; reducing leaching of nutrients and other chemical inputs from cultivated lands into terrestrial and aquatic environments; decreasing dependence from international plant derived protein imports to Europe; increasing the level of diversity in primary production systems; and fostering the recovery of biological diversity.

2.1.1. Increasing production efficiency and coping with climate change, while ensuring sustainability and resilience

Activities will enhance productivity as well as the adaptive capacity of plants, animals and production systems to cope with rapidly changing environmental/climatic conditions and increasingly scarce natural resources. The resulting innovations will help to move towards a low energy, low emission and low waste economy and to reduce natural resources demand along the entire food and feed supply chain. In addition to contributing to food security, new opportunities will be created for the use of biomass and by-products from agriculture for a wide range of non-food applications.

Multi-disciplinary approaches will be sought to improve the performance of plants, animals and micro-organisms, while ensuring efficient resource use (water, land, soil, nutrients, energy and other inputs) and the ecological integrity of rural areas. Emphasis will be placed on integrated and diverse production systems and agronomic practices, including the use of precision technologies and ecological intensification approaches to benefit both conventional and organic agriculture. Also urban greening will be promoted, with new forms of agriculture, horticulture and forestry in urban and peri-urban areas. These shall be considered by addressing new requirements for plant characteristics, cultivation methods, technologies, marketing and urban design, in relation with human health and well-being, environment and climate change. Genetic improvement of plants and animals for adaptation, health and productivity traits will call for all appropriate conventional and modern breeding approaches and for preservation and better use of genetic resources.

Due attention will be given to soil management for increasing the productivity of crops. Bearing in mind the overall objective of ensuring high quality and safe food production, plant and animal health will be promoted. Activities in the area of plant health and plant protection will increase knowledge and support the development of integrated environmentally friendly pest management strategies, products and tools to prevent the introduction of pathogens, control pest and diseases and reduce yield losses at pre- and post-harvest levels. In the area of animal health, strategies for the eradication or effective management of diseases, including zoonoses, and research on antimicrobial resistance will be promoted. Integrated control of disease, parasites and pests will be strengthened, starting from a better understanding of host-pathogen interactions, to surveillance, diagnostics and treatments. Studying the effects of practices on animal welfare will help meet societal concerns. The above listed areas will be underpinned by more fundamental research to address relevant biological questions as well as to

support the development and implementation of Union policies and supported by adequate assessment of their economic and market potential.

2.1.2. Providing ecosystem services and public goods

Agriculture and forestry are unique systems delivering commercial products but also wider societal public goods (including cultural and recreational value) and important ecological services such as functional and in-situ biodiversity, pollination, water storage and regulation, soil functions, landscape, erosion reduction, resilience to flooding and droughts and carbon sequestration / greenhouse gas mitigation. Research activities will contribute to a better understanding of the complex interactions between primary production systems and ecosystems services and will support the provision of these public goods and services, through the delivery of management solutions, decision-support tools and the assessment of their market and non-market value. Specific issues to be dealt with include the identification of rural and (peri-)urban farming/forest systems and landscape patterns likely to achieve these goals. Shifts in the active management of agricultural systems - including the use of technologies and change of practices - will increase greenhouse gas mitigation and the adaptive capacity of the agriculture sector to the adverse effects of climate change.

2.1.3. Empowerment of rural areas, support to policies and rural innovation

Development opportunities for rural communities will be mobilised by strengthening their capacity for primary production and delivery of ecosystems services as well as by opening avenues for the production of new and diversified products (including food, feed, materials and energy) which meet the increasing demand for low-carbon short-chain delivery systems. Socio-economic research and science and society studies along with the development of new concepts and institutional innovations is needed to ensure cohesion of rural areas and prevent economic and social marginalisation, foster diversification of economic activities (including the service sector), ensure appropriate relations between rural and urban areas, as well as facilitate knowledge exchange, demonstration, innovation and dissemination and foster participatory resource management. Also, there is a need to look at ways in which public goods in rural areas can be converted into local/regional socio-economic benefits. Innovation needs defined at regional and local levels will be complemented by cross-sectoral research actions at international, inter-regional and European levels. By providing the necessary analytical tools, indicators, integrated models and forward-looking activities, research projects will support policy makers and other actors in the implementation, monitoring and assessment of relevant strategies, policies and legislation, not only for rural areas but for the whole bioeconomy. Tools and data are also required to allow for proper assessment of potential trade-offs between various types of resource use (land, water, soil, nutrients, energy and other inputs) and bioeconomy products. Socio-economic and comparative assessment of farming/forestry systems and their sustainability performance will be addressed.

2.1.4. Sustainable forestry

The aim is to sustainably produce bio-based products ecosystems, services (including water-related and climate-mitigation services) and sufficient biomass, with due consideration to economical, ecological and social aspects of forestry as well as to regional differences. Overall, activities in the forestry sector will seek to promote multi-functional forests which deliver a variety of ecological, economic, and social benefits. Activities will focus on the further development of sustainable forestry systems which can address societal challenges and demands, including forest owners' needs, by putting in place multifunctional approaches that reconcile the need for delivering smart, sustainable and inclusive growth taking into account climate change. These sustainable forestry systems are instrumental in the strengthening of forest resilience and biodiversity protection and the need to meet the increased biomass demand. This will need to be underpinned by research on tree health and on forest protection and restoration from fire.

2.2. *Sustainable and competitive agri-food sector for a safe and healthy diet*

Consumer needs for safe, healthy, high quality and affordable food have to be addressed, while considering the impacts of food consumption behaviour and food and feed production on human health, the environment and the global ecosystem. Food and feed security and safety, the competitiveness of the European agri-food industry and the sustainability of food production, supply and consumption will be addressed, covering the whole food chain

and related services, whether conventional or organic, from primary production to consumption. This approach will contribute to achieving food safety and security for all Europeans and eradication of hunger in the world; decreasing the burden of food- and diet-related diseases by promoting the shift towards healthy and sustainable diets, via consumer education and innovations in agriculture and the food industry; reducing water and energy consumption in food processing, transport and distribution; reducing food waste by 50 % by 2030; and achieving a broad diversity of healthy, high quality and safe food for all.

2.2.1. Informed consumer choices

Consumer preferences, attitudes, needs, behaviour, lifestyle and education as well as the cultural component of food quality will be addressed, and communication between consumers and the food chain research community and its stakeholders will be enhanced in order to improve public understanding of food production generally and to enable informed choice, sustainable and healthy consumption and their impacts on production, inclusive growth and quality of life, especially of vulnerable groups. Social innovation will respond to societal challenges, and innovative predictive models and methodologies in consumer science will deliver comparable data and lay the ground for responses to Union policy needs.

2.2.2. Healthy and safe foods and diets for all

Nutritional needs, a balanced diet and the impact of food on physiological functions and on physical and mental performance will be addressed as well as the links between diet, demographic trends (such as ageing) and chronic diseases and disorders. Dietary solutions and innovations leading to improvements in health and well-being will be identified. Chemical and microbial food and feed contamination, risks and exposures as well as allergens will be analysed, assessed, monitored, controlled and traced throughout the food, feed and drinking water supply chains from production and storage to processing, packaging, distribution, catering, and preparation at home. Food safety innovations, improved tools for risk and risk-benefit assessment and for risk communication and improved food safety standards to be implemented throughout the food chain will lead to enhanced consumer trust and protection in Europe. Globally improved food safety standards will also help to strengthen the competitiveness of the European food industry.

2.2.3. A sustainable and competitive agri-food industry

The needs for the food and feed industry to cope with social, environmental, climate and economic change from local to global will be addressed at all stages of the food and feed production chain, including food design, processing, packaging, process control, waste reduction, by-product valorisation and the safe use or disposal of animal by-products. Innovative and sustainable resource-efficient technologies and processes as well as diversified, safe, healthy, affordable and high quality products will be generated and underpinned with science-based evidence. This will strengthen the innovation potential of the European food supply chain, enhance its competitiveness, create economic growth and employment and allow the European food industry to adapt to changes. Other aspects to address are traceability, logistics and services, socio-economic and cultural factors, animal welfare and other ethical issues, the resilience of the food chain against environmental and climate risks, the limitation of negative impacts of food chain activities and of changing diets and production systems on the environment.

2.3. *Unlocking the potential of aquatic living resources*

One of the main features of living aquatic resources is that they are renewable and their sustainable exploitation relies on in-depth understanding and a high degree of quality and productivity of the aquatic ecosystems. The overall objective is to manage aquatic living resources to maximise social and economic benefits/returns from Europe's oceans, seas and inland waters.

This includes the need to optimise the sustainable contribution of fisheries and aquaculture to food security in the context of the global economy and to reduce the Union's heavy dependence on seafood imports (approximately 60 % of total European seafood consumption depends on import, and the Union is the world's largest importer of fisheries products), and to boost marine and maritime innovation through biotechnologies to fuel smart "blue" growth. In line with current policy frameworks, in particular the Integrated Maritime Policy and the Marine

Strategy Framework Directive ([11]), research activities will underpin the ecosystem approach to the management and exploitation of natural resources, while enabling sustainable use of marine goods and services, and the 'greening' of the sectors involved.

2.3.1. Developing sustainable and environmentally friendly fisheries

The new Common Fisheries Policy, the Marine Strategy Framework Directive and the Union's 2020 Biodiversity Strategy call for European fisheries to be more sustainable, competitive, and environmentally friendly. The move towards an ecosystem approach to fisheries management will require an in-depth understanding of marine ecosystems. New insights, tools and models will be developed to improve understanding of what makes marine ecosystems healthy and productive and to assess, evaluate and mitigate the impact of fisheries on marine ecosystems (including deep sea). New harvest strategies and technologies will be developed which provide services to society while maintaining healthy marine ecosystems. The socio-economic effects of management options will be measured. The effects and adaptation to environmental changes, including climate change, will also be investigated along with new assessment and management tools to deal with risk and uncertainty. Activities will support research on the biology, genetics and dynamics of fish populations, on the role of key species in the ecosystems, on fishing activities and their monitoring, on fishing sector behaviours and adaptation to new markets (e.g. eco-labelling) and on fishing industry involvement in decision making. The shared use of maritime space with other activities, particularly in the coastal zone, and its socio-economic impact will also be addressed.

2.3.2. Developing competitive and environmentally friendly European aquaculture

Sustainable aquaculture has a large potential for the development of healthy, safe and competitive products tailored to consumer needs and preferences as well as for environmental services (bioremediation, land and water management etc.) and energy production but it needs to be fully realised in Europe. Knowledge and technologies will be strengthened in all aspects of domestication of established species and diversification for new species while taking into account the interactions between aquaculture and the aquatic ecosystems in order to reduce the impact of aquaculture on the environment, and the effects of climate change and how the sector can adapt to them. Continuation of research efforts is particularly needed on health and diseases of farmed aquatic organisms (including prevention and mitigation tools and methods), on nutrition issues (including development of alternative tailor-made ingredients and feeds for aquaculture), and on reproduction and breeding which are among the main obstacles in the sustainable development of European aquaculture. Innovation will also be promoted for sustainable production systems inland, on the coastal zone and offshore. The specificities of the European ultra-periphery will also be taken into account. Emphasis will also be given to understanding the social and economic dimensions of the sector to underpin cost- and energy-efficient production matching with the market and consumer demands, while ensuring competitiveness and attractive prospects for investors and producers.

2.3.3. Boosting marine and maritime innovation through biotechnology

More than 90 % of the marine biodiversity remains unexplored, offering a huge potential for discovery of new species and applications in the field of marine biotechnologies, which is foreseen to generate a 10 % annual growth for this sector. Support will be given to further explore and exploit the large potential offered by marine biodiversity and aquatic biomass to bring new innovative and sustainable processes, products and services on the markets with potential applications in sectors including chemical and material industries, fisheries and aquaculture, and pharmaceutical, energy supply and cosmetic industries.

2.4. *Sustainable and competitive bio-based industries and supporting the development of a European bioeconomy*

The overall objective is to accelerate the conversion of fossil-based European industries to low-carbon, resource-efficient and sustainable ones. Research and innovation will provide the means to reduce the Union's dependency on fossil fuels and contribute to meeting its energy and climate change policy targets for 2020 (10 % of transport fuels from renewables and a 20 % reduction of greenhouse gas emissions). Estimates conclude that a shift to

biological raw materials and biological processing methods could save up to 2,5 billion tons of CO2 equivalent per year by 2030, increasing markets for bio-based raw materials and new consumer products substantially. Reaping these potentials requires building a broad knowledge base and developing relevant (bio)technologies, focusing mainly on three essential elements: a) transforming current fossil-based processes by resource- and energy-efficient biotechnology-based ones; b) establishing reliable, sustainable and appropriate supply chains of biomass, byproducts and waste streams and a wide network of biorefineries throughout Europe; and c) supporting market development for bio-based products and processes, taking account of the associated risks and benefits. Synergies will be sought with the specific objective 'Leadership in Enabling and Industrial Technologies'.

2.4.1. Fostering the bioeconomy for bio-based industries

Major progress towards low-carbon, resource-efficient and sustainable industries will be supported through discovery and exploitation of terrestrial and aquatic biological resources, while minimising adverse environmental impacts and water footprint, for example through the establishment of closed circuits of nutrients, including between urban and rural areas. Potential trade-offs between the various uses of biomass should be examined. Activities should focus on non-food-competitive biomass and also consider the sustainability of related land use systems. The development of bio-based products and biologically active compounds for industries and consumers with novel qualities, functionalities and improved sustainability will be targeted. The economic value of renewable resources, biowaste and by-products will be maximised through new and resource-efficient processes, including the transformation of urban biowaste into agricultural inputs.

2.4.2. Developing integrated biorefineries

Activities will be supported to boost sustainable bioproducts, intermediates and bioenergy/biofuels, predominantly focusing on a cascade approach, prioritising the generation of high added value products. Technologies and strategies will be developed to assure the raw material supply. Enhancing the range of types of biomass for use in second and third generation biorefineries, including forestry, biowaste and industrial by-products, will help avoid food/fuel conflicts and support economic and environmentally friendly development of rural and coastal areas in the Union.

2.4.3. Supporting market development for bio-based products and processes

Demand-side measures will open new markets for biotechnology innovation. Standardisation and certification at Union and international levels is needed for, amongst others, determination of bio-based content, product functionalities and biodegradability. Methodologies and approaches to life-cycle analysis need to be further developed and continuously adapted to scientific and industrial advances. Research activities supporting product and process standardisation (including harmonisation of international standards) and regulatory activities in the field of biotechnology are considered essential for supporting the creation of new markets and for realising trade opportunities.

2.5. *Cross-cutting marine and maritime research*

The aim is to increase the impact of Union seas and oceans on society and economic growth through the exploitation of marine resources as well as the use of different sources of marine energy and the wide range of different uses that is made of the seas. Activities shall focus on cross-cutting marine and maritime scientific and technological challenges with a view to unlocking the potential of seas and oceans across the range of marine and maritime industries, while protecting the environment and adapting to climate change. A strategic coordinated approach for marine and maritime research across all challenges and priorities of Horizon 2020 will also support the implementation of relevant Union policies to help deliver key blue growth objectives.

Due to the multidisciplinary nature of marine and maritime research, close coordination and joint activities with other parts of Horizon 2020, especially the specific objective "Climate action, environment, resource efficiency and raw materials" of the priority "Societal challenges", will be pursued.

2.5.1. Climate change impact on marine ecosystems and maritime economy

Activities will be supported to increase the current understanding of the functioning of marine ecosystems and the interactions between oceans and the atmosphere. This will increase the ability to assess the role of the oceans on climate and the impact of climate change and ocean acidification on marine ecosystems and coastal areas.

2.5.2. Developing the potential of marine resources through an integrated approach

Boosting long-term, sustainable maritime growth and creating synergies across all maritime sectors requires an integrated approach. Research activities will focus on preserving the marine environment as well as on the impact of maritime activities and products on non-maritime sectors. This will allow advances in the field of eco-innovation, such as new products, processes and the application of management concepts, tools and measures, to assess and mitigate the impact of human pressures on the marine environment in order to advance towards a sustainable management of maritime activities.

2.5.3. Cross-cutting concepts and technologies enabling maritime growth

Advances in cross-cutting enabling technologies (e.g. ICT, electronics, nanomaterials, alloys, biotechnologies, etc.) and new developments and concepts in engineering will continue to enable growth. Activities will allow major breakthroughs in the field of marine and maritime research and ocean observation (e.g. deep-sea research, observing systems, sensors, automated systems for monitoring of activities and surveillance, screening marine biodiversity, marine geohazards and remotely operated vehicles). The aim is to reduce the impact on the marine environment (e.g. underwater noise and introduction of invasive species and pollutants from sea and land) and to minimise the carbon foot-print of human activities. Cross-cutting enabling technologies will underpin the implementation of marine and maritime Union policies.

2.6. *Specific implementation aspects*

Beyond the general sources of external advice, specific consultations will be sought from the Standing Committee on Agricultural Research (SCAR) on a range of issues, including strategic aspects through its foresight activity and the coordination of agricultural research between national and Union levels. Appropriate links with the actions of relevant European Innovation Partnerships and the relevant aspects of the research and innovation agendas of European Technology Platforms will also be established.

The impact and dissemination of research results will be actively supported through specific actions on communication, knowledge exchange and the involvement of various actors all along the projects. Implementation will combine a wide range of activities, including substantial demonstration and pilot activities. Easy and open access to research results and best practices will be fostered.

The specific support to SMEs will allow for an increased participation of farms, fishermen and other types of SMEs in research and demonstration activities. The specific needs of the primary production sector for innovation support services and outreach structures will be taken into account. Implementation will combine a wide range of activities, including knowledge exchange actions where the involvement of farmers or other primary producers and intermediaries will be actively ensured in view of summarising the research needs of end-users. Easy and open access to research results and best practices will be fostered.

Support to standardisation and regulatory aspects will be used to help accelerate market deployment for novel bio-based goods and services.

Consideration may be given to support relevant Joint Programming Initiatives (JPIs) and relevant public-public and public-private partnerships.

Synergies with and further deployment by other Union funds related to this societal challenge, such as the European Agricultural Fund for Rural Development (EAFRD) and the European Maritime and Fisheries Fund (EMFF), will be sought.

Forward-looking activities will be undertaken across the sectors of the bioeconomy, including the development of data bases, indicators and models addressing global, European, national and regional dimensions. A European bioeconomy observatory shall be developed for mapping and monitoring Union and global research and

innovation activities including technology assessment, developing key performance indicators, and monitoring innovation policies in the bioeconomy.

3. SECURE, CLEAN AND EFFICIENT ENERGY

3.1. *Reducing energy consumption and carbon footprint by smart and sustainable use*

The energy sources and consumption patterns of Europe's industries, transport systems, buildings, districts, towns and cities are largely unsustainable, leading to significant environmental and climate change impacts. Real-time energy management for new and existing near-zero-emission, near-zero-energy and positive energy buildings, retrofitted buildings as well as active buildings, highly efficient industries and mass take-up of energy-efficient approaches by companies, individuals, communities, cities and districts will require not only technological advances, but also non-technological solutions such as new advisory, financing and demand management services and input from the behavioural and social sciences while at the same time taking into account questions of public acceptance. In this way improved energy efficiency may provide one of the most cost-effective ways to reduce energy demand, thereby enhancing security of energy supply, reducing environmental and climate impacts and boosting competitiveness. To meet these challenges the further development of renewable energies and the tapping of energy efficiency potentials are important.

3.1.1. Bringing to mass market technologies and services for a smart and efficient energy use

Reducing energy consumption and eliminating energy waste, while providing the services that society and economy need, requires not only that more efficient, cost-competitive, environmentally friendly and smarter equipment, products and services are brought to mass market but also the integration of components and devices in such a way that they cooperate to optimise the overall energy use of buildings, services and industry.

To ensure full adoption and full benefits for consumers (including the possibility for them to monitor their own consumption), energy performance of these technologies and services needs to be customised and optimised for and in their application environments. This requires researching, developing and testing innovative ICT and monitoring and control techniques as well as demonstration projects and pre-commercial deployment activities to ensure interoperability and scalability. Such projects should aim to contribute to significantly reducing or optimising the overall energy consumption and energy costs by developing common procedures to collect, collate and analyse energy consumption and emissions data to improve the measurability, transparency, public acceptability, planning and visibility of energy use and its environmental impacts. Security and privacy by design to protect monitoring and control techniques should be safeguarded in these processes. Developing platforms and applying them for verifying the stability of such systems will help to ensure reliability.

3.1.2. Unlocking the potential of efficient and renewable heating-cooling systems

A substantial share of energy is consumed for heating or cooling purposes across the Union, and the development of cost-effective and efficient technologies and system integration techniques, such as network connectivity with standardised languages and services in this area, would have a major impact in reducing energy demand. This requires research and demonstration of new design techniques and systems and components for industrial, commercial and residential applications, for example in decentralised and district supply of hot water, space heating and cooling. This should encompass different technologies, such as solar, thermal, geothermal, biomass, heat pumps, combined heat and power, and recovery of waste energy, and meet the requirements of near-zero-energy buildings and districts and support smart buildings. Further breakthroughs are needed, in particular, in storage for thermal energy from renewable energy sources and to foster the development and deployment of efficient combinations of hybrid heating and cooling systems, for centralised and de-centralised applications.

3.1.3. Fostering European Smart Cities and Communities

Urban areas are one of the largest consumers of energy in the Union and emit a correspondingly large share of greenhouse gases, while generating a substantial amount of air pollutants. At the same time, urban areas are affected by decreasing air quality and climate change and have to develop their own mitigation and adaptation strategies. Finding innovative energy solutions (e.g. energy efficiency, electricity and heating and cooling supply systems, and integration of renewables in the built environment), integrated with transport systems, smart

construction and urban planning solutions, waste and water treatment as well as ICT solutions for the urban environment is therefore crucial in the transformation towards a low-carbon society. Targeted initiatives in support to the convergence of industrial value chains of the energy, transport and ICT sector for smart urban applications need to be envisaged. At the same time, new technological, organisational, planning and business models need to be developed and tested at full scale according to the needs and means of cities and communities and their citizens. Research is also needed to understand the social, environmental, economic and cultural issues that are involved in this transformation.

3.2. *Low-cost, low-carbon electricity supply*

Electricity will play a central role in the establishment of an environmentally sustainable low-carbon economy. Renewable energy sources lie at the core of this development. The uptake of low-carbon electricity generation is too slow due to the high costs involved. There is a pressing need to find solutions that reduce costs significantly, with enhanced performance, sustainability and public acceptance to accelerate the market deployment of low-cost, reliable and low-carbon electricity generation. Activities shall focus on research, development and full scale demonstration of innovative renewables, including small and micro-scale energy systems, efficient, flexible and low-carbon emission fossil power plants and carbon capture and storage, or CO2 re-use technologies.

3.2.1. Developing the full potential of wind energy

The objective for wind energy is to reduce the cost of electricity production of onshore and offshore wind by up to about 20 % by 2020 compared to 2010, to increasingly move offshore, and to enable proper integration in the electricity grid. The focus will be on the development, testing and demonstration of next generation wind energy conversion systems of larger scale (including innovative energy storage systems), higher conversion efficiencies and higher availabilities for both on- and offshore (including remote locations and hostile weather environments) as well as new serial manufacturing processes. Environmental and biodiversity aspects of wind energy development will be taken into account.

3.2.2. Developing efficient, reliable and cost-competitive solar energy systems

The cost of solar energy, covering photovoltaics (PV) and concentrating solar power (CSP), should be halved by 2020 compared to 2010, if it is to substantially increase its share of the electricity market.

For PV, this will need further research on, inter alia, novel concepts and systems as well as demonstration and testing of mass production with a view to large-scale deployment and building integration of PV.

For CSP, the focus will be on developing ways to increase efficiency while reducing costs and environmental impact, enabling industrial up-scaling of demonstrated technologies by building first-of-a-kind power plants. Solutions to efficiently combine the production of solar electricity with water desalination will be tested.

3.2.3. Developing competitive and environmentally safe technologies for CO2 capture, transport, storage and re-use

Carbon capture and storage (CCS) is a key option that has to be widely deployed on a commercial scale at global level to meet the challenge of a decarbonised power generation and low-carbon industry by 2050. The objective is to minimise the extra-cost of CCS in the power sector for coal-fired, gas-fired and oil-shale fired power plants compared to equivalent plants without CCS and energy intensive industrial installations.

Support will be given, in particular, to demonstrate the full CCS chain for a representative portfolio of different capture, transport, storage and re-use technology options. This will be accompanied by research to further develop these technologies and to deliver more competitive capture technologies, improved components, integrated systems and processes, safe geological storage and rational solutions and public acceptance for the re-use of captured CO2 to enable the commercial deployment of CCS technologies for fossil fuel power plants and other carbon-intensive industries going into operation after 2020. Support will also be given to clean coal technologies as technologies complementary to CCS.

3.2.4. Developing geothermal, hydro, marine and other renewable energy options

Geothermal, hydro, and marine energy as well as other renewable energies can contribute to the decarbonisation of the European energy supply while enhancing its flexibility to variable production and use of energy. The objective is to further develop and bring to commercial maturity cost-effective and sustainable technologies, enabling large-scale deployment at an industrial scale including grid integration. Enhanced geothermal systems is a technology that should be further researched, developed and demonstrated notably in the fields of exploration, drilling and heat production. Ocean energies such as tidal, current or wave energy and osmotic power offer zero-emission and predictable energy and can also contribute to the development of the full potential of offshore wind energy (combination of marine energies). Research activities should include laboratory scale innovative research into low-cost reliable components and materials in a high corrosion, biofouling environment as well as demonstrations under the varied conditions found in European waters.

3.3. *Alternative fuels and mobile energy sources*

Meeting Europe's energy and CO2 reduction goals also requires the development of new fuels and mobile energy sources. This is particularly important to meet the challenge of smart, green and integrated transport. Value chains for these technologies and alternative fuels are not sufficiently developed and must be accelerated to demonstration scale.

3.3.1. Making bioenergy more competitive and sustainable

The objective for bioenergy is to bring to commercial maturity the most promising technologies, to permit large-scale, sustainable production of advanced biofuels of different value chains in a bio-refinery approach for surface, maritime and air transport, and highly efficient combined heat and power and green gas from biomass and waste, including CCS. The aim is to develop and demonstrate the technology for different bioenergy pathways at different scales, taking account of differing geographical and climate conditions and logistical constraints, while minimising negative environmental and social impacts linked to land use. Longer term research will support the development of a sustainable bioenergy industry beyond 2020. These activities will complement upstream (e.g. feedstock, bio-resources) and downstream (e.g. integration into vehicle fleets) research activities carried out in other relevant specific objectives of the priority "Societal challenges".

3.3.2. Reducing time to market for hydrogen and fuel cell technologies

Fuel cells and hydrogen have a great potential to contribute to addressing energy challenges facing Europe. Bringing these technologies to market competitiveness will require significant cost decrease. As an illustration the cost of fuel cell systems for transportation will have to be reduced by a factor of ten over the next 10 years. To do so, support will be given to demonstrations and pre-commercial deployment activities for portable, stationary and micro-stationary, transport applications and the related services, as well as long-term research and technology development to build up a competitive fuel cell chain and a sustainable hydrogen production and infrastructure across the Union. Strong national and international cooperation is needed to enable market breakthroughs of a sufficient scale, including the development of appropriate standards.

3.3.3. New alternative fuels

There is a range of new options with long term potential, such as powdered metal fuel, fuel from photosynthetic micro-organisms (in water and land environments) and from artificial photosynthesis mimics and solar fuels. These new paths may offer potential for more efficient energy conversion and more cost-competitive and sustainable technologies. Support will be given notably to bring these new and other potential technologies from laboratory to demonstration scale size in view of pre-commercial demonstration by 2020.

3.4. *A single, smart European electricity grid*

Electricity networks have to respond to three interrelated challenges to enable a consumer-friendly and increasingly decarbonised electricity system: creating a pan-European market; integrating a massive increase of renewable energy sources; and managing interactions between millions of suppliers and customers (where increasingly households will be both), including owners of electrical vehicles. Future electricity networks will play a key role for the transition to a decarbonised energy system, while providing additional flexibility and cost

benefits to the consumers. The overriding goal by 2020 is to transmit and distribute about 35 % ([12]) of electricity from dispersed and concentrated renewable energy sources.

A strongly integrated research and demonstration effort will support the development of new components, technologies, and procedures which will respond to the particularities of both the transmission and distribution side of the grid, as well as flexible energy storage.

All options to successfully balance energy supply and demand must be considered to minimise emissions and costs. New smart energy grid technologies, back-up and balancing technologies enabling higher flexibility and efficiency, including conventional power plants, new grid components to improve the transmission capacity and quality as well as the reliability of grids have to be developed. New power systems technologies and a bi-directional digital communication infrastructure must be researched and integrated into the electricity grid as well as used to establish smart interactions with other energy grids. This will contribute to better planning, monitoring, control and secure operation of networks, including standardisation issues, in normal and emergency conditions as well as to managing the interactions between suppliers and customers and to transporting, managing and trading energy flow. For the deployment of future infrastructure, indicators and cost benefit analysis should take into account energy system-wide considerations. In addition, synergies between smart grids and telecommunication networks will be maximised in order to avoid duplication of investments, to increase safety and to accelerate the take up of smart energy services.

Novel energy storage means (including both batteries and large scale storage means such as power-to-gas) and vehicle systems will provide the required flexibility between production and demand. Improved ICT technologies will further increase the flexibility of electricity demand by providing customers (industrial, commercial and residential) with the necessary automation tools. Security, reliability and privacy are important issues here as well.

New planning, market and regulatory designs need to drive the overall efficiency and cost-effectiveness of the electricity supply chain and interoperability of infrastructures as well as the emergence of an open and competitive market for smart energy grid technologies, products and services. Large-scale demonstration projects are needed to test and validate solutions and assess the benefits for the system and for individual stakeholders, before deploying them across Europe. This should be accompanied by research to understand how consumers and businesses react to economic incentives, behavioural changes, information services and other innovative opportunities provided by smart grids.

3.5. *New knowledge and technologies*

Novel, more efficient and cost-competitive as well as clean, safe and sustainable energy technologies will be required for the long term. Progress should be accelerated through multi-disciplinary research and joint implementation of pan-European research programmes and world-class facilities to achieve scientific breakthroughs in energy-related concepts and enabling technologies (e.g. nano-science, material science, solid state physics, ICT, bio-science, geosciences, computation and space). Safe and environmentally sustainable unconventional gas and oil resources exploration and production as well as the development of innovations in future and emerging technologies will also be supported, where appropriate.

Advanced research will also be needed to provide solutions to adapt energy systems to changing climatic conditions. Priorities may be adjusted to new scientific and technological needs and opportunities or newly-observed phenomena which could indicate promising developments or risks to society and which may emerge during the course of implementation of Horizon 2020.

3.6. *Robust decision making and public engagement*

Energy research should support and be strongly aligned with the energy policy. Extensive knowledge and research on the uptake and use of energy technologies and services, infrastructure, markets (including regulatory frameworks) and consumer behaviour is required to provide policy makers with robust analyses. Support will be given, in particular in the frame of the Commission's Information System for the SET-Plan (SETIS), to develop robust and transparent theories, tools, methods, models and forward-looking and perspective scenarios to assess

the main economic and social issues related to energy; to build databases and scenarios for an enlarged Union and for the assessment of the impact of energy and energy-related policies on the security of supply, consumption, the environment, natural resources, climate change, society and competitiveness of the energy industry; and to carry out socio-economic research activities as well as science in society studies.

Taking advantage of the possibilities offered by web and social technologies, and consumer behaviour, including that of vulnerable consumers such as persons with disabilities and behavioural changes, will be studied in open innovation platforms such as living labs and large-scale demonstrators for service innovation as well as through panel surveys, while ensuring privacy.

3.7. *Market uptake of energy innovation - building on Intelligent Energy Europe (IEE)*

Innovative market uptake and replication solutions are essential for the roll-out of new energy technologies in time and through a cost-effective implementation. In addition to technology-driven research and demonstration, this requires actions with clear Union added value aiming to develop, apply, share and replicate non-technological innovations with a high leverage factor in the Union's sustainable energy markets across disciplines and levels of governance.

Such innovations will focus on creating favourable market conditions at regulatory, administrative and financing level for low-carbon, renewable and energy-efficient technologies and solutions. Support will be given to measures facilitating the energy policy implementation, preparing the ground for roll-out of the investments, supporting capacity-building and acting on public acceptance. Attention will also be given to innovation for the smart and sustainable use of existing technologies.

Research and analysis repeatedly confirm the crucial role of the human factor in the success and failure of sustainable energy policies. Innovative organisational structures, the dissemination and exchange of good practices and specific training and capacity-building actions will be encouraged.

3.8. *Specific implementation aspects*

The priority setting for the implementation of the activities in this societal challenge is led by the need to strengthen energy research and innovation at the European level. A main aim will be to support the implementation of the research and innovation agenda of the Strategic Energy Technology Plan (SET Plan) ([13]) to achieve the objectives of the Union's energy and climate change policy. The SET Plan roadmaps and implementation plans will therefore provide a valuable input for the formulation of the work programmes. The SET Plan governance structure will be used as a principle basis for strategic priority setting and the coordination of energy research and innovation across the Union.

The non-technological agenda will be guided by the Union's energy policy and legislation. The enabling environment for mass deployment of demonstrated technological and service solutions, processes and policy initiatives for low-carbon technologies and energy efficiency across the Union shall be supported. This may involve support to technical assistance for the development and roll-out of energy efficiency and renewable energy investments.

In the field of market uptake, activities shall build upon and further enhance those undertaken within the Intelligent Energy Europe (IEE) programme.

Partnering with European stakeholders will be important to share resources and implement joint activities. It may be envisaged, on a case-by-case basis, that existing European Industrial Initiatives (EIIs) of the SET Plan are turned into formalised public-private partnerships, if considered appropriate, to increase the level and coherence of funding and to stimulate joint research and innovation actions among both public and private stakeholders. Consideration will be given to provide support, including with Member States, to alliances of public research performers, in particular the European Energy Research Alliance (EERA) established under the SET Plan to pool public research resources and infrastructures to address critical research areas of European interest. International coordination actions shall support the SET Plan priorities according to the variable geometry principle, taking account of countries' capabilities and specificities. Appropriate links with the actions of relevant European

Innovation Partnerships and the relevant aspects of the research and innovation agendas of European Technology Platforms will also be established.

Consideration may be given to support relevant Joint Programming Initiatives (JPIs) and relevant public-public and public-private partnerships. Activities shall also focus on increasing the support and promoting the involvement of SMEs.

The Commission's Information System for the SET Plan (SETIS) will be mobilised to develop, together with stakeholders, key performance indicators (KPIs) to monitor the progress of implementation. These KPIs will be revised on a regular basis to account of the latest developments. More broadly, implementation under this societal challenge will seek to improve the coordination of relevant Union programmes, initiatives and policies, such as cohesion policy, in particular through the national and regional strategies for smart specialisation, and the emission trading schemes (ETS), for example concerning support to demonstration projects.

4. SMART, GREEN AND INTEGRATED TRANSPORT

4.1. *Resource-efficient transport that respects the environment*

Europe has set a policy target of achieving a 60 % reduction of CO2 by 2050 compared to 1990 levels. It aims at halving the use of 'conventionally-fuelled' cars in cities and achieving virtually CO2-free city logistics in major urban centres by 2030. Low-carbon fuels in aviation should reach 40 % by 2050, and CO2 emissions from maritime bunker fuels should be reduced by 40 % by 2050 ([14]) compared to 2005 levels.

It is essential to reduce this environmental impact through targeted technological improvement, bearing in mind that each mode of transport faces varying challenges and is characterised by specific technology integration cycles.

Research and innovation will substantially contribute to the development and take up of the necessary solutions for all transport modes, which will drastically reduce transport emissions that are harmful to the environment (such as CO2, NOx, SOx and noise), lower the dependence of transport on fossil fuels, and hence reduce transport impact on biodiversity and climate change and preserve natural resources.

This will be done through work on the following specific activities:

4.1.1. Making aircraft, vehicles and vessels cleaner and quieter will improve environmental performance and reduce perceived noise and vibration

The activities in this domain will focus on the end products, but will also address lean and ecological design and manufacturing processes, considering the entire life cycle process and with recyclability integrated in the design phase. Activities will also cover the upgrading of existing products and services by integration of new technologies.

(a) Developing and accelerating the take-up of cleaner and quieter propulsion technologies is important for reducing or eliminating impacts on climate and health of European citizens, e.g. CO2, noise and pollution from transport. New and innovative solutions are necessary, based on electric engines and batteries, hydrogen and fuel cells, gas-powered engines, advanced architectures and technologies in engines or hybrid propulsion. Technological breakthroughs will also help improve the environmental performance of traditional and new propulsion systems.

(b) Exploring options for the use of low emission alternative energies will help reduce the consumption of fossil fuels. This includes using sustainable fuels and electricity from renewable energy sources in all modes of transport including aviation, reducing fuel consumption through energy harvesting or diversified energy supply and other innovative solutions. New holistic approaches will be pursued encompassing vehicles, energy storage, energy supply, fuelling and charging infrastructure, including vehicle-to-grid interfaces and innovative solutions for the use of alternative fuels.

(c) Improving the overall performance of aircraft, vessels and vehicles by reducing their weight and lowering their aerodynamic hydrodynamic or rolling resistance by using lighter materials, leaner structures and innovative design will contribute to lower fuel consumption.

4.1.2. Developing smart equipment, infrastructures and services

This will help optimise transport operations and reduce resource consumption. The focus will be on solutions for the efficient planning, design, use and management of airports, ports, logistic platforms and surface transport infrastructures, as well as on autonomous and efficient maintenance, monitoring and inspection systems. New policies, business models, concepts, technologies and IT solutions are to be adopted to increase capacity. Particular attention will be given to the climate resilience of equipment and infrastructures, cost-efficient solutions based on a life-cycle approach, and the wider take-up of new materials and technologies allowing for more efficient and lower cost maintenance. Attention will also be paid to accessibility, user friendliness and social inclusiveness.

4.1.3. Improving transport and mobility in urban areas

This will benefit a large and increasing share of the population which lives and works in cities or uses them for services and leisure. New mobility concepts, transport organisation, multimodal accessibility models, logistics, provision of innovative vehicles and urban public services and planning solutions need to be developed and tested, which will contribute to reduce congestion, air pollution and noise and improve the efficiency of urban transport. Public and non-motorised transport as well as other resource-efficient transport options for passengers and freight should be developed as a real alternative to the use of private motor vehicles, supported by greater use of intelligent transport systems as well as by innovative supply and demand management. Special emphasis shall be given to the interaction between the transport system and other urban systems.

4.2. *Better mobility, less congestion, more safety and security*

Relevant European transport policy goals aim to optimise performance and efficiency in the face of growing demands for mobility, to make Europe the safest region for aviation, railways and waterborne transport and to move towards the target of zero fatalities in road transport by 2050 and of halving the road casualties by 2020. By 2030,30 % of road freight transport over 300 kilometres should shift to rail and waterborne transport. A seamless, accessible, affordable, user-oriented and efficient pan-European transport of people and goods, also internalising external costs, requires a new European multimodal transport management, information and payment system, as well as efficient interfaces between long distance and urban mobility networks.

A better European transport system will contribute to a more efficient use of transport, improve the quality of life of citizens and support a healthier environment.

Research and innovation will make important contributions to these ambitious policy goals through activities in the following specific activities:

4.2.1. A substantial reduction of traffic congestion

This can be achieved by implementing an intelligent, multi-modal and fully intermodal 'door-to-door' transport system and by avoiding unnecessary use of transport. This means promoting greater integration between transport modes, the optimisation of transportation chains and better integrated transport operations and services. Such innovative solutions will also facilitate accessibility and passenger choices, including for the ageing population and vulnerable users, and provide opportunities to reduce congestion by improving incident management and the development of traffic optimisation schemes.

4.2.2. Substantial improvements in the mobility of people and freight

This can be achieved through the development, demonstration and widespread use of intelligent transport applications and management systems. This entails planning demand analysis and management, information and payment systems that are interoperable Europe-wide, and the full integration of information flows, management systems, infrastructure networks and mobility services into a new common multi-modal framework based on

open platforms. This will also ensure flexibility and rapid responses to crisis events and extreme weather conditions by reconfiguring travel and haulage across modes. New positioning, navigation and timing applications, made possible through the Galileo and the European Geostationary Navigation Overlay Service (EGNOS) satellite navigation systems, will be instrumental in achieving this objective.

(a) Innovative air traffic management technologies will contribute to a step-change in safety and efficiency with rapidly increasing demand, to achieve improved punctuality, to reduce time spent in travel-related procedures at airports and to achieve resilience in the air transport system. The implementation and further development of the 'Single European Sky' will be supported with research and innovation activities providing solutions for increased automation and autonomy in air traffic management and aircraft operation and control, better integration of air and ground components, and novel solutions for the efficient and seamless handling of passengers and freight throughout the transport system.

(b) For waterborne transport, improved and integrated planning and management technologies will contribute to the emergence of a 'Blue Belt' in the seas around Europe, improving port operations, and to a suitable framework for inland waterways.

(c) For rail and road, the optimisation of network management and interoperability will improve the efficient use of infrastructure and make cross-border operations easier. Comprehensive cooperative road traffic management and information systems will be developed, relying on vehicle-to-vehicle and vehicle-to-infrastructure communication.

4.2.3. Developing new concepts of freight transport and logistics

This can reduce pressure on the transport system and the environment and improve safety and freight capacity. The activities can, for example, combine high performance and low environmental impact vehicles with smart, secure on-board and infrastructure-based systems. This should be based on an integrated logistics approach in the field of transport. Activities will also support the development of the e-Freight vision of a paperless freight transport process, where electronic information flows, services and payments are linked to physical freight flows across transport modes.

4.2.4. Reducing accident rates, fatalities and casualties and improving security

This will be achieved by addressing aspects inherent to the organisation, management and monitoring of performance and risk of transport systems and by focusing on the design, manufacturing and operations of aircraft, vehicles, vessels, infrastructures and terminals. The focus will be on passive and active safety, preventive safety and enhanced automation and training processes to reduce the risk and impact of human errors. To better anticipate, assess and mitigate the impact of weather, natural hazards and other crisis situations, special tools and techniques will be devised. Activities will also focus on the integration of security aspects in the planning and management of passenger and freight flows, on the conception of aircraft, vehicles and vessels, on traffic and system management and on the design of transport infrastructures and of freight and passenger terminals. Intelligent transport and connectivity applications may also provide useful tools for enhanced security. Activities will also focus on improving the safety of all road users, especially those at greatest risk, particularly in urban areas.

4.3. *Global leadership for the European transport industry*

By staying ahead in technological development and improving the competitiveness of existing manufacturing processes, research and innovation will contribute to growth and highly skilled jobs in the European transport industry, in the face of growing competition. At stake is the further development of the competitiveness of a major economic sector that directly represents 6,3 % of the Union gross domestic product (GDP) and employs nearly 13 million people in Europe. Specific objectives include the development of the next generation of innovative and environmentally friendly air, waterborne and land transport means, ensuring sustainable

manufacturing of innovative systems and equipment and preparing the ground for future transport means, by working on novel technologies, concepts and designs, smart control systems, efficient development and production processes, innovative services and certification procedures. Europe aims at becoming the world leader in efficiency, environmental performance and safety in all modes of transport and at enhancing its leadership in global markets both for end-products as well as for subsystems.

Research and innovation will focus on the following specific activities:

4.3.1. Developing the next generation of transport means as the way to secure market share in the future

It will help enhance European leadership in aircraft, high speed trains, conventional and (sub)urban rail transport, road vehicles, electromobility, passenger cruise ships, ferries and specialised high technology ships and maritime platforms. It will also spur the competitiveness of European industries in upcoming technologies and systems and support their diversification towards new markets, including in sectors other than transport. This includes the development of innovative safe and environmentally friendly aircraft, vehicles and vessels that incorporate efficient propulsion systems, high performance and intelligent operation and control systems.

4.3.2. On-board, smart control systems

These are needed to realise higher levels of performance and system integration in transport. Appropriate interfaces for communications between aircraft, vehicles, vessels and infrastructures in all relevant combinations will be developed, taking into account impacts of electromagnetic fields, with a view to defining common operational standards. They may include delivering traffic management and user information direct to in-vehicle devices, supported by reliable real-time traffic data on road conditions and congestion from the same devices.

4.3.3. Advanced production processes

These will allow customisation, lower lifecycle cost and development time and facilitate the standardisation and certification of aircraft, vehicles and vessels as well as their components, equipment and related infrastructure. Activities in this area will develop fast and cost-efficient design and manufacturing techniques, including assembly, construction, maintenance and recycling, through digital tools and automation, and capacity to integrate complex systems. This will foster competitive supply chains able to deliver with short time to market and reduced costs without compromising operational safety and security. Transport applications of innovative materials are also a priority both for environmental and competitiveness goals as well as for increased safety and security.

4.3.4. Exploring entirely new transport concepts

This will help enhance Europe's competitive edge in the longer term perspective. Strategic multidisciplinary research and proof-of-concept activities shall address innovative transport systems solutions. This will include fully automated and other new types of aircraft, vehicles and vessels with long term potential and high environmental performance as well as new services.

4.4. *Socio-economic and behavioural research and forward-looking activities for policy making*

Actions to support policy analysis and development including gathering evidence to understand behaviour on spatial, socio-economic and wider societal aspects of transport are necessary to promote innovation and create a shared evidence base to meet the challenges raised by transport. Activities will target the development and implementation of European research and innovation policies for transport and mobility, prospective studies and technology foresight, and strengthening of the ERA.

Understanding local and regional specificities, user behaviour and perceptions, social acceptance, impact of policy measures, mobility, changing needs and patterns, evolution of future demand, business models and their implications are of paramount importance for the evolution of the European transport system. Scenario development taking into account societal trends, evidence on causalities, policy objectives and technology foresight in a 2050 perspective will be carried out. In view of better understanding the links between territorial development, social cohesion and the European transport system, robust models are needed on which sound policy decisions can be taken.

Research will focus on how to reduce social and territorial inequalities in access to mobility and on how to improve the position of vulnerable transport users. Economic issues must also be addressed, focusing on ways to internalise the externalities from transport across modes, as well as taxation and pricing models. Prospective research is needed to assess future requirements for skills and jobs, research and innovation development and uptake as well as transnational cooperation.

4.5. *Specific implementation aspects*

The activities will be organised in such a way as to allow for an integrated and mode-specific approach as appropriate. Multiannual visibility and continuity will be necessary in order to take into account the specificities of each transport mode and the holistic nature of challenges as well as relevant aspects of the strategic research and innovation agendas of European Technology Platforms.

Consideration may be given to support relevant Joint Programming Initiatives (JPIs) and the relevant public-public and public-private partnerships. Appropriate links with the actions of relevant European Innovation Partnerships will also be established. Activities shall also focus on increasing the support and promoting the involvement of SMEs.

5. CLIMATE ACTION, ENVIRONMENT, RESOURCE EFFICIENCY AND RAW MATERIALS

5.1. *Fighting and adapting to climate change*

Current CO2 concentrations in the atmosphere are close to 40 % higher than those at the start of the industrial revolution and at the highest levels experienced in the last 2 million years. Non-CO2 greenhouse gases also contribute to climate change and are playing an increasingly significant role. Without decisive action, climate change could cost the world at least 5 % of GDP each year, and up to 20 % under some scenarios. In contrast, with early and effective action the net costs could be limited to around 1 % of GDP per year. Meeting the 2 °C target and avoiding the worst impacts of climate change will require developed countries to cut greenhouse gas emissions by 80-95 % by 2050 compared to 1990 levels.

The aim of this activity is therefore to develop and assess innovative, cost-effective and sustainable adaptation and mitigation measures and strategies, targeting both CO2 and non-CO2 greenhouse gases and aerosols, and underlining both technological and non-technological green solutions, through the generation of evidence for informed, early and effective action and the networking of the required competences.

To achieve this, research and innovation will focus on the following:

5.1.1. Improving the understanding of climate change and the provision of reliable climate projections

Better understanding of the causes and evolution of climate change and more accurate climate projections are crucial for the society to protect lives, goods and infrastructures and ensure effective decision making and adequate mitigation and adaptation options. It is essential to further improve the scientific knowledge base of climate drivers, processes, mechanisms, feedbacks and thresholds associated with the functioning of terrestrial, marine and polar ecosystems and the atmosphere. Improved understanding will also allow more accurate detection of climate change and attribution to natural and anthropogenic causal factors. Improved reliability of climate projections and predictions at pertinent temporal and spatial scales will be supported via the improvement of measurements and via the development of more accurate scenarios and models, including fully coupled Earth-system models taking into account paleoclimate history.

5.1.2. Assessing impacts and vulnerabilities and developing innovative cost-effective adaptation, risk prevention and management measures

There is incomplete knowledge on the ability of society, economy and ecosystems to adapt to climate change. Effective, equitable and socially acceptable measures towards a climate-resilient environment, economy and society require the integrated analysis of current and future impacts, vulnerabilities, population exposure, risks and their management, second order effects such as migration and conflicts, costs and opportunities associated with climate change and variability, taking into account extreme events and related climate-induced hazards and their recurrence. This analysis will also be developed on the adverse impacts of climate change on biodiversity,

ecosystems and ecosystem services, water resources, infrastructures and economic and natural assets. Emphasis will be placed on the most valuable natural ecosystems and built environments, as well as key societal, cultural and economic sectors across Europe. Actions will investigate the impacts and growing risks for human health stemming from climate change, climate-induced hazards and increased greenhouse gas concentrations in the atmosphere. Research will evaluate innovative, equitably distributed and cost-effective adaptation responses to climate change, including the protection and adaptation of natural resources and ecosystems, and related effects, to inform and support their development and implementation at all levels and scales. This will also include the potential impacts, costs, risks and benefits of geo-engineering options. The complex inter-linkages, conflicts and synergies of adaptation and risk-prevention policy choices with other climate and sectoral policies will be investigated, including impacts on employment and the living standards of vulnerable groups.

5.1.3. Supporting mitigation policies, including studies that focus on impact from other sectoral policies

The Union's transition to a competitive, resource-efficient and climate change resilient economy and society by 2050 requires the design of effective and long-term low-emission strategies and major advancements in our capacity to innovate. Research will assess the environmental and socio-economic risks, opportunities and impacts of climate change mitigation options. It will also assess impact from other sectoral policies. Research will support the development and validation of new climate-energy-economy models, taking into account economic instruments and relevant externalities, with the aim of testing mitigation policy options and low-carbon technology pathways at different scales and for the key economic and societal sectors at Union and global level. Actions will facilitate technological, institutional and socio-economic innovation by improving the links between research and application and between entrepreneurs, end users, researchers, policy makers and knowledge institutions.

5.2. *Protecting the environment, sustainably managing natural resources, water, biodiversity and ecosystems*

Societies face a major challenge to establish a sustainable balance between human needs and the environment. Environmental resources, including water, air, biomass, fertile soils, biodiversity and ecosystems, and the services they provide underpin the functioning of the European and global economy and quality of life. Global business opportunities related to natural resources are expected to amount to over EUR 2 trillion by 2050 ([15]). Despite this, ecosystems in Europe and globally are being degraded beyond nature's ability to regenerate them, and environmental resources are being over-exploited and even destroyed. For example, 1 000 km^2 of some of the most fertile soils and valuable ecosystems are lost every year in the Union, while a quarter of fresh water is wasted. Continuing these patterns is not an option. Research must contribute to reversing the trends that damage the environment and to ensuring that ecosystems continue to provide the resources, goods and services that are essential for well-being, economic prosperity and sustainable development.

The aim of this activity is therefore to provide knowledge and tools for the management and protection of natural resources, achieving a sustainable balance between limited resources and the present and future needs of society and the economy.

To achieve this, research and innovation will focus on the following:

5.2.1. Furthering our understanding of biodiversity and the functioning of ecosystems, their interactions with social systems and their role in sustaining the economy and human well-being

Human action may trigger changes in the environment that are irreversible and which alter the character of ecosystems and their biodiversity. It is vital to anticipate these risks by assessing, monitoring and forecasting the impact of human activities on the environment, including land use change, and environmental changes on human well-being. Research on marine (from coastal zones to the deep sea including the sustainability of marine resources), polar, fresh-water, terrestrial and urban ecosystems, including groundwater dependent ecosystems, will improve our understanding of the complex interactions between natural resources and social, economic, and ecological systems, including natural tipping points, and the resilience, or fragility, of human and biological systems. It will examine how biodiversity and ecosystems function and react to anthropogenic impacts, how they can be restored, and how this will affect economies and human well-being. It will also investigate solutions for

addressing resource challenges in the European and international context. It will contribute to policies and practices that ensure that social and economic activities operate within the limits of the sustainability and adaptability of ecosystems and biodiversity.

5.2.2. Developing integrated approaches to address water-related challenges and the transition to sustainable management and use of water resources and services

Freshwater availability and quality have become global issues with far-reaching economic and social implications. With ever-growing demand for different and often conflicting uses (e.g. agriculture, industry, recreational activities, public services, ecosystems and landscape maintenance, environmental restoration and enhancement), increased resource vulnerability exacerbated by climate and global change, urbanisation, pollution and over-exploitation of freshwater resources, maintaining and improving water quality and availability, and mitigating the impact of human activities on fresh water ecosystems is becoming a critical challenge for the users of water in various sectors as well as for aquatic ecosystems.

Research and innovation will address these pressures and provide integrated strategies, tools, technologies and innovative solutions to meet current and future needs. It will aim to develop appropriate water management strategies, improve water quality, cope with imbalances between water demand and availability or supply at different levels and scale, close the water cycle, promote sustainable end-user behaviour and address water-related risks whilst sustaining the integrity, structure and functioning of the aquatic ecosystems in line with the prevailing Union policies.

5.2.3. Providing knowledge and tools for effective decision making and public engagement

Social, economic and governance systems still need to address both resource depletion and the damage to ecosystems. Research and innovation will underpin policy decisions needed to manage natural resources and ecosystems so as to avoid, or adapt to, disruptive climate and environmental change and to promote institutional, economic, behavioural and technological changes that ensure sustainability. Research will thus underpin the development of systems to value biodiversity and ecosystem services, including understanding the stock of natural capital and the flow of ecosystems services. Emphasis will be put on critical policy-relevant ecosystems and ecosystem services, such as fresh water, seas and oceans (including coastal areas), forests, polar regions, air quality, biodiversity, land use and soil. The resilience of societies and ecosystems to pollutants and pathogens and to catastrophic events, including natural hazards (such as seismic and volcanic, flooding and droughts) and forest fires, will be supported through improving capacities for forecasting, early warning and assessing vulnerabilities and impacts, including the multi-risk dimension. Research and innovation will thus provide support for environmental and resource efficiency policies, and options for effective evidence-based governance within safe operating limits. Innovative ways will be developed to increase policy coherence, resolve trade-offs and manage conflicting interests and to improve public awareness of research results and the participation of citizens in decision making.

5.3. *Ensuring the sustainable supply of non-energy and non-agricultural raw materials*

Sectors such as construction, chemicals, automotive, aerospace, machinery and equipment, which have a combined added value in excess of EUR 1 000 billion and provide employment for some 30 million people, all depend on access to raw materials. The Union is self-sufficient in construction minerals. Nonetheless, whilst the Union is one of the world's largest producers of certain industrial minerals, it remains a net importer of most of them. Furthermore, the Union is highly dependent on imports of metallic minerals and is totally import dependent for some critical raw materials.

Recent trends indicate that demand for raw materials will be driven by the development of emerging economies and by the rapid diffusion of key enabling technologies. Europe has to ensure a sustainable management and secure a sustainable supply of raw materials from inside and outside its borders for all sectors that depend on access to raw materials. Policy targets for critical raw materials are outlined in the Commission's Raw Materials Initiative ([16]).

The aim of this activity is therefore to improve the knowledge base on raw materials and develop innovative solutions for the cost-effective and environmentally friendly exploration, extraction, processing, re-use, recycling and recovery of raw materials and for their substitution by economically attractive and environmentally sustainable alternatives with a lower environmental impact.

To achieve this, research and innovation will focus on the following:

5.3.1. Improving the knowledge base on the availability of raw materials

The assessment of the long-term availability of global and Union resources, including access to urban mines (landfills and mining waste), coastal-sea and deep-sea resources (e.g. the sea-bed mining of rare earth minerals), and the associated uncertainties will be improved. This knowledge will help society reach a more efficient use, recycling and reuse of scarce or environmentally harmful raw materials. It will also develop global rules, practices and standards governing economically viable, environmentally sound and socially acceptable resource exploration, extraction and processing, including practices in land use and marine spatial planning on the basis of an ecosystems approach.

5.3.2. Promoting the sustainable supply and use of raw materials, including mineral resources, from land and sea, covering exploration, extraction, processing, re-use, recycling and recovery

Research and innovation is needed over the entire life cycle of materials, in order to secure an affordable, reliable and sustainable supply and management of raw materials essential for European industries. Developing and deploying economically viable, socially acceptable and environmentally friendly exploration, extraction and processing technologies will boost the efficient use of resources. This will include mineral resources, from land and sea, and will also exploit the potential of urban mines. New and economically viable and resource-efficient recycling and materials recovery technologies, business models and processes, including closed-loop processes and systems, will also contribute to reducing the Union's dependence on the supply of primary raw materials. This will include the need for longer use, high-quality recycling and recovery, and the need to drastically reduce resource wastage. A full life-cycle approach will be taken, from the supply of available raw materials to end of life, with minimum energy and resource requirements.

5.3.3. Finding alternatives for critical raw materials

In anticipation of the possible reduced global availability of certain materials, due for example to trade restrictions, sustainable substitutes and alternatives for critical raw materials, with similar functional performance, will be investigated and developed. This will reduce the Union's dependence on primary raw materials and improve the impact on the environment.

5.3.4. Improving societal awareness and skills on raw materials

The necessary move to a more self-reliant and resource-efficient economy will require cultural, behavioural, socio-economic, systemic and institutional change. In order to address the growing problem of skills shortage in the Union's raw materials sector, including the European mining industry, more effective partnerships between universities, geological surveys, industry and other stakeholders will be encouraged. It will also be essential to support the development of innovative green skills. In addition there is still limited public awareness of the importance of domestic raw materials for the European economy. To facilitate the necessary structural changes, research and innovation will aim to empower citizens, policy-makers, practitioners and institutions.

5.4. *Enabling the transition towards a green economy and society through eco-innovation*

The Union cannot prosper in a world of ever increasing resource consumption, environmental degradation and biodiversity loss. Decoupling growth from the use of natural resources requires structural changes in how such resources are used, re-used and managed, while safeguarding our environment. Eco-innovations will enable us to reduce pressure on the environment, increase resource efficiency, and put the Union on the path to a resource- and energy-efficient economy. Eco-innovation also creates major opportunities for growth and jobs, and increases European competitiveness within the global market, which is estimated to grow to a trillion Euro market after 2015 ([17]). 45 % of companies have already introduced some type of eco-innovation. It has been

estimated that around 4 % of eco-innovations led to more than a 40 % reduction of material use per unit of output ([18]), highlighting the great future potential. However, it is not uncommon that highly promising and technically advanced eco-innovative technologies, processes, services and products do not reach the market due to pre-commercialisation challenges and do not realise their full environmental and economic potential as their scaling up and market introduction are perceived as too risky by private investors.

The aim of this activity is therefore to foster all forms of eco-innovation that enable the transition to a green economy.

To achieve this, research and innovation will focus on the following:

5.4.1. Strengthening eco-innovative technologies, processes, services and products, including exploring ways to reduce the quantities of raw materials in production and consumption, overcoming barriers in this context and boosting their market uptake

All forms of eco-innovation, both incremental and radical, combining technological, organisational, societal, behavioural, business and policy innovation, and strengthening the participation of civil society, will be supported. This will underpin a more circular economy, while reducing environmental impacts, increasing environmental resilience and taking account of rebound effects on the environment and potentially on other sectors. This will include user-driven innovation, business models, industrial symbiosis, product service systems, product design, full life cycle and cradle-to-cradle approaches as well as exploring ways to reduce the quantities of raw materials in production and consumption, and overcoming barriers in this context. The potential to move to more sustainable patterns of consumption will be addressed. The aim will be to improve resource efficiency by reducing, in absolute terms, inputs, waste and the release of harmful substances (e.g. those indicated under Regulation (EC) No 1907/2006 of the European Parliament and of the Council ([19]) along the value chain and to foster re-use, recycling and resource substitution.

Emphasis will be given to facilitate the transition from research to market, involving industry and notably start-ups and innovative SMEs, civil society organisations and end-users, from the development of prototypes and demonstration of technical, social and environmental performance, up to the first application and market replication of eco-innovative techniques, products, services or practices of Union relevance. Actions will contribute to removing barriers to the development and wide application of eco-innovation, creating or enlarging markets for the solutions concerned and improving the competitiveness of Union enterprises, especially SMEs, on world markets. Networking among eco-innovators will also seek to enhance the dissemination and exploitation of knowledge and link supply with demand better.

5.4.2. Supporting innovative policies and societal changes

Structural and institutional changes are needed to enable the transition towards a green economy and society. Research and innovation will address the main barriers to societal and market change and will aim to empower consumers, business leaders and policy makers to adopt innovative and sustainable behaviour, with contributions from social sciences and humanities. Robust and transparent tools, methods and models to assess and enable the main economic, societal, cultural and institutional changes needed to achieve a paradigm shift towards a green economy and society will be developed. Research will explore how to promote sustainable lifestyles and consumption patterns, encompassing socio-economic research, behavioural science, user engagement and public acceptance of innovation, as well as activities to improve communication and public awareness. Full use will be made of demonstration actions.

5.4.3. Measuring and assessing progress towards a green economy

It is necessary to develop robust indicators at all appropriate spatial scales that are complementary to GDP, methods and systems to support and assess the transition towards a green economy and the effectiveness of relevant policy options. Driven by a life-cycle approach, research and innovation will improve the quality and availability of data, measurement methods and systems relevant to resource efficiency and eco-innovation and facilitate the development of innovative offset schemes. Socio-economic research will provide a better understanding of the root causes of producer and consumer behaviour and thus contribute to the design of more

effective policy instruments to facilitate the transition to a resource-efficient and climate change resilient economy. Moreover, technology assessment methodologies and integrated modelling will be developed to support resource efficiency and eco-innovation policies at all levels, while increasing policy coherence and resolving trade-offs. The results will enable the monitoring, assessment and reduction in material and energy flows involved in production and consumption, and will enable policy-makers and businesses to integrate environmental costs and externalities into their actions and decisions.

5.4.4. Fostering resource efficiency through digital systems

Innovations in information and communication technologies can constitute a key tool to support resource efficiency. To achieve this objective, modern and innovative ICT will contribute to significant efficiency gains in productivity, notably through automated processes, real time monitoring and decision support systems. The use of ICT will aim to accelerate a progressive dematerialisation of the economy, by increasing the shift towards digital services, and to facilitate changes of consumption behaviours and business models through the use of the ICT of the future.

5.5. *Developing comprehensive and sustained global environmental observation and information systems*

Comprehensive environmental observation and information systems are essential to ensure the delivery of the long-term data and information required to address this societal challenge. These systems will be used to monitor, assess and predict the condition, status and trends of the climate, natural resources including raw materials, terrestrial and marine (from coastal zones to deep sea) ecosystems and ecosystem services, as well as to evaluate low-carbon and climate mitigation and adaptation policies and options across all sectors of the economy. Information and knowledge from these systems will be used to stimulate the smart use of strategic resources, to support the development of evidence-based policies, to foster new environmental and climate services, and to develop new opportunities in global markets.

Capabilities, technologies and data infrastructures for Earth observation and monitoring must build on advances in ICT, space technologies and enabled networks, remotely sensed observations, novel in situ sensors, mobile services, communication networks, participatory web-service tools and improved computing and modelling infrastructure, with the aim of continuously providing timely and accurate information, forecasts and projections. Free, open and unrestricted access to interoperable data and information will be encouraged, as well as the effective and, if required, secure storage, management and dissemination of research results. Activities shall help define future operational activities of the Copernicus programme and enhance the use of Copernicus data for research activities.

5.6. *Cultural heritage*

Cultural heritage assets are unique and irreplaceable in their tangible form as well as in their intangible value, cultural significance and meaning. They are a major driver of societal cohesion, identity and well-being, and they contribute significantly to sustainable growth and job creation. However, Europe's cultural heritage is subject to deterioration and damage, further exacerbated by increasing exposure to human activities (e.g. tourism) and extreme weather events resulting from climate change as well as due to other natural hazards and disasters.

The aim of this activity is to provide knowledge and innovative solutions, through adaptation and mitigation strategies, methodologies, technologies, products and services for the preservation and management of tangible cultural heritage in Europe at risk from climate change.

To achieve this, multidisciplinary research and innovation will focus on the following:

5.6.1. Identifying resilience levels via observations, monitoring and modelling

New and improved damage assessment, monitoring and modelling techniques will be developed to improve the scientific knowledge base of the impact on cultural heritage of climate change and other environmental and human risk factors. The knowledge and understanding generated with the help of scenarios, models and tools, including analysis of the perception of value, will help provide a sound scientific basis for the development of

resilience strategies, policies and standards, within a coherent framework for risk assessment and management of cultural heritage assets.

5.6.2. Providing for a better understanding on how communities perceive and respond to climate change and seismic and volcanic hazards

Research and innovation will, through integrated approaches, develop resource-efficient solutions for prevention, adaptation and mitigation, involving innovative methodologies, technologies, products and services for the preservation of cultural heritage assets, cultural landscapes and historic habitats.

5.7. *Specific implementation aspects*

Activities will enhance the Union's participation in and financial contribution to multilateral processes and initiatives, such as the Intergovernmental Panel on Climate Change (IPCC), the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), and the Group on Earth Observations (GEO). Cooperation with other major public and private research funders as well as with major research networks will improve global and European research efficiency and contribute to global research governance.

Scientific and technological cooperation will contribute to the United Nations Framework Convention on Climate Change (UNFCCC) global technology mechanism and facilitate technology development, innovation and transfer in support of climate adaptation and the mitigation of greenhouse gases.

Building on the outcomes of the UN Rio+20 Conference, a mechanism will be explored to systematically collect, collate and analyse scientific and technological knowledge on key sustainable development and green economy issues, which will include a framework for measuring progress. This will complement existing scientific panels and bodies and seek synergies with them.

Research actions under this societal challenge will contribute to Copernicus operational services by providing a developmental knowledge base for Copernicus.

Consideration may be given to support relevant Joint Programming Initiatives (JPIs) and relevant public-public and public-private partnerships.

Approriate links with the actions of relevant European Innovation Partnerships and the relevant aspects of the research and innovation agendas of European Technology Platforms will also be established.

Specific measures will ensure that results from Union research and innovation in the fields of climate, resource efficiency and raw materials are used downstream by other Union programmes, such as the LIFE programme, ESI Funds, and external cooperation programmes.

Activities will also, inter alia, build upon and enhance those undertaken in the Eco-Innovation Programme.

Actions will also provide the continuous analysis of scientific and technological progress in the Union and its major partner countries and regions, an early investigation of market opportunities for new environmental technologies and practices, and foresight for research and innovation policy.

6. EUROPE IN A CHANGING WORLD - INCLUSIVE, INNOVATIVE AND REFLECTIVE SOCIETIES

This section includes research and innovation activities contributing to make societies more inclusive, innovative and reflective, and also specific measures supporting particular cross-cutting issues mentioned in this societal challenge ([20]).

6.1. *Inclusive societies*

Current trends at play in European societies bring with them opportunities for a more united Europe but also risks and challenges. These opportunities, risks and challenges need to be understood and anticipated in order for Europe to evolve with adequate solidarity and cooperation at social, economic, political, educational and cultural levels, taking into account an increasingly interconnected and interdependent world.

In this context, the objective is to understand, analyse and develop social, economic and political inclusion, as well as inclusive labour markets, combat poverty and marginalisation, enhance human rights, digital inclusiveness, equality, solidarity and inter-cultural dynamics by supporting cutting-edge science, interdisciplinary research, development of indicators, technological advances, organisational innovations, development of regional innovation clusters and new forms of collaboration and co-creation. Research and other activities shall support the implementation of the Europe 2020 strategy as well as other relevant Union policies. Social sciences and humanities research has a leading role to play in this context. Specifying, monitoring, assessing and addressing the objectives of European strategies and policies will require focused research that allows policy makers to analyse and assess the impact and effectiveness of envisaged measures, in particular in favour of social inclusion. To this end, full societal inclusion and participation must encompass all areas of life and all ages.

The following specific objectives will be pursued to understand and foster or implement:

6.1.1. The mechanisms to promote smart, sustainable and inclusive growth

Europe has developed a specific and rather unique combination of economic progress, social policies aimed at a high level of social cohesion, humanistic shared cultural values embracing democracy and the rule of law, human rights, respect and preservation of diversity, as well as the promotion of education and science, arts and humanities as fundamental drivers of social and economic progress and well-being. The constant quest for economic growth carries a number of important human, social, environmental and economic costs. A smart, sustainable and inclusive growth in Europe implies substantial changes in the way growth and societal well-being are defined, measured (including through the measurement of progress beyond the commonly used GDP indicator), generated and sustained over time.

Research will analyse the development of citizen participation, sustainable lifestyles, cultural understanding and socio-economic behaviours and values and how they relate to paradigms, policies and to the functioning of institutions, communities, markets, firms, governance and belief systems in Europe and their relations with other regions and economies. It will develop tools for a better assessment of the contextual and mutual impacts of such evolutions, compare public policies against the variety of challenges across Europe, and analyse policy options and decision making mechanisms in areas such as employment, taxation, inequalities, poverty, social inclusion, education and skills, community development, competitiveness and the internal market with a view to understanding the new conditions and opportunities for greater European integration and the role of its social, cultural, scientific and economic components and synergies as sources of comparative Union advantages at world level.

Demographic change due to ageing societies and migration movements will be analysed in terms of its implications for growth, the labour market and well-being. In this context, to be able to tackle the challenge of future growth, it is important to take into account the different components of knowledge, focusing research on learning, education and training issues, or on the role and place of young people in the society. Research will also develop better tools for assessing sustainability impacts of different economic policies. It will also analyse how national economies evolve and which forms of governance at European and international level could help prevent macro-economic imbalances, monetary difficulties, fiscal competition, unemployment and employment problems and other forms of societal, economic and financial disorders. It will take into account the growing interdependencies between Union and global economies, markets and financial systems and resulting challenges for institutional development and public administration. Against the background of the European public debt crisis, emphasis will also be put on research to define the framework conditions for stable European financial and economic systems.

6.1.2. Trusted organisations, practices, services and policies that are necessary to build resilient, inclusive, participatory, open and creative societies in Europe, in particular taking into account migration, integration and demographic change

Understanding social, cultural and political transformations in Europe requires the analysis of changing democratic practices and expectations as well as of the historical evolution of identities, diversity, territories,

religions, cultures, languages and values. This includes a good understanding of the history of European integration. Research will seek to identify ways to adapt and improve the European welfare systems, public services and the broader social security dimension of policies in order to achieve cohesion and gender equality, to foster participatory, open and creative societies and to promote social and economic equality and intergenerational solidarity. Research will analyse how societies and politics become more European in a broad sense through evolutions of identities, cultures and values, the circulation of knowledge, ideas and beliefs and combinations of principles and practices of reciprocity, commonality and equality, paying particular attention to migration, integration and demographic change. It will analyse how vulnerable populations (e.g. Roma) can participate fully in education, society and democracy, notably through the acquisition of various skills and the protection of human rights. The analysis of how political systems evolve and also respond to the above-mentioned social evolutions will thus be central.

Research will also address the evolution of key systems that provide underlying forms of human and social bonds, such as family, work, education and employment, and help to combat social inequalities, exclusion and poverty.Social cohesion and fair and reliable justice, education, democracy, tolerance and diversity are factors that need to be carefully considered with a view to identifying and better exploiting European comparative advantages at world level and to providing improved evidence-based support to policies. Research will take into account the importance of mobility and migration, including intra-European flows, and demography in the future development of European policies.

In addition, understanding the strains and opportunities arising from the uptake of ICT, both at individual and collective levels, is important in order to open new paths of inclusive innovation. Given the increasing socio-economic importance of digital inclusion, research and innovation actions will promote inclusive ICT solutions and the effective acquisition of digital skills leading to the empowerment of citizens and a competitive workforce. Emphasis will be given to new technological advances that will enable a radical improvement in personalisation, user-friendliness and accessibility through a better understanding of citizen, consumer and user behaviours and values, including persons with disabilities. This will require an "inclusion by design" research and innovation approach.

6.1.3. Europe's role as a global actor, notably regarding human rights and global justice

Europe's distinct historical, political, social and cultural system is increasingly confronted with the impact of global changes. In order to further develop its external action in its neighbourhood and beyond and its role as a global actor, Europe has to improve its capacities for defining, prioritising, explaining, assessing and promoting its policy objectives in interaction with other world regions and societies to further cooperation or prevent or solve conflicts. In this regard, it also has to improve its capacities for anticipating and responding to the evolution and impacts of globalisation. This requires a greater understanding of and learning from the history, cultures and political-economic systems of other world regions, as well as of the role and influence of transnational actors. Finally, Europe also has to contribute effectively to global governance and global justice, in key domains like trade, development, work, economic cooperation, environment, education, gender equality and human rights, defence and security. This implies the potential to build new capacities whether in terms of tools, services, systems and instruments of analysis or in terms of diplomacy in formal and informal international arena with governmental and non-governmental actors.

6.1.4. The promotion of sustainable and inclusive environments through innovative spatial and urban planning and design

80 % of Union citizens live today in and around cities, and inadequate urban planning and design can thus have tremendous consequences on their lives. Understanding how they function for all citizens, as well as understanding their design, liveability and their attractiveness to, inter alia, investment and skills, is critical to Europe's success in creating growth, jobs and a sustainable future.

European research and innovation should provide tools and methods for a more sustainable, open, innovative and inclusive urban and peri-urban planning and design; a better understanding of the dynamics of urban societies and social changes and of the nexus of energy, environment, transport and land-use, including the interplay with

surrounding rural areas; an improved understanding of design and use of public space within cities, also in the context of migration, to improve social inclusion and development and reduce urban risks and crime; new ways to reduce pressures on natural resources and stimulate sustainable economic growth while improving the quality of life of European urban citizens; and a forward-looking vision on the socio-ecological transition towards a new model of urban development reinforcing Union cities as hubs of innovation and centres of job creation and social cohesion.

6.2. *Innovative societies*

The Union share of global knowledge production remains considerable, yet its socio-economic impacts need to be maximised. Efforts will be made to increase the efficiency of research and innovation policies and their transnational policy synergies and coherence. Innovation will be addressed in a wide sense, including large-scale policy, social-, user- and market-driven innovation. The experience and innovative power of creative and cultural Industries will be taken into account. These activities will support the achievement and functioning of the ERA and in particular the Europe 2020 flagship initiatives 'Innovation Union' and the 'Digital Agenda for Europe'.

The following specific objectives will be pursued:

6.2.1. Strengthening the evidence base and support for the Innovation Union and ERA

In order to assess and prioritise investments and strengthen the Innovation Union and the ERA, the analysis of research, education and innovation policies, systems and actors in Europe and third countries as well as the development of indicators, data and information infrastructures will be supported. Forward-looking activities and pilot initiatives, economic and gender analysis, policy monitoring, mutual learning, coordination tools and activities and the development of methodologies for impact assessment and evaluations will also be needed, exploiting direct feedback from stakeholders, enterprises, public authorities, civil society organisations and citizens. This analysis should be conducted in coherence with studies on higher education systems in Europe and third countries within the Erasmus+ programme.

To ensure a single market for research and innovation, measures to incentivise ERA compatible behaviour will be implemented. Activities underpinning policies related to the quality of research training, mobility and career development of researchers will be supported, including initiatives to provide for mobility services, open recruitment, women's participation in the sciences, researchers' rights and links with global researcher communities. These activities will be implemented seeking synergies and close coordination with the Marie Skłodowska-Curie Actions under the priority 'Excellent science'. Institutions presenting innovative concepts for the rapid implementation of ERA principles, including the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers, the Commission Recommendation on the management of intellectual property in knowledge transfer activities and Code of Practice for universities and other public research institutions ([21]), will be supported.

As regards coordination of policies, a facility for policy advice will be set up to make expert policy advice available to national authorities when defining their National Reform Programmes and research and innovation strategies.

To implement the Innovation Union flagship initiative, there is also a need to support market-driven innovation, open innovation, public sector and social innovation in view of enhancing the innovation capacity of firms and fostering European competitiveness. This will require improving the overall framework conditions for innovation as well as tackling the specific barriers preventing the growth of innovative firms. Powerful innovation support mechanisms (such as improved cluster management, public-private partnerships and network cooperation), highly specialised innovation support services (on e.g. IP management/exploitation, networking of IPR owners and users, innovation management, entrepreneurship skills, and networks of procurers) and reviews of public policies in relation to innovation will be supported. Issues specific to SMEs will be supported under the specific objective 'Innovation in SMEs'.

6.2.2. Exploring new forms of innovation, with special emphasis on social innovation and creativity, and understanding how all forms of innovation are developed, succeed or fail

Social innovation generates new goods, services, processes and models that meet societal needs and create new social relationships. As means of innovation are constantly changing, further research is needed into the development of all forms of innovation and the way innovation meets the needs of society. It is important to understand how social innovation and creativity may lead to change in existing structures, practices and policies and how they can be encouraged and scaled-up. It is important to assess the impact of on-line platforms on networking citizens. Support will also be given to the use of design in companies, networking and experimentation of the use of ICT for improving learning processes, as well as to networks of social innovators and social entrepreneurs. Research will also focus on the processes of innovation and how they develop, succeed or fail (including risk taking and the role of different regulatory environments).

It will be essential to promote innovation in order to foster efficient, open and citizen-centric public services (e.g. eGovernment). This will require multidisciplinary research on new technologies and large-scale innovation related in particular to digital privacy, interoperability, personalised electronic identification, open data, dynamic user interfaces, lifelong learning and e-learning platforms, distributed learning systems, citizen-centric public service configuration and integration and innovation driven by users, including in social sciences and the humanities. Such actions will also address social network dynamics and crowd-sourcing and smart-sourcing for co-production of solutions addressing social problems, based, for example, on open data sets. They will help to manage complex decision making, in particular the handling and analysis of huge quantities of data for collaborative policy modelling, simulation of decision making, visualisation techniques, process modelling and participatory systems as well as to analyse changing relationships between citizens and the public sector.

Specific measures shall be developed to involve the public sector as an agent for innovation and change, at national and Union level, in particular through policy support and cross-border innovation measures at the widest geographical level enabling the smart use of ICT in and by public administrations for seamless delivery of public services for citizens and businesses.

6.2.3. Making use of the innovative, creative and productive potential of all generations

Activities will contribute to exploring Europe's opportunities to innovate in terms of new products and technologies, improved services and new business and social models adapted to the changing demographic structure of the society. Activities will enhance taking advantage of the potential of all generations by fostering the development of smart policies to make active ageing a reality in an evolving intergenerational context and by supporting the integration of the generations of young Europeans in all domains of social, political, cultural and economic life, taking into account, amongst others, perception of opportunities for innovation in the context of high unemployment in many Union regions.

6.2.4. Promoting coherent and effective cooperation with third countries

Horizontal activities will ensure the strategic development of international cooperation across Horizon 2020 and address cross-cutting policy objectives. Activities to support bilateral, multilateral and bi-regional policy dialogues in research and innovation with third countries, regions, international fora and organisations will facilitate policy exchange, mutual learning and priority setting, promote reciprocal access to programmes and monitor the impact of cooperation. Networking and twinning activities will facilitate optimal partnering between research and innovation actors on both sides and improve competencies and cooperation capacity in less advanced third countries. Activities will promote coordination of Union and national cooperation policies and programmes, as well as joint actions of Member States and associated countries with third countries in order to enhance their overall impact. Finally, the European research and innovation 'presence' in third countries will be consolidated and strengthened, notably by exploring the creation of European virtual 'science and innovation houses', the provision of services to European organisations extending their activities into third countries, and the opening of research centres, established jointly with third countries, to organisations or researchers from other Member States and associated countries.

6.3. *Reflective societies - Cultural heritage and European identity*

The aim is to contribute to an understanding of Europe's intellectual basis, its history and the many European and non-European influences, as an inspiration for our lives today. Europe is characterised by a variety of different

peoples (including minorities and indigenous people), traditions and regional and national identities as well as by different levels of economic and societal development. Migration and mobility, media, industry and transport contribute to the diversity of views and lifestyles. This diversity and its opportunities should be recognised and considered.

European collections in libraries, including digital ones, archives, museums, galleries and other public institutions have a wealth of rich, untapped documentation and objects for study. These archival resources, together with intangible heritage, represent the history of individual Member States but also the collective heritage of a Union that has emerged through time. Such materials should be made accessible, also through new technologies, to researchers and citizens to enable a look to the future through the archive of the past. Accessibility and preservation of cultural heritage in these forms is needed for the vitality of the living engagements within and across European cultures now and contributes to sustainable economic growth.

The focus of activities shall be the following:

6.3.1. Studying European heritage, memory, identity, integration and cultural interaction and translation, including its representations in cultural and scientific collections, archives and museums, to better inform and understand the present by richer interpretations of the past

The activities will contribute to a critical analysis of how a European tangible and non-tangible heritage has developed over time, including language, memories, practices, institutions and identities. They will include studies of the interpretations and practices of cultural interactions, integration and exclusion.

An intensified European integration process has underlined that a wider European identity sphere exists – one which complements other types of identities in Europe. A broad spectrum of evidence and testimonies of European identity spheres can be found in European and non-European scientific collections, archives, museums, libraries and cultural heritage sites. They offer materials and documents which enable greater understanding of identity building processes that allow reflections about social, cultural or even economic processes that contribute to past, actual and future forms of European identity. The objective is to develop innovations and to use and analyse objects and/or documentation in cultural and scientific collections, archives and museums to improve our understanding of how European identity can be traced, constructed or debated.

The issues of multilingualism, translation and circulation of ideas across Europe and from and to Europe and how they form part of a common European intellectual heritage will be explored.

6.3.2. Researching into European countries' and regions' history, literature, art, philosophy and religions and how these have informed contemporary European diversity

Cultural diversity is an important facet constituting Europe's singularity and providing a source of strength, dynamism and creativity. The activities will address the contemporary European diversity and how this diversity is shaped by history while also helping to analyse how such diversity is conducive to new intercultural developments, or even tensions and conflicts. The role of arts, media, landscapes, literature, languages, philosophy and religions, in relation to this diversity, will be central as they offer various interpretations of the social, political and cultural realities and influence the visions and practices of individuals and social actors.

6.3.3. Researching Europe's role in the world, the mutual influence and ties between the world regions, and a view from outside on European cultures

The activities will address the complexity of the socio-economic and cultural links between Europe and other world regions and assess the potential for improved intercultural exchanges and dialogues taking into account broader social, political and economic developments. They will help to analyse the development of various views in Europe on other world regions and vice versa.

6.4. *Specific implementation aspects*

In order to promote an optimal combination of approaches, cooperation between this societal challenge and the priority "Industrial Leadership" shall be established in the form of cross-cutting actions targeting the field of interaction between humans and technology. Technological innovation based on ICT will play an important role

in enhancing the productivity and engaging the creativity of citizens from all generations in an innovative society.

Implementation under this societal challenge will also enjoy the support of administration and coordination of international networks for excellent researchers and innovators such as COST and EURAXESS, and therefore also contribute to the ERA.

Consideration may be given to support relevant Joint Programming Initiatives (JPIs) and relevant public-public and public-private partnerships.

Appropriate links with the actions of relevant European Innovation Partnerships and the relevant aspects of the research and innovation agendas of European Technology Platforms will also be established.

Research and innovation actions under this societal challenge will contribute to implementing the Union's international research and innovation cooperation activities, by engaging more strategically in science, technology and innovation cooperation with its main third country partners. In this regard, the Strategic Forum for International Scientific and Technological Cooperation (SFIC) will continue to give strategic advice to the Council and the Commission on the international dimension of the ERA.

7. SECURE SOCIETIES - PROTECTING FREEDOM AND SECURITY OF EUROPE AND ITS CITIZENS

The Union, its citizens and its international partners are confronted with a range of security threats and challenges like crime, terrorism and mass emergencies due to man-made or natural disasters. These can span across borders and aim at physical targets or the cyberspace. Attacks against critical infrastructures, networks and Internet sites of public authorities and private entities not only undermine the citizen's trust but may seriously affect essential sectors such as energy, transport, health, finance or telecommunications.

In order to anticipate, prevent and manage these threats, it is necessary to develop and apply innovative technologies, solutions, foresight tools and knowledge, stimulate cooperation between providers and users, find civil security solutions, improve the competitiveness of European security, industry and services, including ICT, and prevent and combat the abuse of privacy and breaches of human rights in Internet and elsewhere, while ensuring European citizens' individual rights and freedom.

The coordination and improvement of the security research and innovation area will thus be an essential element and will help to map present research efforts, including foresight, and improve relevant legal conditions and procedures for coordination, including pre-normative activities.

Activities within this societal challenge shall have an exclusive focus on civil applications and will follow a mission-oriented approach, promote efficient cooperation of end-users, industry and researchers, and integrate the relevant societal dimensions whilst complying with ethical principles. They will support the Union's policies for internal and external security, including the Common Foreign and Security Policy and its Common Security and Defence Policy, and improve cyber security, trust and privacy in the Digital Single Market. The activities will include a focus on the research and development of the next generation of innovative solutions, by working on novel concepts and designs, and interoperable standards. This will be done by developing innovative technologies and solutions that address security gaps and lead to a reduction in the risk from security threats.

The following specific objectives will be pursued:

7.1. *Fighting crime, illegal trafficking and terrorism, including understanding and tackling terrorist ideas and beliefs*

The ambition is both to avoid an incident and to mitigate its potential consequences. This requires new technologies and capabilities for fighting and preventing crime (including cyber crime), illegal trafficking and terrorism (including cyber terrorism), including understanding causes and impacts of radicalisation and violent extremism, and tackling terrorist ideas and beliefs to also avoid aviation-related threats.

7.2. *Protecting and improving the resilience of critical infrastructures, supply chains and transport modes*

New technologies, processes, methods and dedicated capabilities will help to protect critical infrastructures (including in urban areas), systems and services which are essential for the proper functioning of society and economy (including communications, transport, finance, health, food, water, energy, logistic and supply chain, and environment). This will include analysing and securing public and private critical networked infrastructures and services against any type of threats, including aviation-related threats. This will also include protection of maritime transport routes.

7.3. *Strengthening security through border management*

Technologies and capabilities are also required to enhance systems, equipments, tools, processes, and methods for rapid identification to improve land, marine and coastal border security and management, including both control and surveillance issues, while exploiting the full potential of the European Border Surveillance System (EUROSUR). These will be developed and tested considering their effectiveness, compliance with legal and ethical principles, proportionality, social acceptability and the respect of fundamental rights. Research will also support the improvement of the integrated European border management, including through increased cooperation with candidate, potential candidate and European Neighbourhood Policy countries.

7.4. *Improving cyber security*

Cyber security is a prerequisite for people, business and public services in order to benefit from the opportunities offered by the Internet or any other additional data networks and communication infrastructures. It requires providing an improved security for systems, networks, access devices, software and services, including cloud computing, while taking into account the interoperability of multiple technologies. Research and innovation will be supported to help prevent, detect and manage real-time cyber-attacks across multiple domains and jurisdictions, and to protect critical ICT infrastructures. The digital society is in full development with constantly changing uses and abuses of the Internet, new ways of social interaction, new mobile and location-based services and the emergence of the Internet of Things (IoT). This requires a new type of research which should be triggered by the emerging applications, usage and societal trends. Nimble research initiatives will be undertaken, including pro-active R&D, to react quickly to new contemporary developments in trust and security. Particular attention should be given to the protection of children, as they are highly vulnerable to the emerging forms of cyber crime and abuse.

Work here should be conducted in close co-ordination with the ICT strand of the priority "Industrial Leadership".

7.5. *Increasing Europe's resilience to crises and disasters*

This requires the development of dedicated technologies and capabilities to support different types of emergency management operations in crises and disaster situations (such as civil protection, fire fighting, environmental contamination, marine pollution, civil defence, development of medical information infrastructures, rescue tasks, and disaster recovery processes) as well as law enforcement. Research will cover the whole crisis management chain and societal resilience, and support the establishment of a European emergency response capacity.

7.6. *Ensuring privacy and freedom, including in the Internet, and enhancing the societal legal and ethical understanding of all areas of security, risk and management*

Safeguarding the human right of privacy, including in the digital society, will require the development of privacy-by-design frameworks and technologies to underpin new products and services. Technologies will be developed allowing users to control their personal data and its use by third parties, as well as tools to detect and block illegal content and data breaches and to protect human rights on-line, preventing that the behaviour of individuals or groups is limited by unlawful searching or profiling.

Any new security solution and technology needs to be acceptable to the society, comply with Union and international law, and be effective and proportionate in identifying and addressing the security threat. It is therefore essential to understand the socioeconomic, cultural, and anthropological dimensions of security, the causes of insecurity, the role of media and communication and the citizen's perceptions better. Ethical and legal issues and protection of human values and fundamental rights will be addressed, as well as risk and management issues.

7.7. *Enhancing standardisation and interoperability of systems, including for emergency purposes*

Pre-normative and standardisation activities will be supported across all mission areas. Attention will be paid to standardisation gaps and on the next generation of tools and technologies. Activities across all mission areas will also address the integration and interoperability of systems and services, including aspects such as communication, distributed architectures and human factors, including for emergency purposes.

7.8. *Supporting the Union's external security policies, including through conflict prevention and peace-building*

New technologies, capabilities and solutions are required to support the Union's external security policies in civilian tasks, ranging from civil protection to humanitarian relief, border management or peace-keeping and post-crisis stabilisation, including conflict prevention, peace-building and mediation. This will require research on conflict resolution and restoration of peace and justice, on early identification of factors leading to conflict and on the impact of restorative justice processes.

This also requires promoting interoperability between civilian and military capabilities in civilian tasks ranging from civil protection to humanitarian relief, border management or peace-keeping. This will include technological development in the sensitive area of dual-use technologies to enhance interoperability between civil protection and military forces and amongst civil protection forces worldwide, as well as reliability, organisational, legal and ethical aspects, trade issues, protection of confidentiality and integrity of information and traceability of all transactions and processing.

7.9. *Specific implementation aspects*

Whereas research and innovation activities will have an exclusive focus on civil applications, coordination with the activities of the European Defence Agency (EDA) will be actively pursued in order to strengthen cooperation with EDA, notably through the already established European Framework Cooperation (EFC), recognising that there are areas of dual-use technology. Coordination mechanisms with relevant Union agencies, such as the European Agency for the Management of Operational Cooperation at the External Borders of the Member States of the European Union (FRONTEX), European Maritime Safety Agency (EMSA), European Union Agency for Network and Information Security (ENISA) and European Police Office (Europol), will also be further strengthened in order to improve the coordination of Union programmes and policies in the field of both internal and external security, and of other Union initiatives.

Taking into account the particular nature of security, specific arrangements will be put in place with regards to programming and governance, including arrangements with the Committee referred to in Article 10. Classified or otherwise sensitive information related to security will be protected, and particular requirements and criteria for international cooperation may be specified in work programmes. This will also be reflected in the programming and governance arrangements for the specific objective "Secure societies - Protecting freedom and security of Europe and its citizens" (including the comitology aspects).

PART IV

SPREADING EXCELLENCE AND WIDENING PARTICIPATION

The aim is to fully exploit the potential of Europe's talent pool and 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.

There are significant disparities across Europe in research and innovation performance which need to be addressed with specific measures. These measures will aim at unlocking excellence and innovation and will be distinct from, and where appropriate complementary and synergistic with, policies and actions of the ESI Funds. They include:

(a) Teaming of excellent research institutions and low performing RDI regions: Teaming aims at the creation of new (or significant upgrade of existing) centres of excellence in low performing RDI Member States and regions. It will focus on the preparatory phase for setting up or upgrading and modernising such an institution, facilitated by a teaming process with a leading counterpart in Europe, including supporting the development of a business plan. A commitment of the recipient region or Member State (e.g. support via ESI Funds) is expected. Subject to the quality of the business plan, the Commission may provide further seed financial support for the first steps of implementation of the centre.

Building links with innovative clusters and recognising excellence in low performing RDI Member States and regions, including through peer reviews and awarding labels of excellence to those institutions that meet international standards, will be considered;

(b) Twinning of research institutions: Twinning aims at significantly strenghtening a defined field of research in an emerging institution through links with at least two internationally-leading institutions in a defined field. A comprehensive set of measures underpinning this linkage would be supported (e.g. staff exchanges, expert visits, short-term on-site or virtual trainings, and workshops; conference attendance; organisation of joint summer school type activities; dissemination and outreach activities);

(c) 'ERA Chairs': Establishing 'ERA Chairs' aims at attracting outstanding academics to institutions with a clear potential for research excellence, in order to help these institutions fully unlock this potential and hereby create a level playing field for research and innovation in the ERA. This will include institutional support for creating a competitive research environment and the framework conditions necessary for attracting, retaining and developing top research talent within these institutions. Possible synergies with ERC activities should be explored;

(d) Policy Support Facility: This will aim at improving the design, implementation and evaluation of national/regional research and innovation policies. It will offer expert advice to public authorities at national or regional level on a voluntary basis, covering the needs to access the relevant body of knowledge, to benefit from the insight of international experts, to use state-of-the-art methodologies and tools, and to receive tailor-made advice;

(e) Supporting access to international networks for excellent researchers and innovators who lack sufficient involvement in European and international networks. This will include support provided through COST;

(f) Strengthening the administrative and operational capacity of transnational networks of National Contact Points (NCPs), including through training, financial and technical support, while improving the framework for the operation of NCPs and the flow of information between them and the Horizon 2020 implementation bodies, so that NCPs can provide better support to potential participants.

PART V

SCIENCE WITH AND FOR SOCIETY

The 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.

The strength of the European science and technology system depends on its capacity to harness talent and ideas from wherever they exist. This can only be achieved if a fruitful and rich dialogue and active cooperation between science and society is developed to ensure a more responsible science and to enable the development of policies more relevant to citizens. Rapid advances in contemporary scientific research and innovation have led to a rise of important ethical, legal and social issues that affect the relationship between science and society.

Improving the cooperation between science and society to enable a widening of the social and political support to science and technology in all Member States is an increasingly crucial issue which the current economic crisis has greatly exacerbated. Public investment in science requires a vast social and political constituency sharing the values of science, educated and engaged in its processes and able to recognise its contributions to knowledge, society and economic progress.

The focus of activities shall be to:

(a) make scientific and technological careers attractive to young students, and foster sustainable interaction between schools, research institutions, industry and civil society organisations;

(b) promote gender equality, in particular by supporting structural changes in the organisation of research institutions and in the content and design of research activities;

(c) integrate society in science and innovation issues, policies and activities in order to integrate citizens' interests and values and to increase the quality, relevance, social acceptability and sustainability of research and innovation outcomes in various fields of activity from social innovation to areas such as biotechnology and nanotechnology;

(d) encourage citizens to engage in science through formal and informal science education, and promote the diffusion of science-based activities, namely in science centres and through other appropriate channels;

(e) develop the accessibility and the use of the results of publicly-funded research;

(f) develop the governance for the advancement of responsible research and innovation by all stakeholders (researchers, public authorities, industry and civil society organisations), which is sensitive to society needs and demands, and promote an ethics framework for research and innovation;

(g) take due and proportional precautions in research and innovation activities by anticipating and assessing potential environmental, health and safety impacts;

(h) improve knowledge on science communication in order to improve the quality and effectiveness of interactions between scientists, general media and the public.

PART VI

NON-NUCLEAR DIRECT ACTIONS OF THE JOINT RESEARCH CENTRE (JRC)

The JRC shall contribute to the general objective and priorities of Horizon 2020 by providing scientific and technical support to Union policies, in collaboration with relevant national and regional research stakeholders, where appropriate. The JRC activities will be conducted taking into account relevant initiatives at the level of regions, Member States or the Union, within the perspective of shaping the ERA.

1. EXCELLENT SCIENCE

The JRC will carry out research to enhance the scientific evidence base for policy making and to examine emerging fields of science and technology, including through an exploratory research programme.

2. INDUSTRIAL LEADERSHIP

The JRC will contribute to innovation and competitiveness through:

(a) continuing to contribute to the strategic orientation and science agenda of relevant instruments of indirect research, such as European Innovation Partnerships as well as public-private partnerships and public-public partnerships;

(b) support to knowledge and technology transfer through definition of appropriate intellectual property rights frameworks for different research and innovation instruments, and promotion of cooperation in knowledge and technology transfer among large public research organisations;

(c) contributions to facilitating the use, standardisation and validation of space technologies and data, in particular to tackle the societal challenges.

3. SOCIETAL CHALLENGES

3.1. *Health, demographic change and well-being*

The JRC will contribute to the harmonisation of methods, standards, and practices in support of Union legislation targeting health and consumer protection through:

(a) assessment of risks and opportunities of new technologies and chemicals, including nanomaterials, in food, feed and consumer products; development and validation of harmonised measurement, identification and quantification methods, integrated testing strategies and state-of-the-art tools for toxicological hazard assessment, including alternative methods to animal testing; assessment of health effects of environmental pollution;

(b) development and quality assurance of health testing and screening practices, including genetic testing and cancer screening.

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

The JRC will support the development, implementation and monitoring of European agriculture and fisheries policies, including food security and development of the bioeconomy through:

(a) establishment of a global system and tools for crop forecasting and monitoring of crop productivity; support to improve short- to mid-term outlooks of agricultural commodities, including the predicted effects of climate change;

(b) contribution to biotechnological innovation and improved resource efficiency to produce 'more with less' through techno-economic analyses and modelling;

(c) scenario modelling for decision making in agricultural policies and analyses of policy impact at macro/regional/micro levels; analysis of the impact of the "CAP towards 2020" ([22]) on developing/emerging economies;

(d) further development of methods for fisheries control and enforcement and traceability of fish and fish products; development of robust ecosystem health indicators and bioeconomic modelling to better understand the direct effects (e.g. fishing) and indirect effects (climate change) of human activities on the fish stock dynamics, the marine environment, and their socio-economic impact.

3.3. *Secure, clean and efficient energy*

The JRC will focus on the 20-20-20 climate and energy targets and the Union's transition to a competitive low-carbon economy by 2050 with research on technological and socio-economic aspects of:

(a) security of energy supply, in particular as regards links and interdependencies with the extra-European energy supply and transmission systems; mapping indigenous primary and external energy sources and infrastructures on which Europe depends;

(b) energy/electricity transmission networks, in particular modelling and simulation of trans-European energy networks, analysis of smart/super grid technologies, and real-time simulation of power systems;

(c) energy efficiency, in particular methodologies for monitoring and assessing the achievements of energy efficiency policy instruments, techno-economic analysis of the use of energy-efficient technologies and instruments and of smart grids;

(d) low-carbon technologies (including safety of nuclear energy in the Euratom programme), in particular performance assessment and pre-normative research of prospective low-carbon technologies; analysis and modelling of drivers and barriers of their development and deployment; assessment of renewable resources and bottlenecks, such as critical raw materials, in the supply chain of low-carbon technologies; continuous development of the Information System for the SET-Plan (SETIS) and related activities.

3.4. *Smart, green and integrated transport*

The JRC will support the 2050 goals of a competitive, smart, resource-efficient and integrated transport system for safe and secure transport of people and goods through laboratory studies, modelling and monitoring approaches on:

(a) strategic low-carbon transport technologies for all transport modes, including road transport electrification and alternative fuelled aircrafts/vessels/vehicles, and further development of a Commission internal clearing house for collecting and disseminating information on relevant technologies; availability and costs of non-fossil based fuels and energy sources, including impacts of electrified road transport on electricity grids and electricity generation;

(b) clean and efficient vehicles, in particular definition of harmonised test procedures and assessment of innovative technologies in terms of emissions, conventional and alternative fuel efficiency and safety; developing improved methodologies for emission measurements and environmental pressures calculations; coordinating and harmonising emissions inventorying and monitoring activities at European level;

(c) smart mobility systems to achieve secure, intelligent and integrated mobility, including techno-economic assessment of new transport systems and components, applications for improved traffic management and contribution to the design of an integrated approach to transport demand and management:

(d) integrated transport safety, in particular provision of tools and services for collecting, sharing and analysing incidents and accidents information in the aviation, maritime and land transport sectors; enhancing accidents prevention through analysis and crossmodal safety lessons while contributing to cost savings and efficiency gains.

3.5. *Climate action, environment, resource efficiency and raw materials*

The JRC will contribute to the greening of Europe, security of resource supply and a global sustainable management of natural resources through:

(a) enabling access to interoperable environmental data and information through the further development of standards and interoperability arrangements, geo-spatial tools and innovative information communication technology infrastructures such as the Infrastructure for Spatial Information in the European Union (INSPIRE), and other Union and global initiatives;

(b) measuring and monitoring key environmental variables and assessing the state and change of natural resources by further developing indicators and information systems contributing to environmental infrastructures; assessing ecosystem services, including their valuation and climate change effects;

(c) developing an integrated modelling framework for sustainability assessment based on thematic models such as soil, land use, water, air quality, biodiversity, greenhouse gas emissions, forestry, agriculture, energy and transport, also addressing effects of and responses to climate change;

(d) supporting Union development policy goals by promoting technology transfer, monitoring of essential resources (such as forests, soils, and food supplies), and research to limit the impact of climate change and the environmental impacts of resource use, and to resolve trade-offs in the competition for land as between the production of food or energy and biodiversity;

(e) integrated assessment related to sustainable production and consumption policies, including security of supply of strategic raw materials, resource efficiency, low-carbon and clean production processes and technologies, products and services development, consumption patterns and trade. Further development and integration in policy analyses of Life Cycle Assessment;

(f) integrated impact analysis of options for climate change mitigation and/or adaptation based on the development of a quantitative tool set of models at regional and global scale, ranging from the sectoral to the macro-economic level.

3.6. *Europe in a changing world - Inclusive, innovative and reflective societies*

The JRC will contribute to the goals of the flagship initiative "Innovation Union" and the heading "Global Europe" of the Multiannual Financial Framework for 2014-2020 through the following activities:

(a) comprehensive analyses of drivers and barriers of research and innovation, and development of a modelling platform for the assessment of their micro- and macro-economic impacts;

(b) contributions to the monitoring of the implementation of the flagship initiative "Innovation Union" via scoreboards, development of indicators etc., and operation of a public information and intelligence system to host relevant data and information;

(c) operation of a public information and intelligence platform for assisting national and regional authorities with smart specialisation; quantitative economic analysis of the spatial pattern of economic activity, in particular addressing economic, social and territorial disparities and changes in the pattern in response to technological developments;

(d) econometrics and macro-economic analysis of the reform of the financial system to contribute to maintain an efficient Union framework for financial crisis management; continuing to provide methodological support for monitoring of Member State budget positions in relation to the Stability and Growth Pact;

(e) monitoring the functioning of the ERA and analysing drivers of and barriers to some of its key elements (such as mobility of researchers and opening up of national research programmes) and proposing relevant policy options; continuing to play an important role in the ERA through networking, training, opening its facilities and databases to users in Member States and in candidate and associated countries;

(f) developing quantitative economic analysis of the Digital Economy; carrying out research on the impact of information and communication technologies on the goals of the Digital Society; studying the impact of sensitive security issues on the lives of individuals (Digital Living).

3.7. *Secure societies - Protecting freedom and security of Europe and its citizens*

The JRC will contribute to the goals of the heading "Security and Citizenship" of the Multiannual Financial Framework for 2014-2020 through the following activities:

(a) focusing on identification and assessment of the vulnerability of critical infrastructures (including global navigation systems and financial markets); improvement of tools for fighting fraud against the general budget of the Union and for maritime surveillance; operational performance assessment of technologies for or affecting personal identity (digital identity);

(b) enhancing the Union's capacity for disaster risk reduction and management of natural and man-made disasters notably through the development of global multi-hazard early warning and risk management information systems, making use of Earth observation technologies;

(c) continueing to provide tools for the assessment and management of global security challenges such as terrorism and non-proliferation (chemical, biological, radiological and nuclear (in the Euratom programme)) and threats arising from socio-political instability and communicable diseases; new areas to be addressed include vulnerability and resilience to emerging or hybrid threats, e.g. accessibility to raw materials, piracy, resource scarcity/competition and effects of climate change on occurrence of natural disasters.

4. SPECIFIC IMPLEMENTATION ASPECTS

In line with the priorities of the heading "Global Europe" of the Multiannual Financial Framework for 2014-2020, the JRC will strengthen scientific cooperation with key international organisations and third countries (e.g. UN bodies, OECD, United States, Japan, Russia, China, Brazil, and India) in areas having a strong global dimension such as climate change, food security, or nanotechnologies. This cooperation will be coordinated closely with international cooperation activities of the Union and the Member States.

In order to provide an enhanced service to policy making, the JRC will further develop its capacity to analyse and provide cross-sectoral policy options and to carry out related impact assessments. This capacity will be supported in particular through strengthening of:

(a) modelling in key areas (e.g. energy and transport, agriculture, climate, environment, and economics); the focus will be on both sectoral and integrated models (for sustainability assessments), and it will cover scientific-technical as well as economic aspects;

(b) forward-looking studies which will provide analyses of trends and events in science, technology and society and on how these may affect public policies, influence innovation, and reinforce competitiveness and sustainable growth; this would enable the JRC to draw attention to issues that may require future policy intervention and to anticipate customers' needs.

The JRC will strengthen its support to the standardisation process and standards as a horizontal component in support of European competitiveness. Activities will include pre-normative research, development of reference materials and measurements, and harmonisation of methodologies. Five focal areas have been identified (energy; transport; the flagship initiative "Digital Agenda"; security and safety (including nuclear in the Euratom programme); and consumer protection). Moreover, the JRC will continue to promote dissemination of its results and provide support on the management of intellectual property rights to Union institutions and bodies.

The JRC will establish a capacity in behavioural sciences to support the development of more effective regulation, complementing JRC activities in selected fields such as nutrition, energy efficiency and product policies.

Socio-economic research will be part of the activities in relevant areas such as the flagship initiative "Digital Agenda", sustainable production and consumption or public health.

In order to fulfil its mission as reference centre for the Union, to continue to play a vital role in the ERA, and to enter into new fields of research, it is essential that the JRC disposes of state-of-the-art infrastructure. The JRC will continue its renovation and refurbishment programme to ensure compliance with applicable environmental and safety and security regulations, and it will invest into scientific infrastructure, including the development of modelling platforms, facilities for new areas such as genetic testing, etc. Such investments will be done in close coordination with the roadmap of ESFRI and take into account existing facilities in the Member States.

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(1) Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council of 25 October 2012 on the financial rules applicable to the general budget of the Union and repealing Council Regulation (EC, Euratom) No 1605/2002 (OJ L 298, 26.10.2012, p. 1).

(2) OJ L 75, 22.3.2005, p. 67.

(3) Commission Recommendation on the management of intellectual property in knowledge transfer activities and Code of Practice for universities and other public research organisations (C(2008) 1329, of 10.4.2008).

(4) Decision No 1513/2002/EC of the European Parliament and of the Council of 27 June 2002 concerning the sixth framework programme of the European Community for research, technological development and demonstration activities, contributing to the creation of the European Research Area and to innovation (2002 to 2006) (OJ L 232, 29.8.2002, p. 1).

(5) In principle at least 80 %.

(6) A Regional Partner Facility (RPF) is a research infrastructure of national or regional importance in terms of socio-economic returns, training and attracting researchers and technicians, that is recognised as a partner to a pan-European ESFRI or other world-class research infrastructure. The quality of the RPF, including the level of its scientific service, management and access policy, must meet the same standards required for pan-European research infrastructures.

(7) As all research becomes computer- and data-intensive, access to state-of-the-art e-infrastructures has become essential for all researchers. For example GÉANT connects 40 million users in over 8 000 institutions across 40 countries, whereas the European Grid Infrastructure is the world's largest distributed computing infrastructure with over 290 sites in 50 countries. Relentless progress in ICT and the increasing needs of science for computing and processing massive amounts of data pose major financing and organisational challenges for ensuring seamless services to researchers.

(8) Internet of Things will be coordinated as a cross-cutting issue.

(9) Including space-based networks.

(10) Regulation (EU) No 1303/2013 of the European Parliament and of the Council of 17 December 2013 laying down common provisions on the European Regional Development Fund, the European Social Fund, the Cohesion Fund, the European Agricultural Fund for Rural Development and the European Maritime and Fisheries Fund and laying down general provisions on the European Regional Development Fund, the European Social Fund and the Cohesion Fund and repealing Council Regulation (EC) No 1083/2006 (See page 320 of this Official Journal.).

(11) Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) (OJ L 164, 25.6.2008, p. 19).

(12) Commission Staff Working Document SEC(2009) 1295 accompanying the Communication on "Investing in the Development of Low Carbon Technologies (SET-Plan)" (COM(2009) 519 final).

(13) COM(2007) 723.

(14) Commission White Paper on "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system" (COM(2011) 144 final).

(15) Estimates developed by PricewaterhouseCoopers for "sustainability-related global business opportunities in natural resources (including energy, forestry, food and agriculture, water and metals)" and WBCSD (2010) Vision 2050: The New Agenda for Business, World Business Council for Sustainable Development: Geneva, URL: http://www.wbcsd.org/web/projects/BZrole/Vision2050-FullReport_Final.pdf

(16) COM(2008) 699 final.

(17) European Parliament, Policy Department, Economic and Scientific Policy "Eco-innovation - putting the EU on the path to a resource and energy efficient economy; Study and briefing notes", March 2009.

(18) Eco-innovation Observatory "The Eco-Innovation Challenge - Pathways to a resource-efficient Europe - Annual Report 2010", May 2011.

(19) Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (OJ L 396, 30.12.2006, p. 1).

(20) Without prejudice to the budget allocated to this societal challenge.

(21) COM(2008) 1329 final, 10.4.2008.

(22) COM(2010) 672 final.

ANNEX II

PERFORMANCE INDICATORS

The following table specifies a number of key indicators for assessing the results and impacts of the specific objectives of Horizon 2020. These key indicators may be refined during the implementation of Horizon 2020.

1. PART I. PRIORITY 'EXCELLENT SCIENCE'

Indicators for the specific objectives:

- European Research Council (ERC)
  - Share of publications from ERC-funded projects which are among the top 1 % highly cited per field of science
- Future and Emerging Technologies (FET)
  - Publications in peer-reviewed high impact journals
  - Patent applications and patents awarded in Future and Emerging Technologies
- Marie Skłodowska-Curie actions
  - Cross-sector and cross-country circulation of researchers, including PhD candidates
- Research infrastructures (including eInfrastructures)
  - Number of researchers who have access to research infrastructures through Union support

2. PART II. PRIORITY 'INDUSTRIAL LEADERSHIP'

Indicators for the specific objectives:

— Leadership in enabling and industrial technologies

  — Patent applications and patents awarded in the different enabling and industrial technologies

  — Share of participating firms introducing innovations new to the company or the market (covering the period of the project plus three years)

  — Number of joint public-private publications

— Access to risk finance

  — Total investments mobilised via debt financing and venture capital investments

  — Number of organisations funded and amount of private funds leveraged

— Innovation in SMEs

  — Share of participating SMEs introducing innovations new to the company or the market (covering the period of the project plus three years)

  — Growth and job creation in participating SMEs

3. PART III. PRIORITY 'SOCIETAL CHALLENGES'

Indicators for the specific objectives:

— For all societal challenges:

  — Publications in peer-reviewed high impact journals in the area of the various societal challenges

  — Patent applications and patents awarded in the area of the various societal challenges

  — Number of prototypes and testing activities

  — Number of joint public-private publications

Moreover, for each of the challenges, progress shall be assessed against the contribution to the specific objectives which are detailed in Annex I to Regulation (EU) No 104/2013.

4. PART VI. NON-NUCLEAR DIRECT ACTIONS OF THE JOINT RESEARCH CENTRE (JRC)

Indicators for the specific objective:

— Number of occurrences of tangible specific impacts on European policies resulting from technical and scientific support provided by the JRC

— Number of peer reviewed publications in high impact journals

ANNEX III

MONITORING

The Commission will monitor the implementation of Horizon 2020 and in particular the following:

1. Contribution to the realisation of the ERA
2. Widening participation
3. SMEs' participation
4. Social sciences and humanities
5. Science and society
6. Gender
7. International cooperation
8. Sustainable development and climate change, including information on climate change related expenditure
9. Bridging from discovery to market application
10. Digital Agenda
11. Private sector participation
12. Funding for public-private and public-public partnerships
13. Communication and dissemination
14. Participation patterns of independent experts

ANNEX IV

Information to be provided by the Commission in accordance with Article 9(2)

1. Information on individual projects, enabling the monitoring of the entire lifetime of each proposal, covering in particular:

   — submitted proposals,

   — evaluation results for each proposal,

   — grant agreements,

   — completed projects.

2. Information on the outcome of each call and project implementation, covering in particular:

   — results of each call,

   — outcome of negotiations on grant agreements,

   — project implementation, including payment data and outcome of projects.

3. Information on programme implementation, including relevant information at the level of the framework programme, the specific programme, each specific objective and related themes and the JRC, as well as the synergies with other relevant Union programmes.

4. Information on the execution of the Horizon 2020 budget, including information on commitments and payments for initiatives under Articles 185 and 187 TFEU.

ANNEX V

Programme Committee configurations

List of configurations ([1]) of the Programme Committee in accordance with Article 10(2):

1. Strategic configuration: Strategic overview of the implementation of the whole programme, coherence across the different parts of the programme and cross-cutting issues including the specific objectives "Spreading excellence and widening participation" and "Science with and for society".

Part I — Excellence Science:

2. European Research Council (ERC), Future and Emerging Technologies (FET) and Marie Skłodowska-Curie Actions (MSCA)

3. Research infrastructures

Part II — Industrial Leadership:

4. Information and communication technologies (ICT)

5. Nanotechnologies, Advanced materials, Biotechnology, Advanced manufacturing and processing

6. Space

7. SMEs and Access to risk finance

Part III — Societal Challenges:

8. Health, demographic change and well-being

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

10. Secure, clean and efficient energy

11. Smart, green and integrated transport

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

13. Europe in a changing world – Inclusive, innovative and reflective societies

14. Secure societies – Protecting Freedom and security of Europe and its citizens

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(1) With a view to facilitating the implementation of the programme, for each meeting of the Programme Committee as defined in the agenda, the Commission will reimburse, in accordance with its established guidelines, the expenses of one representative per Member State, as well as one expert/adviser per Member State for those agenda items where a Member State requires specific expertise.