

Draft proposal for a

European Partnership under Horizon Europe

Processes4Planet

Version 17 June 2020

Summary

The partnership aims at circularity and an extensive decarbonisation of European process industries, with a strong focus on competitiveness. Within a cross-sectorial approach, it will develop and deploy the innovations needed for a profound transformation of process industries, e.g., cement, chemical, steel, to achieve the EU Green Deal targets by 2050. Due to their resource and energy-intensive nature, the activities of the partnership will play a crucial role. Process industries will be frontrunners in the transition to carbon neutrality in Europe by 2050, by decreasing greenhouse gas emissions and dependence on fossil fuels while increasing the use of renewable energy sources. With the ultimate goal of zero landfilling and water discharge, circular models will be implemented across industrial sectors, value chains and with regions and cities.

About this draft

In autumn 2019 the Commission services asked potential partners to further elaborate proposals for the candidate European Partnerships identified during the strategic planning of Horizon Europe. These proposals have been developed by potential partners based on common guidance and template, taking into account the initial concepts developed by the Commission and feedback received from Member States during early consultation. The Commission Services have guided revisions during drafting to facilitate alignment with the overall EU political ambition and compliance with the criteria for Partnerships.

This document is a stable draft of the partnership proposal, released for the purpose of ensuring transparency of information on the current status of preparation (including on the process for developing the Strategic Research and Innovation Agenda). As such, it aims to contribute to further collaboration, synergies and alignment between partnership candidates, as well as more broadly with related R&I stakeholders in the EU, and beyond where relevant.

This informal document does not reflect the final views of the Commission, nor pre-empt the formal decision-making (comitology or legislative procedure) on the establishment of European Partnerships.

In the next steps of preparations, the Commission Services will further assess these proposals against the selection criteria for European Partnerships. The final decision on launching a Partnership will depend on progress in their preparation (incl. compliance with selection criteria) and the formal decisions on European Partnerships (linked with the adoption of Strategic Plan, work programmes, and legislative procedures, depending on the form). Key precondition is the existence of an agreed Strategic Research and Innovation Agenda / Roadmap. The launch of a Partnership is also conditional to partners signing up to final, commonly agreed objectives and committing the resources and investments needed from their side to achieve them.

The remaining issues will be addressed in the context of the development of the Strategic Research and Innovation Agendas/ Roadmaps, and as part of the overall policy (notably in the respective legal frameworks). In particular, it is important that all Partnerships further develop their framework of objectives. All Partnerships need to have a well-developed logical framework with concrete objectives and targets and with a set of Key Performance Indicators to monitor achievement of objectives and the resources that are invested.

Aspects related to implementation, programme design, monitoring and evaluation system will be streamlined and harmonised at a later stage across initiatives to ensure compliance with the implementation criteria, comparability across initiatives and to simplify the overall landscape. In case you would like to receive further information about this initiative, please contact:

Lead entity (main contact):

A.SPIRE, Àngels Orduna-Cao, aor@spire2030.eu

Commission services (main contact):

DG R&I, Lucía Fernández Macía Lucia.FERNANDEZ-MACIA@ec.europa.eu

DG GROW, Debby De Roover Debby.DE-ROOVER@ec.europa.eu

Partnership sector in DG R&I (overall policy approach for European Partnerships and its coherent application across initiatives), E-mail: RTD-EUROPEAN-PARTNERSHIPS@ec.europa.eu



Processes⁴Planet

Transforming the European Process Industry for a sustainable society

June 2020

Table of Contents

1. General information	7
1.1. Draft title of the European Partnership	7
1.2. Lead entity (main contact)	7
1.3. Commission services (main contact)	7
1.4. Summary	8
2. Context, objectives, expected impacts	9
2.1. Context and problem definition	9
2.2. Common vision, objectives and expected impacts	21
2.2.1. General, specific and operational objectives	24
2.2.2. Specific objectives and operational objectives	26
2.2.3. Alignments with other R&I Partnerships and Initiatives at EU level	30
2.2.4. Phasing-out strategy	37
2.3. Necessity of a European Partnership	38
2.3.1. Added value of sustainable and competitive process industries: an indispensable industrial base for a resilient European society	39
2.3.2. Processes4Planet: contribution to global and EU political objectives	41
2.3.3. Alignments with Member States and relevant authorities	47
2.4. Partner composition and target groups	51
2.4.1. Type and composition of partners	51
2.4.2. International dimension	54
3. Planned implementation	55
3.1. Activities	55
3.1.1. Co-Programming For R&I Implementation	56
3.1.2. Supporting Pathways To Impact	68
3.2. Resources	74
3.3. Governance	80
3.4. Openness and transparency	85
4. ANNEXES	88
4.1. Links of Processes4Planet Roadmap Innovation Programmes to Horizon Europe Intervention Areas	88
4.2. Proposed KPIs	91
4.3. Process to develop the Processes4Planet Roadmap	92
4.4. A.SPIRE Members & Stakeholders involved in the Processes4Planet Roadmap	93
4.4.1. Participation in RoadmapEvents	93
4.4.2. A.SPIRE Members' In-Kind Contribution	93
4.4.3. Stakeholders and Members involved in the creation of roadmap	94
4.5. Evolution of A.SPIRE membership from 2012 to 2020	95
4.5.1. A.SPIRE Founding Members	95
4.6. Abbreviations	96
4.7. Glossary	98
4.8. Bibliography	100

List of Graphs

Graph 1: The European Green Deal	9
Graph 2: Breakdown of direct and electricity CO ₂ emissions of the P4Planet sectors'.....	12
Graph 3: Waste generation in the EU-28 (including the United Kingdom).....	14
Graph 4: Processes4Planet / problems and problem drivers	19
Graph 5: Tree of problems, problem drivers and objectives of Processes4Planet (General, specific and operational objectives).....	24
Graph 6: Specific, operational objectives and Key Performance Indicators for the co-programming partnership	28
Graph 7: Processes4Planet and other EU R&I Partnerships and Initiatives	31
Graph 8: Technological Investment needs for P4Planet's innovation pipeline	37
Graph 9: GDP contribution and direct employment of Processes4Planet sectors (figures 2015, EU-28)	40
Graph 10: Geographical overview of national framework climate laws in Europe (by the end of 2019).....	48
Graph 11: Implementation activities of the co-programmed partnership P4Planet	56
Graph 12: Energy flows of the process industries in 2050.....	57
Graph 13: Resources flows of the process industries in 2050	58
Graph 14: The portfolios of impact, a co-programming tool	62
Graph 15: Links between Processes4Planet's objectives and Horizon Europe structure	64
Graph 16: Main direct links between Processes4Planet's objectives and Intervention Areas of Horizon Europe	65
Graph 17: Potential instruments for innovation development and H4Cs co-investments.....	66
Graph 18: Working Groups/Taskforces of Processes4Planet (subject to adaptations)	77
Graph 19: Governance model of Processes4Planet co-programming partnership	80

List of Tables

Table 1 Key problems and general objectives of the partnership	25
Table 2: specific and operational objectives of the co-programming partnership	27
Table 3 KPIs, progress level by 2024, objectives by 2030	29
Table 4 Links between Processes4Planet and other EU Partnerships & Initiatives addressing material and energy resources	32
Table 5 Links between Processes4Planet and other EU Partnerships mid-stream the circular value chain	33
Table 6 Links between Processes4Planet and other EU Partnerships (Customers).....	34
Table 7 Links between Processes4Planet and cross-cutting and enabling EU Partnerships and Initiatives	35
Table 8 Total investments for all Processes4Planet innovation programmes and estimated public funding in EUR million	36
Table 9 Contribution of Processes4Planet to the achievement of global policies' objectives (qualitative assessment)	41
Table 10 Contribution of Processes4Planet to the achievement of EU policies' objectives (qualitative assessment)	44
Table 11 Contribution of Processes4Planet to the achievement of other EU regulations (qualitative assessment)	45
Table 12 Non-exhaustive list of national (or regional) legislations on climate and circularity (10 April 2020, Processes4Planet).....	50
Table 13 Target groups for Processes4Planet communication	53
Table 14 Innovation Areas to develop P4Planet's Specific Objectives.....	57
Table 15 P4Planet's Innovation Areas and Programmes. Expected milestones	61
Table 16 Investments needed to develop P4Planet's innovations up to 2030.....	76

1. General information

1.1. Draft title of the European Partnership

Draft title: Processes4Planet

Subtitle (tagline): Transforming the European Process Industry for a sustainable society

Processes4Planet, the proposed name for the new partnership, was selected following a consultation with the members of A.SPIRE and other stakeholders. We aimed at a name that reflects the values, vision and mission of the partnership.

A call for potential names was launched to our members in 2019, resulting in a long list of fresh ideas. We then shortlisted several names that set a clear forward-looking approach for the partnership; maintained the spirit of the process industries as well as connecting to society and the planet. The shortlisted names were further discussed, validated and voted on by the A.SPIRE's Board of Directors. The most popular name, Processes4Planet, was considered to best reflect SPIRE's Vision 2050 for a carbon-neutral, circular and competitive process industry.

Processes4Planet portrays a partnership where the planet is at the core and propels the industry to foster a sustainable planet. It pictures an industry that is ready to transform and transition its processes forward as innovation and circular economy drives the process industries into achieving a climate-neutral economy and society.

1.2. Lead entity (main contact)

A.SPIRE aisbl

Rue Belliard 40 Bte 21

B-1000 Brussels

Tel: + 32 (0)2 436 96 14

E-mail: info@spire2030.eu

Main contact: Angels Orduña, Executive Director, e-mail: aor@spire2030.eu

1.3. Commission services (main contact)

DG R&I

Espace ORBAN

Square Frère-Orban 8

1000 Brussels

Tel : +32 22956625

Main contact: Lucía Fernández Macía, Policy Officer – Sustainable Industry Systems (R&I F.3), e-mail:

Lucia.FERNANDEZ-MACIA@ec.europa.eu

DG GROW

Breydel Building (BREY)

Avenue d'Auderghem 45

1040 Brussels

Tel : +3222953823

Main contact: Debby De Roover, Policy Officer – Resource Efficiency and Raw Materials (GROW C.2), e-mail:

Debby.DE-ROOVER@ec.europa.eu

1.4. Summary

The **European Green Deal is a game changer** for our society and more specifically for the process industries. These industries produce materials which directly contribute to the quality of life of citizens and **are essential to most of the value chains of our economy**. Their presence on European territory is of strategic importance for the **resilience of our society to unexpected events and crises**. They represent around 5% of the EU GDP, 6.3 million direct employees, and 19 million indirect employees.

Processes4Planet is a unique cross-sectorial R&I partnership, gathering process industry companies and sector associations (chemicals, steel, cement, minerals and ores, ceramics, non-ferrous metals engineering, and water), small and medium-sized enterprises, research and technology organisations, NGOs, regions, and others.

In full consistency with the New Industrial Strategy for Europe, **Processes4Planet aims at developing and deploying the innovations we need for a profound transformation of the European process industries to make them circular and achieve overall climate neutrality at EU level by 2050, while enhancing their global competitiveness**. The innovations will have an integrated approach on climate and environmental issues.

Through cross-sectorial technological and non-technological innovation efforts, Processes4Planet will achieve three **general objectives**:

- Developing and deploying **climate-neutral solutions**,
- Closing the **energy and feedstock loops**,
- Achieving a **global leadership in climate-neutral and circular solutions**, accelerating innovation and **unlocking public and private investment** (competitiveness).

Processes4Planet will work on emerging technologies and on the scaling up of technologies already developed at higher TRLs to deliver expected CO₂ emission reductions by 2030 and to achieve its full impact by 2050. Processes4Planet will implement its cross-sectorial R&I roadmap based on **four transformation levers**:

- Process innovation, with four core drivers: energy mix (including H₂), energy and resources flexibility/efficiency, electrification of industrial processes and Carbon Capture and Use (CO₂),
- Industrial-urban symbiosis,
- Digitalisation,
- Non-technological innovation.

14 Innovation Areas and 36 Innovation Programmes moving from TRL 1 to 9 have been identified (or from SRL1¹ to 9 for Industrial-Urban Symbiosis). A special focus of the partnership will be fostering local innovation initiatives, so-called “**Hubs for Circularity**” where local public authorities, process industries and other private actors will, together, design and implement integrated business models maximizing the circularity of resources and minimizing impacts on climate. The partnership will also scale-up innovations to industrial dimension through “**first-of-a-kind**” plants (or “**Marbles**”), de-risking investment decisions for subsequent roll-out. The potential of **digital technologies** and of **social innovation** will be fully exploited. Recommendations will be made on **(potentially) required changes in regulations and incentives** to enable industrial-scale deployment and market uptake.

The Processes4Planet’s projects will work through Horizon Europe (HEU) calls and will use a blended finance approach to mobilise funding beyond HEU (notably for high TRLs). A **pro-active and continuous engagement** with Member States, Regions, other R&I Partnerships and Initiatives and other relevant stakeholders is crucial to generate change. Related mechanisms are described in this guidance document (notably the future “Impact Panel” and “Feed-back Panel”), as well as the planned activities and resources to deliver expected impacts on planet and society.

¹ Symbiosis Readiness levels

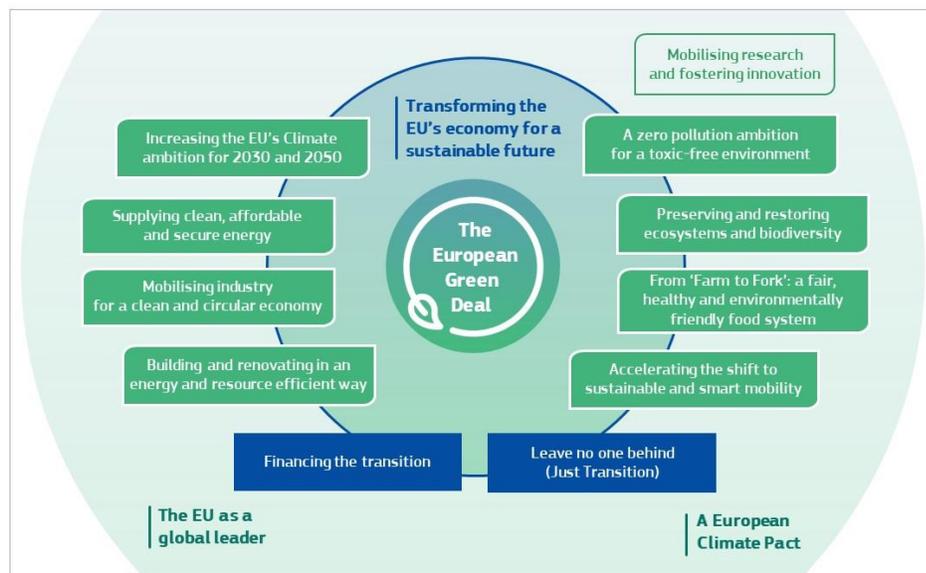
2. Context, objectives, expected impacts

2.1. Context and problem definition

The European Green Deal (European Commission, 2019) is a **game changer for our society at large, and for the European process industries² in particular**. It aims notably to cut CO₂ equivalent emissions by 50-55% by 2030³ and to transform Europe into the first climate-neutral continent by 2050. An **unprecedented transformation of production and consumption practices** must be deployed at scale over less than 30 years.

The European process industries are collectively at the forefront in this transformation. They produce materials which directly contribute to the quality of life of all citizens⁴. They are an integral part of most of the value chains of the European economy. Their presence on European territory ensures the independence and sovereignty of Europe in the production of essential materials and goods. The President of the European Commission stated in her Political Guidelines for the new EU Commission that: “We will work to decarbonise energy-intensive industries. We will be a world leader in circular economy and clean technologies”.

The EU Green Deal confronts the European process industries with very specific challenges which will not be solved by business-as-usual solutions and incremental improvements. **Disruptive technological and non-technological innovations are required**.



Graph 1: The European Green Deal⁵

² Processes4Planet brings together individual companies and European sector associations in the following sectors: cement, ceramics, chemicals, engineering, minerals and ores, non-ferrous metals, steel, and water. Other sectors (companies and associations) will join the partnership over the next few months.

³ Compared to a 40% reduction target by 2030 in the “2030 Climate and Energy Framework” released in 2014 (Communication from the Commission, A policy framework for climate and energy in the period from 2020 to 2030, COM/2014/015 final).

⁴ These materials and goods enable individuals to live in safe and resilient housing, to enjoy a broad range of mobility services, reliable energy production and supply, efficient healthcare and communication services (as well as many other elements of our daily life).

⁵ COM (2019) 640, The European Green Deal, 11 December 2019.

The recently released “**New Industrial Strategy for Europe**”⁶ is very clear in its ambition and in the recommended way forward:

- “Energy-intensive industries are indispensable to Europe’s economy and are relied on by other sectors. Modernising and decarbonising⁷ energy-intensive industries must therefore be a top priority”.
- “Industrial sectors should be invited and incentivised to define their own roadmaps for climate neutrality or digital leadership. These should be enabled by high quality research and skills and supported by the EU. A number of sectors have already taken this approach since the launch of the European Green Deal. In the co-design and entrepreneurial spirit of this strategy, this should be supported through **Public Private Partnerships to help industry develop the technologies to meet their goals**, as has successfully been done in industrial alliances”.

The Processes4Planet Partnership is the answer to this call for action. It will be an essential tool to deliver the innovations we need. It will build on the achievements of SPIRE, the European contractual public-private partnership which aims to enhance resource and energy efficiency in the process industries. But it will represent a **paradigm shift** as it greatly raises the level of ambition by embracing the transformational objectives of the European Union (climate neutrality, circularity, competitiveness).

The overall ambition is not only to transform the operations of the European process industries but also to achieve impact beyond the fences of production plants in Europe. Process industries are indeed massive users of resources and energy. By moving towards the use of upgraded⁸ secondary resources and of renewable energy, they have a unique ability to create a demand at scale and put more pressure on the deployment of affordable climate-neutral energy production and of waste management processes all over Europe. In this respect, Processes4Planet innovations will also play an important role in connection with the new **Circular Economy Action Plan**⁹.

The COVID-19 crisis has led to a much higher awareness of the **strategic importance of retaining entire value chains in Europe**. Process industries are an integral part of all of these strategic value chains. Their presence on European territory strengthens the independence and resilience of our society to unexpected events or crises as it guarantees access to essential products and services to European citizens.

On the other hand, the economic shock resulting from the COVID-19 crisis has very severe economic consequences on individual companies, regions and countries. This could obviously reduce the availability of resources to address medium- to long-term challenges.

Boosting economic growth after the coronavirus lockdown does not mean that green objectives must be sidelined. The coronavirus shutdown should signal a natural swerve in the direction of cleantech and renewables. A green reboot of our economies requires successful innovation, a renewed attractiveness of scientific and technological areas for young people, and an enabling regulatory framework.

Processes4Planet addresses **three interlinked problems that are specific to the process industries**. These problems are described below, as well as the key problem drivers behind each of them.

⁶ Communication from the Commission, A New Industrial Strategy for Europe, COM (2020) 102 final.

⁷ The wording of “decarbonisation” cannot strictly be applied to the chemical industry, as nearly all chemicals contain carbon or are made using carbon (notably organic chemistry compounds and the reduction of ores). In this document, we will give preference to the wording “transition to climate neutrality” which is relevant for all process industry sectors.

⁸ Secondary resources will most often require to be upgraded to fit technical specifications for feedstock in industrial processes. The “upgrading” processes for secondary resources are an essential part of the Processes4Planet R&I roadmap. In this document “recycling” will often refer to the upgrading of secondary or waste-derived resources.

⁹ COM (2020) 98 final, A New Circular Action Plan for a cleaner and more competitive Europe, 11 March 2020.



HIGH IMPACT ON CLIMATE

Process industries are today large CO₂ point source emitters and face major technology and economical gaps to achieve the 2050 target of overall climate neutrality

Even if the European process industries achieved remarkable progress over the past decades and if their products increasingly contribute to mitigating CO₂ emissions from society¹⁰, their own industrial operations still have a **high impact on climate through their greenhouse gas (GHG) emissions**.

Climate problem drivers

- **Dependency on fossil fuels:** the EU process industries are still very dependent on fossil resources. Fossil fuels (coal, oil fuel, gas and other fractions from the petroleum refinery process) are today directly being used as main energy resources in many production processes. Process industries also make use of fossil resources for their feedstock requirements in several cases.
- **Indirect emissions (energy sector):** regarding indirect emissions¹¹, process industries do not hold all the cards. The availability and stability of supply of affordable climate-neutral electricity is essentially under the control of the energy supply sector and changes over time. But process industries do have a crucial role to play, as their transition towards climate neutrality will require massive (additional) amounts of competitive renewable electricity as well as technologies that can use new energy carriers (e.g. hydrogen). The reuse, recycling or recovery of waste as resources for production processes will also increase demand for affordable climate-neutral energy.
- **Process CO₂eq emissions:** CO₂eq emissions from process industries are not only related to the combustion of fuels but also in several sectors to other chemical transformations occurring during the production processes. These “process” emissions cannot be significantly reduced only by improving energy efficiency or moving to renewable energy sources.
- The use of climate-neutral technologies is also most often less economically attractive today than traditional production technologies. The affordability of climate neutral and circular solutions is a transversal problem driver addressed later in this chapter.

Facts and figures

In 2015, the Energy Intensive Industries¹² represented **15% of total direct CO₂eq emissions** in the EU¹³.

- 90% of industry’s direct emissions consist of CO₂.
- Half of the industry’s emissions result from the manufacture of the four industrial commodities: ammonia, cement, ethylene and steel.

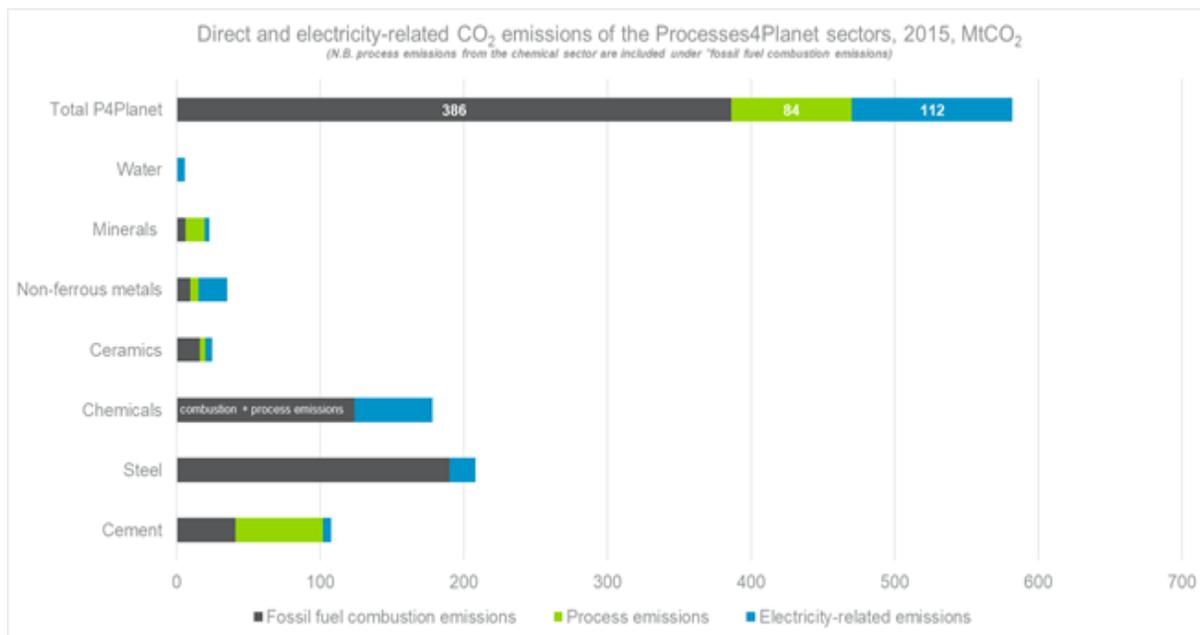
Historical evolution: between 1990 and 2015, the Energy Intensive Industries (EII’s) have reduced their CO₂eq emissions by 36% and accounted for 28% of the total economy-wide emission reductions in the EU.

¹⁰ The progress in direct industrial emissions was essentially achieved through the deployment of already validated techniques or technologies. Further progress will require disruptive technologies as well as stronger cooperation across sectors and along value chains.

¹¹ The level of electrification in process industries remains relatively low, but should increase strongly to deliver on the climate-neutrality objective by 2050.

¹² The iron and steel, cement, chemicals and fertilisers, refineries, non-ferrous metals, ferro-alloys and silicon, pulp and paper, ceramics, lime, and glass industries belong to the Energy Intensive Industries (EIIs) following the EU’s definition. All Energy Intensive Industries are not yet represented in Processes4Planet. Discussions are however ongoing to integrate additional sectors.

¹³ Analytical report on the Strategic Value Chain on low CO₂ industry / Second revised version.



Graph 2: Breakdown of direct and electricity CO₂ emissions of the P4Planet sectors^{14,15}

The Processes4Planet sectors collectively account for around **470 Mt CO₂ of direct emissions in the EU-28, and 112 Mt CO₂ of emissions from purchased electricity¹⁶.**



LINEAR BUSINESS MODELS

Process industries use large amounts of primary material and energy resources; closing the material loops is not in many cases yet technically and/or economically feasible at scale

The growing world population and increasing individual living standards result in a massive demand increase for materials, leading to a comparable increase in the **demand for energy and material resources**. **Access to resources is a strategic security question for Europe's ambition to deliver the Green Deal**. Ensuring the supply of sustainable raw materials (notably, for example, critical raw materials necessary for clean technologies, digital technologies, and biomass resources) by diversifying supply from both primary and secondary sources is one of the pre-requisites to make the transition to a climate-neutral and circular economy happen¹⁷. In the recently released **EU Circular Economy Action Plan¹⁸**, "high impact intermediary products such as steel, cement and chemicals" are some of the product groups identified as priorities for the upcoming sustainable product policy initiative from the EU Commission.

The overall business model of many value chains in which process industries operate is still very much linear: from the sourcing of (mainly) non-renewable natural resources to the disposal of final waste¹⁹.

¹⁴ These figures relate to total CO₂ emissions of the Processes4Planet sectors in the EU 28 (including the United Kingdom).

¹⁵ This graph does not fully represent the extent of process emissions as, for chemicals, process emissions are included under "fossil fuel combustion emissions".

¹⁶ P4Planet Roadmap. Data sources: VUB/IES, Eurostat, EEA, Material Economics, GCCA/CEMBUREAU, CEFIC, Cerame-Unie, EuLA.

¹⁷ COM (2019) 640, The European Green Deal, 11 December 2019, page 8.

¹⁸ COM (2020) 98 final, A New Circular Action Plan for a cleaner and more competitive Europe, 11 March 2020, page 4.

¹⁹ Despite recycling being already very well implemented in specific value chains, in particular for metals. Recycled metal is a today a significant source in Europe (20 to 50% depending on the metal).

Circularity problem drivers

- **Insufficient eco-design approach:** while materials, goods and products are designed for their functionality taking into account their environmental impact, a “circular-by-design” approach should be further implemented in an iterative approach with the development of recycling technologies. As stated in the EU Circular Economy Action Plan, “many products break down too quickly, cannot be easily reused, repaired or recycled, and many are made for single use only”. A smarter design of products will require a very intense collaboration between all actors across the many value chains in which process industries operate. Process industries have an important role to play by developing “circular-by-design” materials in close cooperation with manufacturing industries, recycling technology providers and contractors and by promoting industrial symbiosis.
- **Availability and suitability of secondary materials:** the availability and quality of secondary resources are insufficient. Waste collection/sorting/reconditioning/processing/re-use/recycling/recovery technologies and business models are today inappropriate to ensure that secondary resources are made available in quantities and qualities which fulfil the specifications required by industrial processes. Industrial processes are today not flexible enough to deliver sufficient and/or stable yields with more complex and fluctuating material feeds.
- **Use of secondary resources less economically attractive:** the collection, transport, processing and use of secondary resources is still in many cases less economically attractive than the use of primary resources (in many cases unaffordable).

Water is a crucial resource for the process industries, to which the circularity concept also needs to be applied. This requires innovative technologies (notably green and digital) to deliver a step change in water efficiency, recycling and security, to recover nutrients and other resources, to allow the industrial sector to access to the right quantity and quality of water, and gradually reduce down to zero the discharges.

Facts and figures

According to the International Resource Panel, the **annual global extraction of materials tripled from 1970 to 2017 and continues to grow**²⁰, posing a major global risk.

There is only one planet Earth. Yet, according to the United Nations, should the global population reach 9.6 billion by 2050, **the equivalent of almost three planets** could be required to provide the natural resources needed to sustain current lifestyles²¹.

The World Bank predicts that the global consumption of materials such as biomass, metals and minerals will double in the next forty years^{22,23}, while annual waste generation is projected to increase by 70% by 2050²⁴.

Half of total greenhouse gas emissions and more than 90% of biodiversity loss and water stress come from resource extraction and processing.

Up to 80% of products’ environmental impacts are determined at the design phase²⁵.

Recycling rates and use of recycled materials in the European Union are steadily, but slowly, growing²⁶:

²⁰ Global Resources Outlook 2019: Natural Resources for the Future We Want: The International Resource Panel.

²¹ <https://www.un.org/sustainabledevelopment/sustainable-consumption-production/>

²² These figures should be considered with caution as models related to future material consumption towards 2050 show strong variation in their forecasts (from less than doubling to high multiplication factors compared to today).

²³ OECD (2018), Global Material Resources Outlook to 2060.

²⁴ World Bank (2018), What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.

²⁵ <https://op.europa.eu/en/publication-detail/-/publication/4d42d597-4f92-4498-8e1d-857cc157e6db>

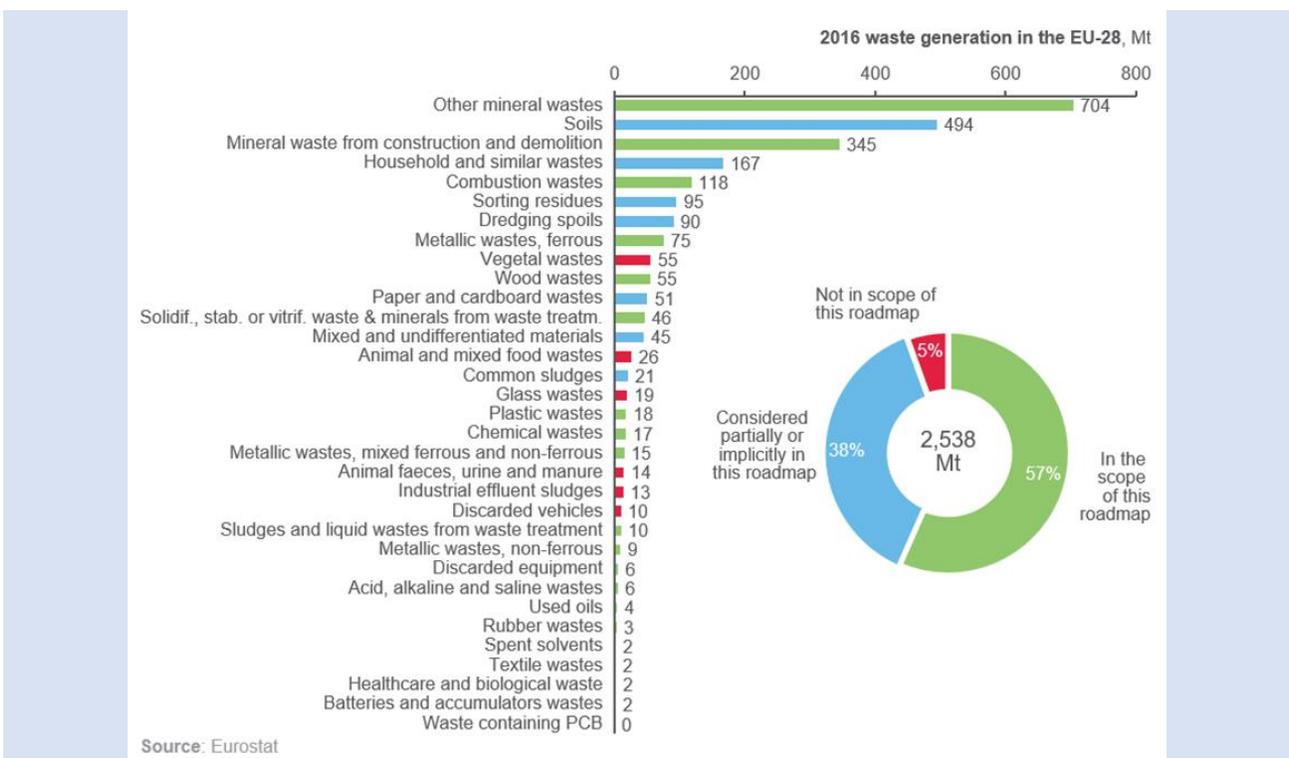
²⁶ In this Guidance Document, “recycling” is a general wording which can include upcycling (conversion of discarded materials into something of equal or greater value) and downcycling (conversion into something of lesser value).

- Overall, the **EU recycled around 55% of all waste** excluding major mineral waste in 2016 (compared with 53% in 2010)²⁷.

- However, the **circular material use rate²⁸** remains at a very low level: only **12% of material resources used in the EU in 2016** came from recycled products and recovered materials^{29,30}.

At global level, according to the Circularity Gap Report 2020 of the CGRi³¹, of all the minerals, fossil fuels, metals and biomass that enter the world economy each year, just 8.6% are cycled back. This has fallen from 9.1% reported in the 2018 Report.

The innovation areas and programmes of the Processes4Planet roadmap offer potential solutions for most of the waste streams and volumes generated in the European Union, as illustrated in Graph 3. Due to its massive demand for resources, the European process industries have a unique potential to implement circular business models at an unprecedented scale.



Graph 3: Waste generation in the EU-28 (including the United Kingdom)

²⁷ The rate for recovering construction and demolition waste reached 89% (2016), the recycling rate of packaging waste exceeded 67% (2016, compared with 64% in 2010) while the rate of plastic packaging recycling was over 42% (2016, compared with 24% in 2005). The recycling rate for municipal waste stood at 46% (2017, compared with 35% in 2007) and for electrical and electronic equipment waste, such as computers, televisions, fridges and mobile phones that include valuable materials which can be recovered (e-waste), the EU reached 41% (2016, compared with 28% in 2010).

²⁸ Circular material use rate, calculation method 2018 edition, Eurostat, 2018.

²⁹ Eurostat, "Circular Economy in the EU", 39/2019, 4 March 2019.

³⁰ The remaining potential for improvement of this rate is huge, even if it is limited by the shortage of recycled and recovered materials versus current needs of our economies (even in case of full recycling/recovery; notably the case in the building sector).

³¹ Circularity Gap Report 2020, CGRi, www.circularity-gap.world/

GLOBAL COMPETITION AND LEVEL OF INVESTMENT



European process industries are highly exposed to global competition

Massive investments are needed in a very short period of time (compared to traditional investment cycles of process industries)

Retaining competitiveness is a growing challenge for European process industries to avoid the risk of industrial production capacities relocating to other continents. The ongoing COVID-19 crisis clearly shows the strategic importance for Europe not only to retain, but to **re-build industrial capacity on its own territory**. The operations of process industries in Europe ensure EU independence and sovereignty, sustain entire value chains in and across our regions and give access to quality jobs for workers over a range of qualification levels.

Process industries are by nature capital intensive sectors³². The threshold for investment is much higher and the investment cycles are much longer than in other sectors³³. It is estimated **that process industries only have, at maximum, two rounds of investment before 2050** (only one round of investment for many large-scale units).

Process industries will therefore only be able to transition towards overall climate-neutrality and circularity (and to become climate and resource frontrunners deploying first commercial applications of technologies by 2030³⁴) if a **very reliable investment scheme over the next 30 years and an appropriate and consistent regulatory framework** can be quickly identified and implemented.

This investment agenda must include currently emerging technologies aiming at full climate neutrality and circularity as well as the deployment of technologies already developed at higher TRLs / SRLs (to deliver expected emission reductions by 2030).

Competitiveness problem drivers

- **Massive investments needed in R&I and full-scale deployment (private and public funding):** the required investments in research and innovation are massive and investments required for full-scale deployment of innovative (climate-neutral, circular, competitive) technologies over such a short period of time are unprecedented (CAPEX). All public and private funding options must be considered to address this challenge. The impact on OPEX should not be underestimated, as this impacts the global competitiveness of European process industries. Preliminary estimates of required investments for all Process4Planet's Innovation Programmes are presented under section 2.2 of this Guidance Document.
- **Need to de-risk investments through first-of-a-kind demonstrators:** the development of reliable technological solutions will require long periods of time as well as large-scale demonstrators which will de-risk investment decisions for the roll-out of newly developed technologies.

³² The term "capital intensive" refers to business processes or industries that require large amounts of investment to produce a good or service and thus have a high percentage of fixed assets, such as property, plant, and equipment (PP&E). Companies in capital-intensive industries are often marked by high levels of depreciation. Capital-intensive industries need to mobilise massive financial resources from capital markets and need a high volume of production to provide an adequate return on investment.

³³ Newly built or revamped production facilities are usually amortised over long operating periods of several decades.

³⁴ COM(2019) 640, The European Green Deal, 11 December 2019, page 8; Masterplan for a Competitive Transformation of EU Energy-intensive Industries / Enabling a Climate-neutral, Circular Economy by 2050 (High-Level Group on Energy-intensive Industries, 2019), p. 37.

Facts and figures

Over the past decade, the global market share of many European process industries has been decreasing, as have production levels in Europe.

In the context of the EU Emission Trading Scheme, many EU Process Industries have been identified by the European Commission to be at **competitive risk from carbon leakage**. These companies are supported by specific mechanisms to maintain their competitiveness (for instance by free allocation of greenhouse gas allowances).

The total investment needed in research & innovation is estimated to amount to around **EUR 33.8 billion up to 2050** of which it is considered at least EUR 19.8 billion is needed during the period 2020-2030. The leverage ratio is considered to be well above 10 considering the scale up to TRL9³⁵ (see section 2.2. of this Guidance Document).

In its report “**Industrial Value Chain – A Bridge towards a Carbon-neutral Europe**”, the Institute for European Studies (VUB, Brussels) gives an overview of additional CAPEX required for the roll out of new technologies for a selection of low-carbon roadmaps or pathways for industrial sectors (at EU and national levels).³⁶

A few examples are given below:

- For Germany alone (all industrial sectors), the industrial transition for a -95% climate path would require **EUR 230 billion**³⁷,
- For the European chemical sector alone, **a total CAPEX of EUR 672 billion** would be required in their ambitious scenario for 2050³⁸,
- The EU Ceramic Industry Roadmap foresees **EUR 130 billion CAPEX by 2050** in its scenario 2 (90 + 40 for writing off plants)³⁹.

The report also insists on the strategic relationship between OPEX and CAPEX: high CAPEX investments in new processes with a significantly higher OPEX compared to (international) competitors will likely not happen. “Therefore, future EU R&D [...] will have to focus on enabling low-CO₂ technologies to deliver OPEX that is competitive with conventional production technologies.”

³⁵ The real ratio will vary depending on the total funding allocated to the Processes4Planet co-programming partnership and to the level of support provided to scale up the innovations to TRL9 across different programmes.

³⁶ Industrial Value Chain – A Bridge towards a Carbon-neutral Europe, Institute for European Studies (IES), 7 September 2018, page 65. https://www.ies.be/files/Industrial_Value_Chain_25sept_0.pdf

³⁷ Klimapfade für Deutschland, BCG and Prognos, 2018, p. 165 | Reference scenario: -61%, CAPEX n.a. Assumptions for reference scenario: approx. 50% GDP growth by 2050.

³⁸ Low carbon energy and feedstock for the European Chemical Industry. For Business as usual (BAU): +119 MtCO₂ (an increase proportional to production volume. Savings from efficiency measures not included), CAPEX EUR 80.5 billion. Assumptions: increased demand for low carbon power, increased demand for CO₂ as feedstock, increased demand for biomass as feedstock, extensive additional investments, 1% growth per annum for the EU chemical industry. In BAU scenario: the power sector does not show further progress in decarbonisation.

³⁹ The European Ceramic Industry Roadmap: paving the way to 2050. Scenario 1: -65%, CAPEX n.a. Assumptions: energy costs 2.5x current rate, costs of biogas 2-3x that of natural gas, rising cost of raw materials from Asia, constant level of production with a similar product mix, barriers regarding alternative fuels are overcome and regulators treat syngas and biogas as producing net-zero emissions.

Cross-cutting problem drivers

In addition to all the above mentioned drivers under each of the three identified problems, process industries are facing three additional drivers which contribute to the climate, circularity and competitiveness issues they are facing:

- **Limited level of digitalisation of the industry:** European process industries have not yet exploited to its full extent the potential of digital technologies in terms of improvement of resource efficiency and productivity. Process industry sectors are relatively less digitalised than service industries and advanced manufacturing industries⁴⁰. Over the next few years, it is essential that data of process industry and related value chains remain under European control and are not controlled by global digital platforms; this represents a clear opportunity for enhanced collaboration with European digital technology SMEs and start-ups.
- **Need for more of industrial competitiveness, lack of a level-playing field:** European process industries are currently confronted by an issue of competitiveness, notably due to access to affordable climate-neutral energy and to the absence of a level-playing field with non-European competitors in terms of carbon pricing. These two issues limit their current ability to transition to climate-neutral solutions.
 - **The markets served by process industries are global.** The potential level of differentiation between produced materials is limited as many process industries are mainly active in global commodities' markets⁴¹. The competition between local producers and importers is most often purely a competition on cost. European process industries are exposed to competition from other areas of the world where environmental as well as social policies may be less stringent and ambitious, which can lead to an uneven playing field and a competitive disadvantage from a purely financial perspective. This disadvantage can also result from relatively higher energy costs and from growing costs of acquisition of CO₂ allowances if measures are not taken to establish a level-playing field with importers of non- (or less-) carbon constrained regions. It can also result from higher operational costs linked to carbon-neutral and circular technologies⁴².
 - The challenge of process industries is not only to bring sustainable, low emission and circular products on the market. It is to make sustainability affordable to manufacturing industries and consumers. **The challenge is to produce sustainable materials which are economically competitive on the global market.**

We also include under this problem driver the following transversal issues:

- **Market uptake of “climate-neutral and circular” materials and goods:**
 - **Social awareness and acceptance:** materials and goods produced from secondary resources are not yet universally accepted by customers. In some cases, they still suffer from a negative image, mainly related to health concerns of end users. Reassurance must be provided to end users, namely by enhancing transparency through full traceability of materials (supported by digital technologies) and by giving access to reliable and validated information for consumers or final users.
 - **Affordability:** climate neutral and circular solutions should be affordable for manufacturing downstream industries.
 - **Regulations and standards:** conservative or composition-based standards, norms and codes can represent a hurdle to the fast deployment of innovation. However, appropriate regulations and

⁴⁰ <https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/imagining-constructions-digital-future>

⁴¹ This is however not valid for all process industry sectors. The chemical industry is also active in global specialty chemicals markets.

⁴² For example, this is the case for carbon capture and use technologies, which will significantly increase total energy consumption.

standards based on targeted performance can encourage implementation of innovative technologies. Green public procurement can also help make a real difference in some instances.

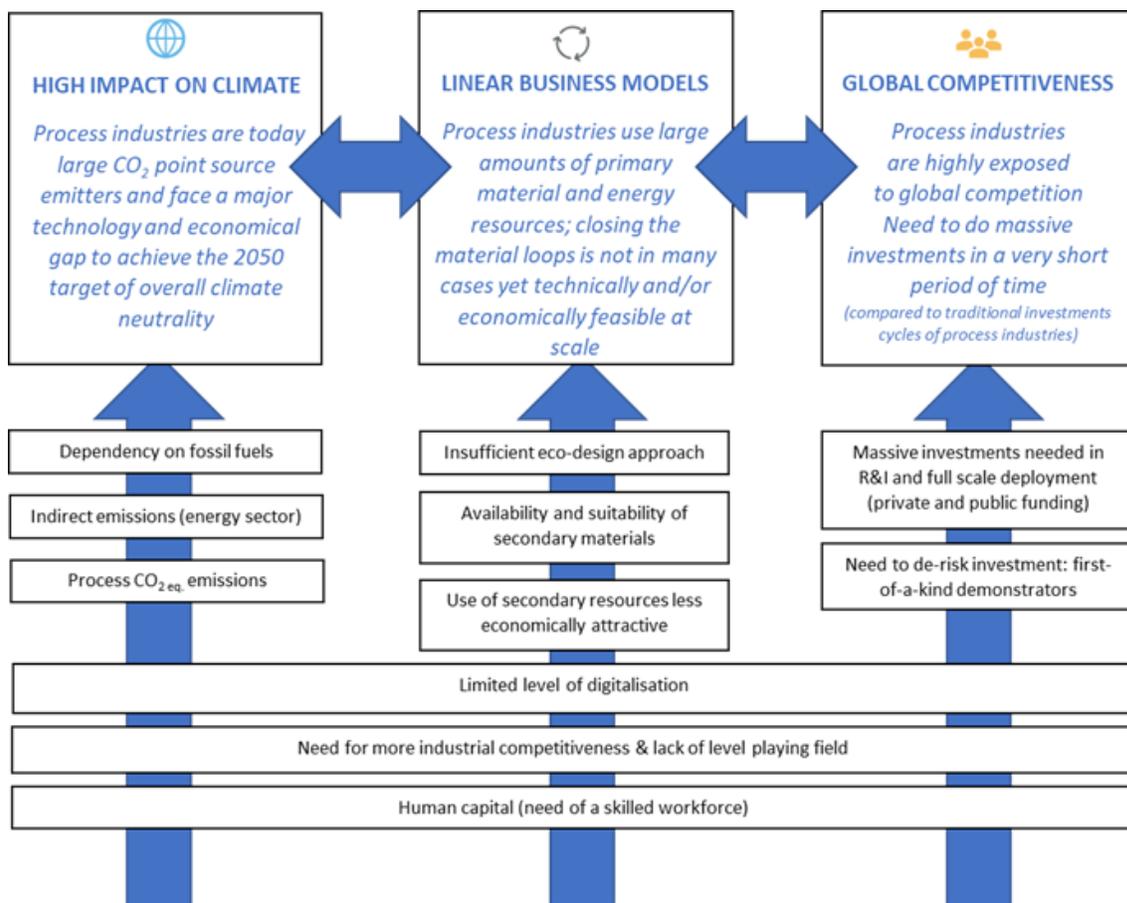
- **Lack of integration (within value chains, across sectors and with society and public authorities):**
 - **Numerous and fragmented value chains:** materials produced by the European process industries are being used in a very large number of value chains. Process industries supply almost all sectors of the economy: they provide inputs to a broad range of sectors, resulting in the commercialisation of tens of thousands of consumer products. The following critical value chains can be mentioned: buildings and construction, electronics and ICT, machinery, batteries, vehicles, transportation (land, water, air), textiles, plastics, packaging, food, water and nutrients, waste treatment, energy and renewables (production, transport, storage), medical and health sector, hygiene, communication, defence, air emission mitigation, waste water treatment and other environmental services.

These value chains most often exhibit a high level of fragmentation (i.e. a high number of individual economic players) from the sourcing of (natural) raw materials to the delivery to the end user. An efficient action on the overall CO₂ footprint (life-cycle approach) and on circular business models requires a much higher level of collaboration and alignment between all actors⁴³. As an example, process industries are only one of the many actors of the construction value chain; the transition towards a climate-neutral built environment will require that all actors coordinate their actions towards common objectives.

The links with manufacturing industries and brand owners must be strengthened to integrate more sustainable, recyclable, recycled and or bio-based materials in the marketed products.
 - **Lack of engagement with local public and private stakeholders** (geographic proximity approach): a stronger engagement at local level with regions, cities, citizens, consumers and other local stakeholders is essential to deliver positive impact, to close material loops and achieve overall climate neutrality at a more favourable overall cost and with shorter delays than by individual actions.
- **Human capital (need of a skilled workforce):** the attractiveness of process industries for highly skilled people and its ability to equip industry workers with the right set of skills to drive the transformation (at all levels in the organisation, with a particular focus on workers in the production facilities) must be improved. In particular, ever increasing pressure from other parts of the world is threatening Europe's leadership position in technology **innovation** in process industries. Losing intellectual capacity invariably leads to a relocation of manufacturing capacity and an associated loss of employment. The implementation of more proactive cross-sectorial collaboration models also requires the upgrading and integration of specific skills.

Graph 4 summarises the three problems and their associated drivers.

⁴³ Digital technologies will support this alignment, notably by enabling a much higher level of data transparency between critical actors of a given value chain



Graph 4: Processes4Planet / problems and problem drivers

Building on the work done by previous R&I partnerships ...

Processes4Planet will build on the experience, achievements and lessons learnt from previous initiatives such as the SPIRE cPPP, which has been instrumental in bringing large and small companies together. SPIRE has achieved significant successes:

- It has enabled an **unprecedented level of cooperation and of trust** across industrial sectors, between large companies, SMEs, research organisations and other members. SPIRE created a win-win relationship between members: while private companies got access to a broad pool of talent, research and technology organisations could access new opportunities for applied research.
- **A private investment leverage factor of 8.5 was achieved**, with a total investment by private companies of EUR 4.52 billion.
- **264 innovations were developed, of which 86 were significant innovations**, through more than 100 projects, classified in three main areas: efficient processes, sustainability and circular economy, and enabling sustainable industry development.
- **All member SME's have been performing well-above the European average**: 40% growth in turnover (double the EU average), seven new employees per SME (more than 3 times the EU average), and 27% of SMEs winning new business through SPIRE contacts.
- **In terms of creation of new skills and jobs profiles**, SPIRE is on track to greatly surpass its contractual target of developing 10 highly skilled new job profiles during Horizon 2020⁴⁴. Eco-Engineer, H₂ economy

⁴⁴ According to [SPIRE 2019 Progress Monitoring Report](#), a sample of 24 projects reported 23 new job profiles under development, and a sample of 39 companies reported 24 new profiles in relation to SPIRE projects and further investments.

Engineer, AI machine learning Expert, Predictive control engineer and Industrial Symbiosis Manager are examples of new job profiles identified by SPIRE projects from 2014 to 2019.

- **SPIRE helped build a growing awareness about the required industrial transformation in Europe.** SPIRE related topics such as resource efficiency and circular economy, energy efficiency, low emissions solutions, industrial symbiosis, digitization of industry or valorisation of key enabling technologies have been prioritised further also at national and regional levels (complementarity to the European agenda). P4Planet's proposal on Industrial-Urban Symbiosis (I-US) builds on SPIRE projects' results and learnings.
- From an **environmental standpoint**, SPIRE exceeded its targets to reduce dependency on fossil fuels (38% versus a target of 30%) and to reduce dependency on non-renewable, primary resources (31% versus a target of 20%). Its performance in reducing emissions was below target (29% versus a target of 40%), which shows the need to focus more efforts on this particular ambition for future innovation activities.

The established trust across the process industry sectors allows the building of a new partnership with solid foundations and a much higher level of ambition, which will integrate new sectors, companies, NGOs, and representatives of regions amongst others.



... but in a much more ambitious and objective-driven approach

Processes4Planet is objective-driven. It embraces and sustains the ambitious sustainability objectives of the European Green Deal. **The extent of the transition process industries are facing over next few decades is unprecedented.** Previously described issues are also **opportunities to profoundly transform our industries and sustain their long-term success.**

Our Vision and Roadmap integrate technological and non-technological innovations which aim at positioning European process industries as global leaders and frontrunners in economically attractive solutions for climate-neutrality and a fully circular economy. They also aim to strengthen their integration in the economic fabric of regions and Member States. Amongst other examples:

- One of the main opportunities lies in developing new industrial ecology business models closing the material loops. This will result in environmental, economic and societal benefits,
- The electrification of industrial processes combined with a sufficient supply of affordable and renewable⁴⁵ electricity will reduce dependency on imports of fossil fuels and secure the cost base of energy intensive industries,
- Process intensification also offers opportunities to save energy and significantly reduce carbon footprint, and reduce process-related waste,
- Gradually but intensively reducing the dependency on fossil resources will enable a fundamental change in the operating model of the industry and could lead to a re-industrialisation of continental regions,
- Digitally enabled solutions will significantly improve process control and operations performance, optimise the use of resources (within each plant but also across sectors and with local communities) and allow for much more efficient predictive maintenance and real-time production scheduling⁴⁶.
- Digitalization will connect and enable value chains by, for example, driving new business models or allowing adaption of production demand to energy supply, in contrast to today's situation.

⁴⁵ Or low carbon electricity.

⁴⁶ In-line monitoring would also be an enabler for processing with more complex and fluctuating material feeds, for example, Process Analytical Technologies would enable the chemical composition analysis of high variability material feeds at intake, and at critical points during processing (measuring Critical Quality Attributes of the product and Critical Process Parameters of the process) to assist in processing with new materials feeds and understanding their behaviour during the process so that it can be controlled.

The process industries are ideally positioned to drive the transformation of entire value chains towards sustainability through intense collaboration with upstream and downstream sectors.

2.2. Common vision, objectives and expected impacts

Common vision

Processes4Planet's ambition is to achieve a profound change in the way we produce and consume the materials that citizens need to sustain their quality of life.

Processes4Planet is about **transforming European process industries to make them circular and achieve overall climate neutrality at EU level by 2050, while enhancing their global competitiveness.**

The future of the Europe process industries lies in strongly enhanced cooperation across sectors and across borders, enabling a meaningful step change in competitiveness and sustainability performance that brings benefits for Europe and all its citizens.

This change is in every aspect aligned with the EU Green Deal objectives, with the new EU Industrial strategy and other EU political objectives and EU policies, as explained under section 2.3 of this document. This systemic change requires disruptive process technologies, as well as further improvement and large-scale deployment of more established ones.

Processes4Planet defines three specific ambitions to drive the change towards a sustainable society: climate neutrality, circularity and competitiveness.



Towards climate neutrality: process industries as frontrunners in a transition which sustains quality of life for all

Ambition: Towards climate neutrality in 2050

The process industries are critical to **deliver on ambitious climate objectives** while sustaining (and wherever possible) enhancing quality of life for all citizens.

Reaching the European climate ambitions will not be feasible without the disruptive transition of the process industries that Processes4Planet aims to foster, as they are today a significant contributor to greenhouse gas emissions. Process industries will also be, due to the extent of their energy consumption, a critical enabler for a fast, large scale and **cost competitive** deployment of climate-neutral energy and energy carriers (for instance green hydrogen) in Europe. They can also contribute to smoothing out grid fluctuations resulting from the integration of renewables.

The innovative process technologies developed by Processes4Planet supported by an appropriate regulatory and investment framework will enable an economically competitive production of climate-neutral materials, which will be needed to sustain the delivery of day-to-day services enhancing the quality of life of citizens.



Example – The innovation programme focusing on the electrification of industrial processes aims at a dramatic decrease of CO₂ emissions while reducing European dependency on fossil fuels and sustaining the delivery of high-quality, safe and affordable materials and goods. If properly coordinated with the energy sector, it also has the potential to decrease the cost of renewable energy for all.



Towards circularity: closing the loops of water reuse and from waste to resources

Ambition: Near-Zero landfilling and near-zero water discharge in 2050⁴⁷

Our society must achieve a **paradigm shift in the way resources are being managed and used**. Waste generation must be minimised beginning with the design stage of materials and products. Disposal of reusable wastes must disappear as waste flows from municipalities and industries are collected better, sorted better and processed in an innovative way to fulfil the specifications of resources needed for the production of new marketable materials and goods. The use of captured CO₂ and an effective management of water resources are also essential components of the circular business models of the future.

The Process Industries are again crucial to deploy a circular economy at scale and to deliver on EU ambitions in this area due to their resource- and energy-intensive nature. They can only achieve this change if robust and novel collaboration models are permanently established across industrial sectors, across value chains and with regions, living labs, municipalities and citizens in addition to the technology developments required.



Enhanced competitiveness: a thriving industry providing quality jobs for all industry workers

Ambition: EU's process industry's GVA growing quicker than the EU GDP

Innovative process technologies are essential to sustain the competitiveness of European process industries in their transition towards fully sustainable business models. A flourishing process industry supports (new) skills development and provides (new) quality jobs for industry workers at all qualification levels in Europe. An industry leading in technological innovation can efficiently deploy sustainable processes around the world, contributing to the achievement of global emissions reduction objectives.

Processes4Planet: a unique cross-sectorial innovation partnership

Our partnership is unique in its nature as it currently brings together individual companies from eight major process industry sectors, all related European sector associations and the European institutions around a shared ambitious vision and a common R&I roadmap. It will integrate other sectors as well as newcomers from regions, NGOs and other stakeholders over next few months. Processes4Planet is committed to enlarge its membership base towards all relevant process industry and waste management sectors.

Cross-sectorial innovation efforts maximise efficiency in the allocation of resources and supports cross-fertilisation between projects to better address common challenges. The cross-sectorial approach also enhances our ability to engage with other partnerships representing upstream or downstream industries in a variety of value chains, as well as to establish strong territorial connections (notably with Member States, regions and municipalities/communities).

A planetary emergency

Climate change and Biodiversity loss are two of today's most pressing global challenges, constituting an existential threat to humanity. Planning for planetary emergency is a pragmatic response to a known risk and humanity's insurance plan for survival and a positive future⁴⁸.

The Processes4Planet partners share a common sense of emergency. There is no time to lose to accelerate the reduction of greenhouse gas emissions and to reach a novel circular society and economy model. Processes4Planet will work on emerging technologies aiming at full climate neutrality and circularity, but also

⁴⁷ The "near-Zero" ambition is explained by the fact that specific waste streams (such as medical, military waste of specific end-of-life waste types) or polluted water streams will still require safe disposal facilities.

⁴⁸ Club of Rome, Climate-Planetary Emergency, <https://clubofrome.org/impact-hubs/climate-emergency/>

on the scaling up of technologies already developed at higher TRLs in order to deliver expected emission reductions by 2030.

The achievement of the 2030 climate targets requires the fast deployment of “transition technologies” which can deliver significant emission savings and fill the gap before more disruptive technologies are fully validated.

Processes4Planet co-programming partnership takes an integrated approach to climate and environmental issues. In particular, through the development of climate neutral and circular solutions, P4Planet goes beyond including a focus on the elimination of emissions of pollutants from industrial installations. All the innovations developed will enable progress towards climate neutrality and circularity which always consider there are no other negative effects for the environment.

By doing so, European process industries respond to the call for action of the EU Green Deal: page 8 of the document⁴⁹ states that **“EU industry needs ‘climate and resource frontrunners’ to develop the first commercial applications of breakthrough technologies in key industrial sectors by 2030”**.

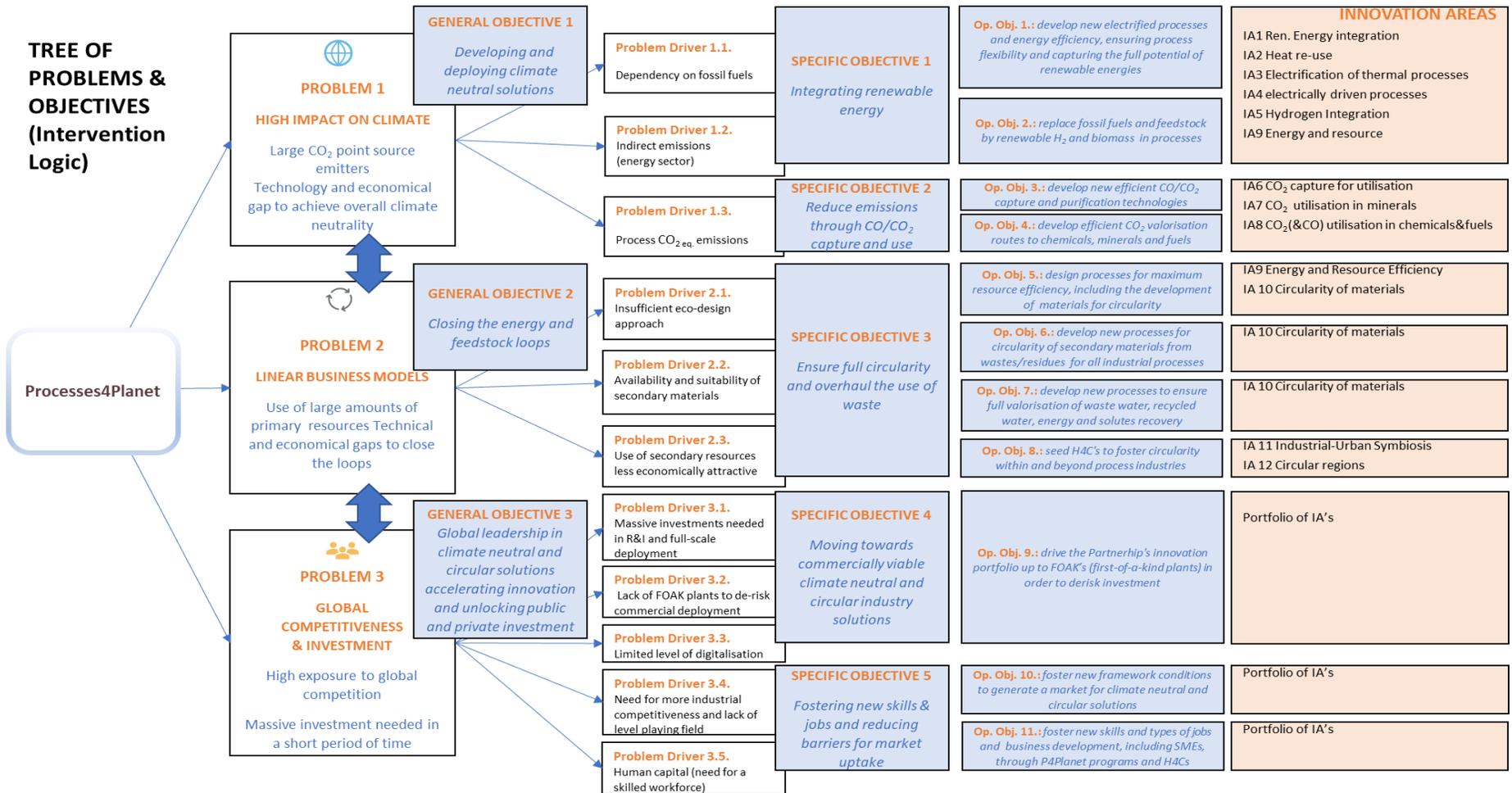
To help industries make the European Green Deal a success, we must therefore also establish links with the Innovation Fund, InvestEU, relevant IPCEI, Just Transition Mechanism and other means of promoting demonstration and deployment. The Processes4Planet partnership is a key tool to help make the future Alliance on Low-Carbon industries a success⁵⁰. The link with this Alliance will be important, given that the objectives of both this partnership and the Alliance are closely related.

⁴⁹ COM(2019) 640, The European Green Deal, 11 December 2019.

⁵⁰ See the key role of partnerships in this respect in the New Industrial Strategy for Europe: Communication from the Commission, A New Industrial Strategy for Europe, COM(2020) 102 final, page 10. The Alliance on Low-Carbon Industries would be built on a similar model as the recently launched Battery Alliance or Clean Hydrogen Alliance.

2.2.1. General, specific and operational objectives

The general, specific and operational objectives of the Processes4Planet partnership are presented in Graph 5 which shows their direct connection to the previously detailed problems and problem drivers as well as to the Innovation Areas of the Processes4Planet roadmap. The various levels of the objectives and their related KPIs are further explained over the next few pages.



Graph 5: Tree of problems, problem drivers and objectives of Processes4Planet (General, specific and operational objectives)

Problems	General objectives
 <p>HIGH IMPACT ON CLIMATE</p> <p><i>Process Industries are today large CO₂ point source emitters and face a major technology and economic gap to achieve the 2050 target of overall climate neutrality</i></p>	<p><i>G.O. 1: Developing and deploying climate neutral solutions</i></p> <p>The transition to climate neutrality can only be achieved if technological and non-technological innovations are brought to readiness for subsequent deployment.</p>
 <p>LINEAR BUSINESS MODELS</p> <p><i>Process industries use large amounts of primary resources. Closing the material loops is in many cases not yet technically/economically feasible at scale</i></p>	<p><i>G.O. 2: Closing the energy and feedstock loops</i></p> <p>Through technological and non-technological innovations, cross-sectoral collaboration and engagement with the local ecosystem, process industries will develop and deploy sustainable circular business models and will move towards resource circularity and resource efficiency.</p> <p>Our ambition is to move towards the closure of resource loops. For some processes, the limited availability of secondary resources will still require the reduced use of primary materials (e.g. in the construction value chain where C&D waste will not fulfil the needs for new construction materials within a foreseeable time frame).</p>
 <p>GLOBAL COMPETITION</p> <p><i>Process industries are highly exposed to global competition</i></p> <p><i>Massive investments are needed over a very short period of time (compared to traditional investment cycles of process industries)</i></p>	<p><i>G.O. 3: Achieving a global leadership in climate neutral and circular solutions, accelerating innovation and unlocking public and private investment</i></p> <p>The competitive position of the European process industries will be enhanced by a strong positioning as global leaders in economically attractive solutions for climate-neutrality and a fully circular economy and a strengthened integration in the economic fabric of regions and Member States.</p> <p>The partnership will define a reliable investment agenda for process industries over next 30 years, in particular for the key phase for commercial deployment of sustainable technologies by 2030 (i.e. between 2025 and 2030). It will also address the required framework conditions to generate a market for climate neutral and circular solutions and to trigger deployment of innovation (consistent regulatory framework, level playing field).</p>

Table 1 Key problems and general objectives of the partnership

2.2.2. Specific objectives and operational objectives

Specific objectives	Operational objectives
<p><i>S.O. 1</i></p> <p><i>Integrating renewable energy</i></p> <p>The integration of renewable energy in process industry sectors requires innovation efforts on several fronts detailed in the related operational objectives.</p>	<p><i>O.O. 1</i></p> <p><i>Develop new electrified processes and enhance energy efficiency, ensuring process flexibility and capturing the full potential of renewable energies</i></p>
	<p><i>O.O. 2</i></p> <p><i>Replace fossil fuels and feedstock by renewable H₂ and biomass in processes</i></p>
<p><i>S.O. 2</i></p> <p><i>Reducing emissions through CO/CO₂ capture and use</i></p> <p>The focus will be on the development of efficient, technically and economically feasible solutions to capture, purify and use CO/CO₂ emissions from process industries (in particular unavoidable process emissions)⁵¹ for the production of materials and chemicals (including energy carriers) with a lower environmental footprint compared to current production.</p>	<p><i>O.O. 3</i></p> <p><i>Develop new efficient CO/CO₂ capture and purification technologies</i></p>
	<p><i>O.O. 4</i></p> <p><i>Develop efficient CO₂ valorisation routes to chemicals, fuels and minerals (building materials)</i></p>
<p><i>S.O. 3</i></p> <p><i>Ensure full circularity and overhaul the use of waste</i></p> <p>This specific objective relates to a broad range of innovations: the development of solutions to ensure higher yields from complex and fluctuating raw material feeds, contributing to the development of efficient collection, sorting, transportation, treatment and feeding technologies for waste-derived and water resources, the utilisation of all energy and material resources in waste water, ensuring full traceability of value chains (a crucial instrument to deploy circular business models at scale and to serve customers' growing demand for product-related information), and achieving a step change in resource efficiency through digital</p>	<p><i>O.O. 5</i></p> <p><i>Design processes for maximum resource efficiency, including the development of materials for circularity</i></p>
	<p><i>O.O.6</i></p> <p><i>Develop new processes for circularity of secondary materials from wastes/residues for all industrial processes</i></p>
	<p><i>O.O. 7</i></p> <p><i>Develop new processes to ensure full valorisation of waste water, recycled water, energy and solutes recovery</i></p>

⁵¹ The Process Industries acknowledge the potential future contribution of geological storage of CO₂ to achieve the European carbon neutrality objective within agreed deadlines but not as a permanent, long-term solution. Technology development and innovation remain required in the capture and use of CO₂. Geological storage raises other open questions related to infrastructure (pipelines and injection), appropriate injection sites (geological research) as well as social acceptance, which are not in the scope of action of Processes4Planet.

<p>technologies. These various aspects are addressed in the related operational objectives.</p>	<p><i>O.O. 8</i></p> <p><i>Seed H4Cs to foster circularity within and beyond process industries</i></p> <p>A “Hub For Circularity” is defined as a cluster of facilitated interconnected industrial and/or public facilities within a given geographical area, which collectively achieve a demonstrable level of circularity in their use of resources by following a common business to territory plan.</p> <p>This approach may involve investment to achieve targeted results. For existing facilities, these should be self-justified by the achieved higher efficiency.</p>
<p><i>Moving towards commercially viable climate neutral and circular industry solutions</i></p> <p>The economic viability of the technological and non-technological solutions to major challenges faced by process industries is the key contribution of Processes4Planet to an increased competitiveness of these sectors in Europe.</p>	<p><i>O.O. 9</i></p> <p><i>Drive the Partnership’s innovation portfolio up to “First-Of-A-Kind” demonstrators to de-risk investment</i></p> <p>Funding support is needed for First-Of-A-Kind plants (demonstrators) to de-risk the investment for subsequent roll-out.</p>
<p><i>Fostering new skills & jobs and reducing barriers for market uptake</i></p> <p>One of the key challenges of process industries is to ensure a good fit between future needs in terms of talents and skills and education and training programmes. New job profiles will be needed to design and deploy climate neutral and circular economy solutions, at all qualification levels.</p> <p>This objective also addresses the development of digital skills in areas such as data science, digital twinning, machine learning, robotics and artificial intelligence and the ability to apply systems thinking.</p> <p>It also covers the need to define enabling framework conditions to develop market uptake at the scale of transformative solutions and products.</p>	<p><i>O.O. 10</i></p> <p><i>Foster new framework conditions to generate a market for climate neutral and circular solutions</i></p> <hr/> <p><i>O.O. 11</i></p> <p><i>Foster new skills and types of jobs and business development, including SMEs, through Processes4Planet programmes and Hubs for Circularity (H4Cs)</i></p>

Table 2: specific and operational objectives of the co-programming partnership

Key Performance Indicators

The connections between specific objectives, operational objectives and selected KPIs for the co-programming partnership are illustrated in Graph 6.



Graph 6: Specific, operational objectives and Key Performance Indicators for the co-programming partnership

Notes:

All targets are based on 1990 industry baseline reference (as recommended by the European Commission)

Strong links exist between the three general objectives of the partnership. As an example, even if KPI 2 (CO₂ capture and use) is in this graph directly connected to General Objective 1 (climate), the use of CO₂ as feedstock also contributes to General Objective 2 (circular economy) though a novel model of circularity of carbon.

* Relevant number of demonstrators: sufficient number to provide facts and data necessary to confirm feasibility and large-scale potential.

** Demonstrators: we refer to demonstrators at TRL 7 – System prototype demonstration in operational environment. These demonstrators will confirm the achievable impact (% of target, absolute tonnage.), to be used as a base to extrapolate the potential impact for full scale roll-out in the market. and/or at TRL 8 – System complete and qualified.

*** Energy efficiency targets will vary from solution to solution and should not be confused with the final 100% target, but will contribute to it when combined with other solutions.

**** Waste reduction enabled through the P4Planet solutions. We will implement these solutions within Process industries. For waste outside our Industries, we aim to catalyse the development of circular industry through H4Cs and EU ad-hoc policies.

***** We estimate that reaching the highest level of symbiosis (Kalundborg example) requires years. Hence, throughout Horizon Europe, the H4Cs will be on a trajectory towards maturity.

Table 3 details the targeted progress level by 2024 and the objectives by 2030 for each of the KPIs.

	KPI / OBJECTIVE BY 2030	EXPLANATIONS
CLIMATE	100% of total CO _{2eq} emission reduction potential by integration of renewable energy & energy efficiency** demonstrated through R&I projects at TRL7 **	CO _{2eq} emission reduction potential, measured through a relevant* number of demonstrators**
	100% of total CO _{2eq} emission reduction potential through CO ₂ Capture and Use demonstrated through R&I projects at TRL7 **	CO _{2eq} emission reduction potential, measured through a relevant* number of demonstrators**
CIRCULARITY	100% (TBD) of waste reduction potential demonstrated through R&I projects at TRL7**	Waste**** reduction potential, measured through a relevant* number of demonstrators**
	90% (TBD) secondary materials re-use potential demonstrated through R&I projects at TRL7**	Secondary materials re-use intensity potential, measured through a relevant* number of demonstrators**
	90% (TBD) of wastewater re-use/recycling potential demonstrated through R&I projects at TRL7**	Water re-use/recycling potential, through energy and solute recovery measured through a relevant*- number of demonstrators**
	15+ H4Cs launched into the process of development (*****)	Number of H4C seeded through P4Planet projects across EU regions / sites
COMPETITIVENESS & CROSS-CUTTING	Launch 15+ marbles integrating solutions developed through Processes4Planet portfolio towards the 100% target+	Marbles: first-of-a-kind plants at TRL9
	Leverage factor: 5 to 10	Private investment level (leverage)
	60 significant innovations reaching TRL 7-8, of which a substantial part will lead to marbles	
	CAPEX & OPEX reduction through the innovations	
	Impact on SMEs through projects and H4Cs	
	20 new types of skills and jobs, of which at least 10 integrated into specific academic curricula and 10 integrated into company training programs	Skills and job profiles for operators or high-skilled profiles

Table 3 KPIs, progress level by 2024, objectives by 2030

Notes:

All targets are based on 1990 industry baseline reference (as recommended by the European Commission)

* Relevant number of demonstrators: sufficient number to provide facts and data necessary to confirm feasibility and large-scale potential.

** Demonstrators: we refer to demonstrators at TRL 7 – System prototype demonstration in operational environment. These demonstrators will confirm the achievable impact (% of target, absolute tonnages...), to be used as a base to extrapolate the potential impact for full scale roll-out in the market and/or at TRL 8 – System complete and qualified.

*** Energy efficiency targets will vary from solution to solution and should not be confused with the final 100% target but will contribute to it when combined with other solutions.

**** Waste reduction enabled through the P4Planet solutions. We will implement these solutions within Process industries. For waste outside our Industries, we aim to catalyse the development of circular industry through H4Cs and EU ad-hoc policies.

***** We estimate that reaching the highest level of symbiosis (Kalundborg examples) requires years. Hence, throughout Horizon Europe, the H4Cs will be on a trajectory towards maturity.

The Specific objectives and the KPIs are clustered here under three distinct categories: climate, circularity and competitiveness. However, climate neutrality and circularity cannot be achieved in silos, they are interconnected and so are the Specific objectives and KPIs depicted above. It will be through added reductions of GHG emissions via different innovative solutions that the targets of the KPIs will be reached. The Innovation Areas and Programmes of Processes4Planet's roadmap provide the needed additionality to reach the objectives above and the ambitions of the 2050 roadmap.

For example, the integration of renewable energy (SO1, KPI1) is needed for the reduction of CO₂ emissions related to electrification but also for the valorization of CO₂ through CCU (SO2) thus influencing the achievements of KPI2 to reduce CO₂ emissions related to the process. On the other hand, if circular solutions would depend on fossil fuels, they would not comply with the climate neutrality objectives. Thus, the integration of renewable energy will also influence the achievement of SO3 to ensure full circularity and all its related KPIs.

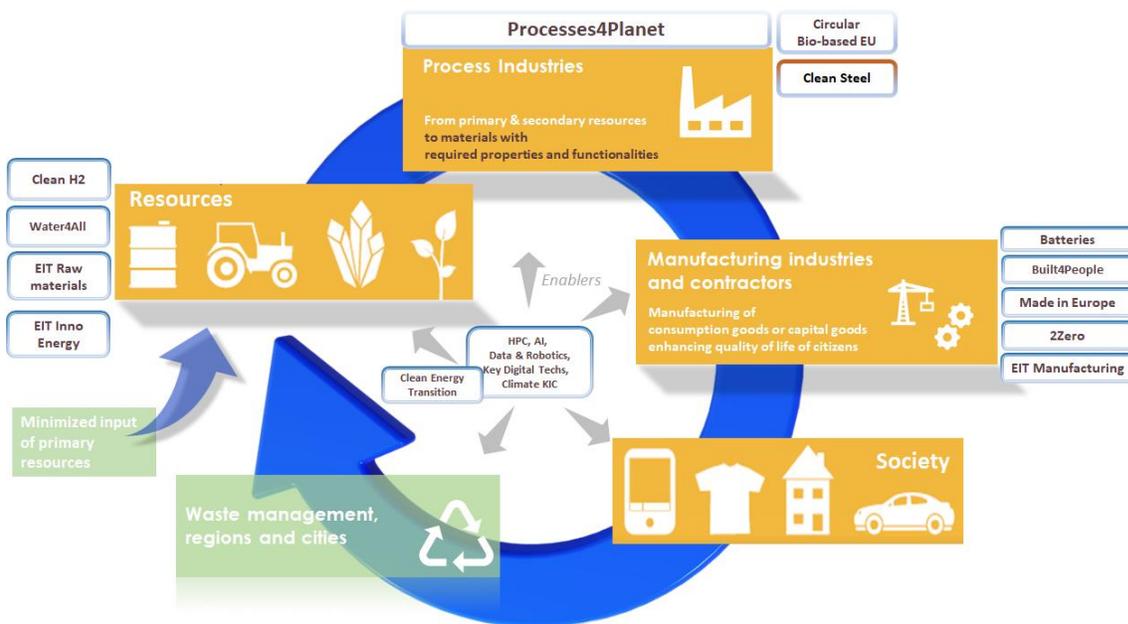
Demonstrators at TRL / SRL 7-8 will provide a relative % contribution to the ambition of a specific innovation. The KPIs will measure this capacity for impact. The successful integration of the innovative solutions into 'First of a Kind' plants (Marbles) at TRL9 will show the feasibility to generate the expected impact once the solutions are rolled out. When monitoring the progress of the portfolios of impact, we will extrapolate the impact of the innovations at deployment level considering a 50% and a 90% adoption rate in the European Union and a 10% adoption worldwide.

2.2.3. Alignments with other R&I Partnerships and Initiatives at EU level

Processes4Planet is excellently positioned within the circular value chain of EU Partnerships and Initiatives where each player has a distinct and complementary role in the life-cycle phases of production, consumption of goods and upcycling of resources. This section describes the links and alignments that Processes4Planet are seeking with relevant partnerships and Initiatives for the process industries' value chains. The activities to enable collaboration with them are described in chapter 3.

Processes4Planet will establish links with relevant European Partnerships candidates for Horizon Europe as well as with other relevant initiatives at EU level (see an overview in Graph 7 below). The establishment of effective collaboration processes is important to exploit opportunities of cross-fertilisation and maximisation of impact through an optimal use of the resources. It is important to bear in mind that good collaboration is time consuming and establishing links with all can prove too high a burden. Support from the public side will be very important to coordinate and rationalise these efforts.

During the development of the Processes4Planet's roadmap, **A.SPIRE has established dialogue and set alignments across roadmaps.** This has been fundamental to setting the right scope for our Innovations Programmes. The Association also keeps regular contacts with other Initiatives and Partnerships to explore the joint efforts needed to reach climate neutrality, circularity and competitiveness ambitions.



Graph 7: Processes4Planet and other EU R&I Partnerships and Initiatives

The portfolio of candidate partnerships under Horizon Europe is reviewed in the recent report “European Partnerships under Horizon Europe: results of the structured consultation of Member States” released by the European Commission on December 12th, 2019⁵².

- **Material and energy resources: Clean Hydrogen, Water4ALL, EIT Raw Materials, EIT Inno Energy.** It is essential to keep track of upstream developments and outcomes to ensure that the Processes4Planet portfolio of innovations can be fuelled in appropriate time with the required material and energy resources. Process industries will also make their needs and expectations very clear towards those R&I partnerships and initiatives which will directly or indirectly contribute to the success of the industrial transition towards carbon neutrality, circularity and competitiveness. Linking from (raw) resources to materials.

“Material and energy resources” partnerships and initiatives	Links with Processes4Planet
Clean Hydrogen	<p>Hydrogen is a key enabler for process industries to store / use energy, to avoid the dependency on fossil fuels and to serve as climate-neutral feedstock in several sectors.</p> <p>Conversations with Clean Hydrogen have been key to align our roadmaps. As a general point of agreement, electrolytic production of green hydrogen is within the scope of Clean Hydrogen not within the P4Planet roadmap. Nonetheless, since hydrogen can be produced for use within some industrial processes of the Energy Intensive Industries, both Partnerships agree that the integrated production of hydrogen developed by the process industry for their own</p>

⁵² https://www.era-learn.eu/documents/final_report_ms_partnerships.pdf

	<p>utilisation is within P4Planet scope. In the same approach it is possible to make H₂ from side streams of the PI as there are, for example, H₂S and CH₄.</p>
Water4All	<p>Water is a crucial resource for process industries, both as feedstock and as a cooling agent and an energy carrier in many production processes. A sustainable use of water enables a higher energy efficiency of our production processes and of Industrial-Urban Symbiosis.</p> <p>The water sector is one of A.SPIRE's founding members and as a general point of agreement, R&I aiming to improve the use of Water in the Process Industries would be handled, as a priority, by P4Planet, while those developments related to other industries would by default be handled by Water4All. On the other hand, while innovation related to Urban Water would naturally remain within the Water4All partnership, the connection with Industrial-Urban Symbiosis will be within the scope of Processes4Planet, especially for the exchange of energy and resource extraction and with a strong link to digitalisation.</p>
EIT Raw Materials ⁵³	<p>A sustainable supply of raw materials is vital for the future of Europe. EIT Raw Materials are members of A.SPIRE and their participation in our Working Groups has ensured a good identification of the areas for active collaboration and alignment:</p> <ul style="list-style-type: none"> • Innovative mining technologies, research and education to sustain access to raw materials, • Material processing technologies (both for primary and secondary resources), • Potential bottlenecks in raw materials supply, both for the production of current key technologies as well as the breakthrough of emerging ones (the shift towards renewable energies, e-mobility and Industry 4.0 are examples of extensive innovation processes that trigger the need for new kinds of advanced materials and raise new concerns about the availability of critical raw materials), • Improvement of both the amount and quality of raw materials recovered from secondary sources (end-of-life products, industrial residues, tailings, urban and landfill mining), • Design of products and services for the circular economy.
EIT Inno Energy	<p>A continuous alignment and permanent exchanges are required to support joint sustainable energy innovations which provide industry with new technologies that reduce energy costs, increase system performance, decrease greenhouse gas (GHG) emissions and increase competitiveness.</p> <p>The cost-effective supply of affordable renewable energy at an unprecedented scale is pivotal for the transformation of the Process industry and a key success factor for the effective deployment of the Carbon Capture and Use processes which are to be developed by Processes4Planet projects.</p>

Table 4 Links between Processes4Planet and other EU Partnerships & Initiatives addressing material and energy resources

⁵³ EITs perform a wide range of activities: education courses (technical and entrepreneurial skills), tailored business creation and acceleration services and innovation driven research projects. Clear agreements should be made both on innovation and skills-jobs to ensure optimal alignment with the activities of the Processes4Planet co-programming partnership.

- **Other partnerships midstream in the circular value chain: Clean Steel and Circular Bio-based EU.** Midstream companies are crucial to close the circular loops of energy and resources. They are the link between the (Raw) resources and the manufacturing of the final goods the citizens will consume. Through our unique cross-sectoral approach, P4PLANET is the crucial mid-stream Partnership to achieve the transformation of the major EU Process Industry sectors (eight sectors currently, and soon to increase to 10 with the inclusion of Refining and Pulp and Paper). The role of the Waste management sector will be fundamental to achieve our circularity ambitions and deliver broad impact to society across borders. From A.SPIRE we are working to engage this sector in our partnership. Glass and other EII sectors are also welcome.

Other partnerships and initiatives midstream in the circular value chain	Links with Processes4Planet
Clean Steel	<p>Steel sector is one of the founding members of A.SPIRE and a positive and fluent dialogue already takes place to ensure good complementarities and to generate synergies.</p> <p>The private parties of both partnerships have reached the initial agreement that technological developments or innovations which are specific to steel sector will be within the scope of Clean Steel while those of cross-sectoral interest will be within P4Planet. An analysis of Clean Steel Building Blocks and P4Planet Innovation Programmes is ongoing identifying which areas are intrinsic of each partnership and in which areas there is complementary or need for further alignment. The analyses is based on the evolving roadmaps of P4Planet and Clean Steel.</p>
Circular Bio-based EU (CBE)	<p>The move from fossil to bio-based feedstock represents an opportunity for several value chains in which process industries are operating – notably for the chemical sector. The impact on the life-cycle carbon footprint should be the right criteria for decision-making.</p> <p>Both partnerships have made alignments on their respective roadmaps. While Circular Bio-based EU focuses only on bio-based resources, P4Planet’s main strength lies in its capacity to fuel its processes with a mix of resources thus contributing to the development of a fully circular economy.</p> <p>A main point of discussion focuses on how to establish a good synergy on innovation regarding CCU. Both Partnerships agree that CBE should focus on CCU of biogenic CO₂ and the use of biotech processes, while Processes4Planet focuses on CO₂ from the PI and all other kinds of processes. A strong point of synergy will certainly be the common recycling of polymers from fossil-/bio-origin and in industrial symbiosis. CBE can also provide renewable feedstock to Processes4Planet either as an energy source or a chemical source.</p>

Table 5 Links between Processes4Planet and other EU Partnerships mid-stream the circular value chain

- **Customers and final users (product manufacturing industries, contractors): Built4People, Made in Europe, 2Zero, Batteries, EIT Manufacturing.** The materials produced by process industries will reach the final user through the products delivered by brand owners. All the innovations and outcomes generated by Processes4Planet will thus impact downstream products and can help to achieve a multiplier effect down the different value chains.

Customers/final users	Links with Processes4Planet
Customers: Buil4People, MadeinEurope, 2Zero, Batteries, EIT Manufacturing	The main expectation of Processes4Planet towards these partnerships and initiatives is related to the technical and economic feasibility of the eco-design of products (circular by design), the re-use, recycling or recovery of material resources when the use phase of consumption or capital goods comes to an end. A strong alignment of R&I efforts will be required to move towards closed material loops (over a maximised number of life cycles). Linking from materials-to-products-to-recoverable waste.

Table 6 Links between Processes4Planet and other EU Partnerships (Customers)

- Cross-cutting enablers along the life cycle:** R&I developments from other partnerships or initiatives will be very important to enable the innovations and solutions of P4Planet at different levels. Collaboration with all will be relevant for the required remodelling of skills of the workforce (retraining existing workforce and educating the future workforce).

“Cross-cutting enablers”	Links with Processes4Planet
Digital Partnerships: AI, Data & Robotics High Performance Computing Key Digital Technologies	Digital Partnerships (AI, data and robotics, High-performance computing and Key Digital Technologies) will be key to accelerate the progress of P4Planet innovations. The recently released European Commission White Paper on Artificial Intelligence ⁵⁴ , for example, underlines the need to create testing and experimentation sites to support the development and subsequent deployment of novel AI applications. AI, cybersecurity and smart data are areas of particular relevance for future collaboration.
CLIMATE KIC	The link to territorial developments (local climate-neutrality initiatives) is vital for Europe to become the first climate neutral continent in the world. Climate KIC is also a member of A.SPIRE and has contributed to our Working Groups which has ensured alignments in our respective strategies. Alignments with this initiative are sought in relation to the geographical proximity approach and initiatives to reduce CO ₂ equivalent emissions. Of special interest to us are their initiatives on sustainable production systems and on urban transitions as well as on the skills agenda.
Clean Energy Transition	The Clean Energy Transition co-fund partnership will foster joint actions between Horizon Europe and national funding programmes on common R&I priorities, building on – and bringing forward – the work carried out in the SET-Plan. It will specifically focus on renewable energy, energy grids, CCUS and cities and communities, including housing regarding energy consumption. We see good value in P4Planet connecting to Clean Energy Transition with regard to the connection with the energy sector. This could be done through SET PLAN IWG6, which is co-chaired by A.SPIRE. SET PLAN #6 networking events, for example, could become a platform to initiate a dialogue between the enablers (energy sector, energy grid etc.) and the users of energy and other members of

⁵⁴ COM(2020) 65 final, EU Commission White Paper on Artificial Intelligence - A European approach to excellence and trust

	the IWG6. This platform would facilitate the identification of the right alignments along the value chain that will lead to a good flow of renewable energy into the processes through an optimal energy efficiency. Considering the types of members of SET PLAN #6, this would help mutually enrich diverse roadmaps and work programmes (Clean Energy Transition, P4planet's. Clean Steel, FCH and those roadmaps of specific sectors such as chemicals, cement, pulp and paper or turbines). It would also provide the Implementation Plan of SET PLAN action 6 with a more holistic perspective for mutual benefit.
Alliance on Low-Carbon Industries & HLG-EII	P4Planet can also be a key tool to help make the future Alliance on Low-Carbon Industries a success. The link with this Alliance will be relevant, given that the objectives of both, the partnership and the Alliance are closely related ⁵⁵ .
IPCEI initiatives	<p>IPCEIs (Important Project of Common European Interest) are also relevant initiatives for engagement. IPCEIs enable Member States to offer a diversified portfolio of support forms (repayable advances, loans, guarantees, grants) and in justified cases allow public support up to 100% of the funding gap on the basis of a large set of eligible costs. Costs of first industrial deployment (i.e. between pilot line and start of mass production) are considered eligible. IPCEIs are complementary to R&I partnerships. They benefit from the outcomes of R&I partnerships. Vice versa, IPCEIs can also feed industry's further R&I needs into partnerships.</p> <p>The Strategic Forum on IPCEI selected in 2019 six strategic value chains, which are: Connected, clean and autonomous vehicles; Smart health; Low-CO₂ emission industry; Hydrogen technologies and systems; Industrial Internet of Things; and Cybersecurity.</p>

Table 7 Links between Processes4Planet and cross-cutting and enabling EU Partnerships and Initiatives

- **The link to society: moving towards closed loops.** The process industries impact a variety of value chains delivering materials that the final users will purchase as a final good (a house, a car, a laptop, shoes, etc...).

The recyclability of the materials produced by Processes4Planet industries is key to allow real circularity and not just recyclability. Citizens consume the materials produced by the process industry through the goods they purchase (consumption goods) or through the capital goods they invest in (buildings). Municipalities and regions collect and manage waste facilitating reuse, recycling or landfilling to their best capacities. In our conversations with representatives from regions, the focus is often on how to manage waste (linear approach) not on how to manage resources (circular approach).

The Hubs for Circularity concept represents an important opportunity to identify and develop the missing links that will allow the **move from waste-to-resources at scale**. This is the pivotal role of the seeding projects for Hubs for Circularity in Processes4Planet. Our connection to the waste management sector will also be very relevant for this purpose: the link to move from waste to resources at scale will be key to close the loops and reach a truly circular economy. The Hubs for Circularity will also contribute to the Urban Agenda for the EU and to the transition towards smart cities and communities.

⁵⁵ See the key role of partnerships in this respect in the New Industrial Strategy for Europe: Communication from the Commission, A New Industrial Strategy for Europe, COM(2020) 102 final, page 10

Required R&I investments

Table 8 summarises preliminary estimates of required investments for all Process4Planet innovation programmes. The total investments needed are estimated to amount to around EUR **33.8 billion up to 2050**. Investments required for the wide deployment (“roll-out”) of the technologies are excluded from this table. This includes the total investments of the projects (CAPEX for the innovative parts of installations, and OPEX for testing, including materials etc.) from TRL1 to 9 (first-of-a-kind demonstration plants).

Timing	TRL1-3	4-6	7-8	9	Non-technological	Total
2020-2024	€1 692	€2 749	€ 2 448	€1 300	€111	€8 299
2024-2030	€295	€1 372	€3 338	€6 488	€47	€11 539
2030-2040	€228	€450	€1 515	€9 040	€83	€11 316
2040-2050	€0	€0	€124	€2 430	€64	€2 618
Total	€2 215	€4 571	€7 425	€19 258	€303	€33 771

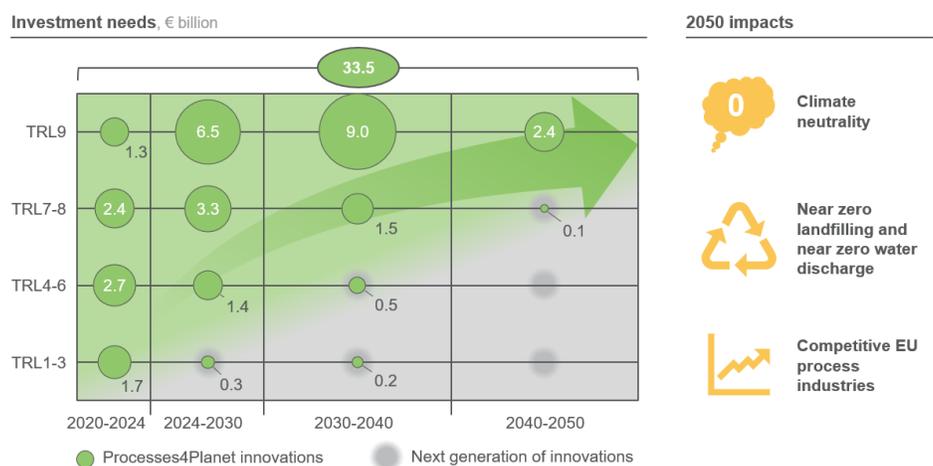
Table 8 Total investments, up to 2050, for all Processes4Planet innovation programmes and estimated funding in EUR million⁵⁶

Investments along all the TRLs/SRLs are more intensive up to 2030 (EUR 19.8 billion) and decrease a little from then to 2050 (EUR 13.9 billion). The investments to reach TRL7-8 are also more intense in the next decade: EUR 9.9 billion by 2030 compared to EUR 2 billion from 2030 to 2050. However, if we consider only the investments at TRL9, we observe the balance is different. The intensity is lower in the next decade (EUR 7.7 billion) compared to the investment from 2030 to 2050 (EUR 11.47 billion). This is due to the need to intensify the development of the first stages of innovation to deliver the needed solutions in a timely manner. The investments in the First of a Kind plants will be subject to relevant advances in solutions to be integrated at real industrial scale. A good number of solutions will be ready by 2030 but others will require more time to reach TRL7-8.

The non-technological investments amount to EUR 303 million up to 2050. The technological investments are higher in the first and second decades, as most innovation is frontloaded to face the urgency of the addressed problems. Investment needs decrease in the third decade. Further information on the investments up to 2030 and on the leverage factors is provided in chapter 3.2 (Resources).

Graph 8 depicts a more detailed breakdown of the technological investment needs to move from TRL 1 to 9. Note that estimates after 2030 are more uncertain than the estimates before 2030 and will need to be reviewed when the degree of success of the solutions is assessed.

⁵⁶ The investment needs have been estimated on the level of innovation programmes based on inputs by A.SPIRE working groups. Some guiding principles were used to make the investment estimates more balanced and internally consistent. The scope of the investments includes total investments of the project (CAPEX for the innovative parts and costs of testing, including materials etc.). The scope is as small as possible to deliver the insights required for the achievement of each TRL. This means, for example, that for the use of hydrogen, H₂ production and transport is not in scope, but only the integration of hydrogen in the industrial process is included.



Graph 8: Technological Investment needs for P4Planet's innovation pipeline

Besides the direct investments shown in Graph 6, indirect investments are expected (e.g. in the supply chains to produce components, transport, etc.). For full deployment (“roll-out”) across Europe, additional investments are estimated at **several hundreds of billions of Euros**, based on available sectorial and/or national roadmaps (see section 2.1).

2.2.4. Phasing-out strategy

Phasing out of innovation areas/innovation programmes

The Processes4Planet partnership will design and implement a permanent **“Project Portfolio Monitoring” (PPM) process**⁵⁷. The main objective of this process will be to track the progress made within each innovation programme (IP) and innovation area (IA) towards the overall objectives of the partnership.

The PPM process will deliver a holistic and updated overview of the achieved results⁵⁸. It will help all partners to determine which IAs/IPs are successful and need to be supported further and which are not delivering and need to be either stopped or substituted by novel IAs/IPs in order to achieve the transition goals.

It will also aim at making sure that contextual success factors for fast deployment (notably related to an enabling regulatory framework) are in place when innovations reach TRL9/SRL9 and are considered as economically and technically feasible.

This process will ensure the phasing out in due time of each individual innovation area or programme, so that resources are allocated in the most efficient way towards the delivery of expected impacts.

Phasing out of the partnership

The partners of Processes4Planet are committed to the success of the partnership. **They consider the transition towards a climate-neutral, circular and competitive EU process industry as a NECESSITY.** It is actually an “existential concern” for each of their sectors and for many value chains.

They believe therefore that a phasing-out or an exit strategy should only be considered when the transition to a climate-neutral-circular society and economy at scale is well in progress and can be sustained in time through market uptake.

⁵⁷ See more details under section 3.1. (Activities of the partnership).

⁵⁸ Beyond tracking the progress of each individual technology along the TRL scale.

Relevant political institutions and bodies could (of course) consider in the future that other policy instruments than a co-programming partnership could better support the achievement of the very same outcomes. Even if, currently, they strongly believe **that Processes4Planet is the right vehicle**, the partners remain fully available to examine possible other instruments at this stage and the related transfer of knowledge and information towards other potential future instruments.

As of today, the partners can only insist on the **added value of Processes4Planet’s unique cross-sectorial approach and on the importance of a long-term commitment of all organisations towards the common objectives**.

2.3. Necessity of a European Partnership

The **Processes4Planet** Partnership represents a **sound, robust and effective added value for Europe** by gathering the European Process Industry sectors to collectively invest in solutions for Europe’s transition towards becoming the first climate neutral continent in the world (EU President Ursula von der Leyen, opening speech)⁵⁹. The European Green Deal acknowledges that the energy-intensive industries are committed to these objectives⁶⁰, that they are indispensable as suppliers of several key value chains and that their decarbonisation⁶¹ and modernisation is essential⁶².

Processes4Planet teams-up energy-intensive industries with other sectors such as water and engineering (conversations with waste management are on-going) that are relevant to transform the industrial processes and improve the process industries competitive position. Together, P4Planet’s sectors are at the centre of the required transformation of our production and consumption models. They are ideally positioned to fulfil an **enabling role** to close the loops and recuperate bulk amounts of waste into new resources to be reintroduced in the industrial processes instead of going to landfill. Moreover, any reduction of CO₂ emissions by the process industries will have an immediate multiplying effect in all the value chains they supply.

The challenges and the extent of the transitions that our society requires over the next decades are unprecedented. **The climate neutrality and circularity targets can only be reached jointly** through the common and cross-sectorial R&I strategy provided by P4Planet’s 2050 roadmap. The **directionality** provided by this joint approach is a great added value compared to regular calls in Horizon Europe which cover a relevant but more compartmentalised approach.

The Processes4Planet’s roadmap shows the investment routes towards a modernised and climate-neutral process industry. Two key proposals show the level of **additionality** of this partnership, the “Marbles” and the Hubs for Circularity:

- The Marbles (First of a Kind (FOAK) - industrial scale plants, TRL9) are the ultimate milestone in the R&I investments chain for the process industry to be deliver impact. At this stage, the investments required are massive and the risk is equally high. Marbles will de-risk investment decisions for subsequent full roll-out at industrial scale.
- The Hubs for Circularity aim at co-investment models in industrial sites or regions that can create truly circular economic solutions and be the engines of the transition towards climate neutrality and near zero landfill. These new circular business models will be generated through technological and non-technological innovations, cross-sectorial collaboration and engagement with each local ecosystem.

⁵⁹ Speech in the European Parliament Plenary Session, Ursula von der Leyen. Strasbourg, 27 November 2019.

⁶⁰ As per the [recommendations](#) of the High-Level Group of Energy-intensive industries published by the European Commission.

⁶¹ The wording of “decarbonisation” cannot strictly be applied to the chemical industry, as many chemicals do contain carbon (notably organic chemistry compounds). In this document, we will give preference to the wording “transition to climate neutrality” which is relevant for all process industry sectors.

⁶² [European Green Deal](#). Page.7

- Through the comprehensive approach described above, Processes4Planet co-programming Partnership will be instrumental in:
 - Defining a well-structured and timely intervention logic based on a joint R&I strategy aligned with EU policy, Member States policies, global environmental targets and social demands alike.
 - Setting up a unique EU-wide and cross-sectoral innovation eco-system bringing together individual companies, European sector associations, academia, research and technology centres, EU authorities, Member States, Regions, other R&I funding bodies and all relevant stakeholders.
 - Setting up, from a bottom up approach, the priority of portfolios of impact to develop the innovation programmes of P4Planet’s roadmap. These portfolios will result in a combination of innovations which, together, will allow the delivery of solutions to tackle climate neutrality and circularity (near zero landfilling).
 - Establishing a continuous and integrated monitoring of all related R&I projects. The established portfolio monitoring system provides a holistic and updated overview of the progress made on the entire R&I agenda of the partnership, an analysis of achieved successes and failures and an identification of required next steps to scale up innovation to higher TRLs and deliver impacts with shortest delays.
 - Setting-up a structured dialogue on the financial and investments flow needed to deliver impact to society.
 - Promoting sustainable process industries in Europe and beyond. The innovations developed by P4Planet will be first implemented in Europe (95% as per the results of SPIRE, the predecessor of P4Planet) and then exported globally. We have a single planet.
 - Bringing large and small companies together and sustaining the growth of innovative SMEs which are providers to the process industries and will find their new market opportunities by their involvement in P4Planet’s projects and activities.

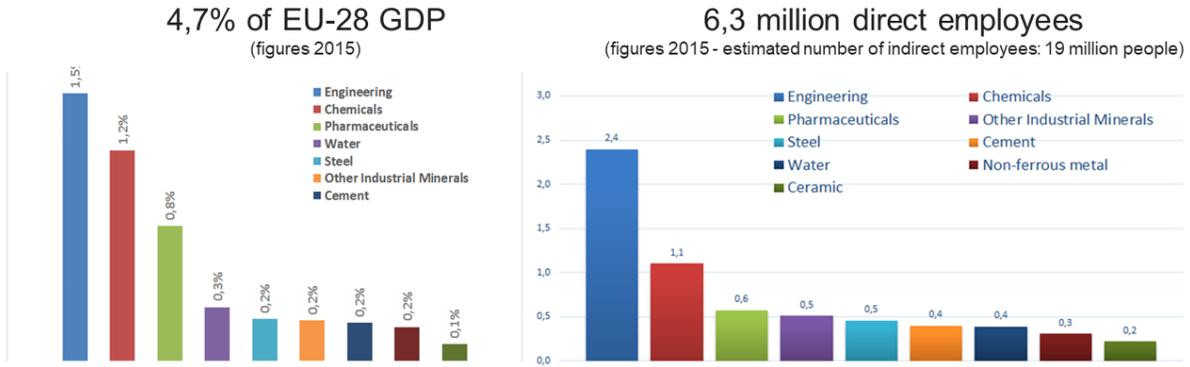
2.3.1. Added value of sustainable and competitive process industries: an indispensable industrial base for a resilient European society

As stated in the recently released New Industrial Strategy for Europe⁶³, “energy-intensive industries are indispensable to Europe’s economy and are relied on by other sectors”.

The process industry sectors represented within Processes4Planet generated, in 2015, a turnover of **EUR 1.8 trillion** and a total added value of **EUR 565 billion**, contributing to **4.7% of the EU-28 GDP**. They employed directly more than **6.3 million people** and, indirectly, an estimated **19 million people** (see Graph 9), providing quality jobs to employees at all levels of qualification. The Processes4Planet sectors are **the largest investors** in EU manufacturing as a whole: investing a total amount of around **EUR 78.8 billion** in 2015 (CAPEX).

The European process industries are crucial elements of **an exceptionally large number of value chains** producing goods and services which directly contribute to the quality of life of European citizens. This is notably the case for the healthcare, energy, hygiene, agriculture, construction, communication, defence and environmental services value chains (among many others).

⁶³ Communication from the Commission, A New Industrial Strategy for Europe, COM(2020) 102 final



Graph 9: GDP contribution and direct employment of Processes4Planet sectors (figures 2015, EU-28)

A strengthened presence of **entire value chains on European territory** is essential to increase the **resilience of European society to unexpected events and crises** which can alter global trade exchanges – as recently experienced during the COVID-19 crisis. Our collective ambition should be to bring the production of essential goods geographically closer to final users.

The ongoing health crisis also demonstrates that science-based decision-making, creativity and innovation deliver the best solutions, even more so in extreme circumstances. Science must inform our approach to address the major threat posed by climate change and related impacts on ecosystems.

President Ursula von der Leyen said in her recent speech at the European Parliament Plenary on the EU coordinated action to combat the coronavirus pandemic and its consequences, that it was “the moment to be ready for that new world. To use all the power of our common spirit and the strength of our shared purpose. The starting point for this must be making our economies, societies and way of life more sustainable and resilient”.

Ambitious and coordinated innovation efforts must result in robust and competitive circular business models taking full benefit of the potential offered by secondary resources and implementing climate-neutral processes in our countries and regions, for a resilient European Union.

Due to their strategic importance for society, process industries have continued to run their facilities during the COVID-19 crisis, together with ports, other logistic hubs and industrial sites. These sectors are key to relaunch the European economy post COVID-19. They demonstrate their willingness to re-think production models through their commitment to the Processes4Planet partnership.

The roadmap of Processes4Planet provides many of the solutions we need to enhance our collective resilience. A deeper analysis and identification of priority topics will be done at co-programming level where each Horizon Europe programme will be further developed. This must be part of the open dialogue process with Member States and with civil society. Our dialogue with other R&I partnerships and initiatives (e.g. Circular by Design) will also consider joint post COVID-19 solutions.

2.3.2. Processes4Planet: contribution to global and EU political objectives

Processes4Planet is designed to deliver on global and EU political objectives while addressing specific concerns of industry.

Global policies

GLOBAL POLICIES	SPECIFIC OBJECTIVES	Contribution of Processes4Planet	Related Innovation Areas (Processes4Planet Roadmap)
<p>United Nations Sustainable Development Goals</p> <p>(UN General Assembly 2015)</p>	 Clean water and sanitation  Affordable and clean energy  Decent work and economic growth  Industry, innovation and infrastructure  Responsible consumption and production  Climate action	<p>Ensuring availability and sustainable management of water is essential to increase efficiency, competitiveness and reduce the impact on nature and biodiversity.</p> <p>The electrification of industrial processes will create an economic lever able to decrease the cost of renewable energy for all.</p> <p>Enhanced competitiveness and skills will sustain entire value chains and good quality jobs.</p> <p>The core of Processes4Planet is to deliver technological and non-technological innovations for a competitive and sustainable industry.</p> <p>Circular and climate-neutral processes will massively decrease the environmental footprint of materials and goods.</p> <p>Innovative process technologies and business models are required to fill the technology gap existing between the level of decarbonisation achievable with validated technologies and the overall objective of climate neutrality.</p>	All
<p>Paris Agreement</p> <p>(21st Conference of Parties to the United Nations Framework Convention on Climate Change, 2015)</p>	<p>Global temperature rises by 2100 to be well below 2 degrees Celsius above pre-industrial levels + pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius</p> <p>Overall climate neutrality by 2050</p>	<p>Innovative process technologies and business models are required to fill the technology gap existing between the level of decarbonisation achievable with validated technologies and the overall objective of climate neutrality.</p>	1-2-3-4-5-6-7-8-9-11-12-13-15-16

Table 9 Contribution of Processes4Planet to the achievement of global policies' objectives (qualitative assessment)

EU POLICIES	SPECIFIC OBJECTIVES	Contribution of Processes4Planet	Related Innovation Areas (Processes4Planet Roadmap)
<p>EU Green Deal</p> <p>“Mobilizing the industry for a clean and circular economy”⁶⁴</p>	<p>EU’s industry transition to a sustainable model of inclusive growth.</p> <p>‘Climate and resource frontrunners’ to develop the first commercial applications of breakthrough technologies in key industrial sectors by 2030.</p> <p>Green Deal Investment Plan: essential to prepare a pipeline of sustainable projects + creation of high-quality jobs.</p> <p>Mobilizing research and fostering innovation:</p> <ul style="list-style-type: none"> • New technologies, sustainable solutions and disruptive innovation • Large-scale deployment and demonstration of new technologies across sectors and across the single market, building new innovative value chains. 	<p>This overall objective is reflected in all general, specific and operational objectives.</p> <p>Processes4Planet addresses key priority areas for breakthrough technologies mentioned in the Communication of the Commission: clean hydrogen, other alternative fuels, energy storage, CCU.</p> <p>Processes4Planet aims at defining a reliable investment agenda with validated technologies and at enhancing skills of highly skilled workers and operators alike, considering gender balance aspects.</p> <p>The core of Processes4Planet is to scale up innovative technologies to TRL8 within the Horizon Europe programme as well as to scale up to TRL 9 by mobilisation of investment through large-scale demonstrators and innovative/circular regional hubs across the EU.</p>	<p>All</p>
<p>EU Long-term strategy towards 2050⁶⁵</p>	<p>For industry to become greenhouse gas emission free, significant modernization or replacement of existing installations will be required (e.g., to implement electrification, increased use of hydrogen, renewable synthetic gas, biomass and waste, and new process to implement a larger fraction of upgraded secondary resources).</p> <p>Some process-related emissions in the industry will be difficult to eliminate; carbon capture should therefore be considered.</p> <p>Steel, cement and chemicals dominate industrial emissions and a priority in these sectors will be a scale-up of already known technologies in the next 10 to 15 years.</p> <p>Circular economy: reduced use of primary raw materials and recovery and recycling to reduce CO₂ emissions and the EU’s reliance on critical raw materials.</p>	<p>Processes4Planet addresses the technologies listed in the EU long-term strategy to evolve towards a greenhouse gas emission free industry.</p> <p>Scaling-up technologies and de-risking investment is at the core of the partnership.</p> <p>Reducing the use of primary resources through eco-design and closing the loop of entire value chains is one of the general objectives of Processes4Planet.</p>	<p>1-2-3-4-5-6-7-8-9-11-12-13-15-16</p> <p>1-2-8-10-11-12-13-15-16</p>

⁶⁴ COM (2019) 640, The European Green Deal, 11 December 2019 (pages 7, 15 and 18).

⁶⁵ Communication from the Commission, A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, COM/2018/773 final.

<p>EU New Industrial Strategy for Europe⁶⁶</p>	<p>Europe needs an industry that becomes greener and more digital while remaining competitive on the global stage.</p> <p>To become more competitive as it becomes greener and more circular, industry will need a secure supply of clean and affordable energy and raw materials. Stepping up investment in research, innovation, deployment and up-to-date infrastructure will help develop new production processes and create jobs in the process.</p> <p>Energy-intensive industries are indispensable to Europe’s economy and are relied on by other sectors. Modernising and decarbonising energy-intensive industries must therefore be a top priority.</p> <p>The EU Emissions Trading System Innovation Fund will help deploy other large-scale innovative projects to support clean products in all energy-intensive sectors.</p> <p>Industrial sectors should be invited and incentivised to define their own roadmaps for climate neutrality or digital leadership. These should be enabled by high quality research and skills and supported by the EU. Several sectors have already taken this approach since the launch of the European Green Deal. In the co-design and entrepreneurial spirit of this strategy, this should be supported through Public Private Partnerships to help industry develop the technologies to meet their goals, as has successfully been done in industrial alliances.</p> <p>Place-based innovation and experimentation should be encouraged.</p> <p>Europe will need to ensure that education and training keep pace. Making lifelong learning a reality for all will become even more important.</p>	<p>Processes4Planet is the answer of the process industries to the call for action from the European Commission in its New Industrial Strategy. It sets a clear cross-sectorial roadmap to move towards climate neutrality and circularity while enhancing the global competitiveness of the European energy intensive industries.</p> <p>The core of Processes4Planet is to scale up innovative technologies at TRL 9 and to mobilise investment through large-scale demonstrators and innovative/circular regional hubs across the EU. The concept of “place-based innovation” is an integral part of the Processes4Planet roadmap.</p>	<p>All</p>
<p>New Circular Economy Action Plan for a cleaner and more competitive Europe⁶⁷</p>	<p>The Commission will propose a sustainable product policy legislative initiative. Priority will be given to addressing several products including high impact intermediary products such as steel, cement and chemicals.</p> <p>Secondary raw materials face several challenges in competing with primary raw materials for reasons not only related to their safety, but also to their performance, availability and cost.</p> <p>The Commission will ensure that its instruments in support of skills and job creation contribute also to accelerating</p>	<p>Processes4Planet will deliver a crucial contribution to the achievement of the objectives of the Circular Economy Action Plan. One of its general objectives is to develop circular business models through technological and non-technological innovations, cross-sectoral collaboration and engagement with the local ecosystem.</p> <p>Technological and non-technological innovations will aim at maximizing resource efficiency and flexibility. The</p>	

⁶⁶ Communication from the Commission, A New Industrial Strategy for Europe, COM(2020) 102 final.

⁶⁷ COM(2020) 98 final, A New Circular Action Plan for a cleaner and more competitive Europe, 11 March 2020.

	<p>the transition to a circular economy, including in the context of updating its Skills Agenda, launching a Pact for Skills with large-scale multi-stakeholder partnerships, and the Action Plan for Social Economy.</p> <p>The EU will also incentivise the uptake of carbon removal and increased circularity of carbon.</p> <p>Horizon Europe will support the development of indicators and data, novel materials and products, substitution and elimination of hazardous substances based on “safe by design” approach, circular business models, and new production and recycling technologies, including exploring the potential of chemical recycling, keeping in mind the role of digital tools to achieve circular objectives.</p>	<p>following specific objectives will be pursued:</p> <ul style="list-style-type: none"> • Development of solutions to ensure higher yields from complex and fluctuating raw material feeds. • Development of better collection, sorting, transportation, treatment, handling and feeding technologies for waste-derived resources. • Full traceability of value chains (a crucial instrument to deploy circular business models at scale and to serve customers’ growing demand for product-related information). • Step change in resource efficiency through digital technologies. <p>Processes4Planet also adopted as one of its specific objectives the development of technically and economically feasible solutions to capture and use residual CO₂ emissions from process industries (notably for unavoidable process emissions).</p>	
<p>White Paper on Artificial Intelligence</p> <p>(A European approach to excellence and trust)⁶⁸</p>	<p>Europe can combine its technological and industrial strengths with a high-quality digital infrastructure and a regulatory framework based on its fundamental values to become a global leader in innovation in the data economy and its applications.</p> <p>It is important to create testing and experimentation sites to support the development and subsequent deployment of novel AI applications.</p> <p>Developing the skills necessary to work in AI and upskilling the workforce to become fit for the AI-led transformation will be a priority of the revised Coordinated Plan on AI to be developed with Member States.</p> <p>In the context of Horizon Europe, the Commission will set up a new public private partnership in AI, data and robotics to combine efforts, ensure coordination of research and innovation in AI, collaborate with other public-private partnerships in Horizon Europe and work together with the testing facilities and the Digital Innovation Hubs.</p>	<p>Processes4Planet is fully committed to collaborate with the future public private partnership on Artificial Intelligence. This collaboration is crucial to achieve the objectives of Processes4Planet related to digitalisation. The deployment of AI in process industries, across sectors and across value chains will help achieve a step change in resource efficiency, climate impacts and circularity. At local level, Hubs for Circularity must fully exploit AI technologies.</p>	

Table 10 Contribution of Processes4Planet to the achievement of EU policies’ objectives (qualitative assessment)

⁶⁸ COM (2020) 65 final, EU Commission White Paper on Artificial Intelligence - A European approach to excellence and trust.

OTHER EU TARGETS, ACTION PLANS, FRAMEWORKS	SPECIFIC OBJECTIVES	Contribution of Processes4Planet	Related Innovation Areas (Processes4Planet Roadmap)
<p>The 2030 climate and energy framework⁶⁹</p> <p>The Energy Efficiency Directive</p> <p>The Renewable Energy Directive</p> <p>The EU Emissions Trading System</p>	<p>EU-wide targets for the period from 2021 to 2030:</p> <p>Reduction of at least 40% in greenhouse gas emissions (from 1990 levels).</p> <p>Share of at least 32% renewable energy.</p> <p>Improvement of at least 32.5% in energy efficiency.</p> <p>43% reduction target for EU-ETS sectors by 2030 vs. 2005</p>	<p>The European Green Deal sets even more ambitious targets by 2030 and – more importantly – sets the clear goal of a climate neutral Europe by 2050.</p> <p>The entire EU energy and climate regulatory framework and related directives will be adapted to reflect this new ambition.</p> <p>Processes4Planet will work both on emerging technologies aiming at full climate neutrality and circularity and on the scaling up of technologies already developed at higher TRLs (to deliver expected emission reductions by 2030).</p>	<p>1-2-3-4-5-6-7-8-9-11-12-13-15-16</p>
<p>EU Skills Agenda⁷⁰</p>	<p>Improving the quality and relevance of skills formation</p> <p>Boosting skills intelligence and cooperation in economic sectors:</p> <p>The innovation-driven transition to a low carbon and circular economy as well as Key Enabling Technologies (KETs) are transforming an increasing number of sectors. The supply of the right skills at the right time is key for enabling competitiveness and innovation.</p>	<p>Each innovation project in the Processes4Planet portfolio will address skills in order to better anticipate and manage the transformative change with regard to skills requirements.</p> <p>Work-based learning and business-education partnerships will be considered to achieve the right set of tools.</p>	<p>All</p>
<p>EU Strategic Energy Technology Plan (SET-Plan)</p>	<p>Improvement of energy efficiency in industry</p> <p>Development of renewable fuels and bioenergy</p> <p>Carbon capture and utilisation/storage</p>	<p>Processes4Planet integrates all technologies listed as relevant for the process industries.</p>	<p>1-4-5-6-7-8-9</p>

Table 11 Contribution of Processes4Planet to the achievement of other EU regulations (qualitative assessment)

⁶⁹ Communication from the Commission, A policy framework for climate and energy in the period from 2020 to 2030, COM/2014/015 final.

⁷⁰ Communication from the Commission, A new skills agenda for Europe – Working together to strengthen human capital, employability and competitiveness, COM/2016/0381 final.

Other reference documents

The Masterplan for a Competitive Transformation of EU Energy-intensive Industries enabling a Climate-neutral, Circular Economy by 2050⁷¹

The recently released report “**Masterplan for a Competitive Transformation of EU Energy-intensive Industries Enabling a Climate-neutral, Circular Economy by 2050**” (High Level Group on Energy Intensive Industries, 2019) underlines as priorities the need to “develop climate-neutral solutions and finance their uptake” through:

- **Establishing major R&D&I programmes across all technological readiness levels** (TRL), with a focus on bringing solutions closer to the market, and achieving better integration with national programmes, properly supported by coherent state aid rules,
- Developing **industrial demonstrators** of key breakthrough technologies by 2030,
- Facilitating access to private capital at affordable cost, including through de-risking instruments.

Analytical report on the Strategic Value Chain on low CO₂ industry / Second revised version⁷²

This detailed report analyses CO₂ emissions reduction pathways applicable energy intensive industries, namely:

- Energy efficiency and process integration,
- Alternative feedstocks/fuels (captured CO₂, hydrogen, biomass and waste),
- Electrification,
- Hydrogen-based processes,
- Carbon capture and utilisation (CCU)/CO₂-valorisation,
- Recycling, materials efficiency and circular economy,
- Higher valorisation of waste streams, materials and water efficiency.

In its conclusions, this report states that “there is a strong need for further developing existing instruments for supporting high-risk innovation projects in industry taking into consideration different stages of development”. It also underlines that “the steel, chemical and cement industries have in common, that their short-term targets (e.g. until 2025/2030) focus on the technological improvement of low-carbon “breakthrough technologies” for carbon avoidance. This includes R&D projects, pilot plants and the successive integration of new technologies in existing industrial processes. The scaling up to industrial scale operation is typically seen in the timeframe 2025-2035 and beyond. This generally stepwise implementation will depend on the technical feasibility, the availability of renewable energy and competitiveness and it is thus aligned along this time scale until ~2050 with the goal to reach 80-95% GHG emission reduction in the long-term”.

⁷¹ Report released on November 28th, 2019.

⁷² Report released on May 8th, 2019.

2.3.3. Alignments with Member States and relevant authorities

This section describes the importance of aligning Processes4Planet innovation efforts with Member States. The proposed activities and impacts on the partnership governance are described respectively under sections 3.1 and 3.3.

The nature and the size of the process industries' production facilities make them an important physical, economic and social pillar of each given region and country. An enhanced competitiveness and sustainability of these industries represent crucial factors in the economic success of regions and in the achievement of their sustainability objectives.

Processes4Planet adds to Member States' policies as many technological and non-technological innovations require a scale that surpasses the national level:

- **De-risking technologies for large scale implementation** requires R&I investments (and a market volume) that quickly surpass the possibilities of a single Member State (even if the active support of Member States is a key success factor for the entire partnership),
- The development of **regional circularity models** requires the consideration of a radius around production plants which might cover several Member States,
- A partnership with the unique ability to **monitor a broad portfolio of projects** and to disseminate lessons learned across multiple sectors and countries is a particularly effective way to speed up the transformation.

Member States have been involved in the development of the Processes4Planet partnership since the early stages: from the start the Processes4Planet Vision and Roadmap were developed with input received from a variety of stakeholders and through regular consultations performed at different levels, including at national and regional levels^{73 74}.

Many EU Member States have adopted or are considering the adoption of national climate laws. In addition, the climate laws that were adopted pre-Paris agreement are now being updated with more ambitious targets for 2030 and new targets for 2050. The climate law status quo is illustrated in Graph 10 from the European Climate Foundation⁷⁵.

⁷³ Processes4Planet has connected to different Member States in several ways: discussions with colleagues of the permanent representations of Eastern Europe countries in Brussels (e.g. Slovenia, Romania...); ad-hoc meetings or workshops with national representatives in the various countries (e.g. Poland, Austria and Portugal); joint industrial delegation visits to specific countries (e.g. Italy) or ad-hoc meetings to identify the connections between the Roadmap and national policies (e.g. Germany and France) ; workshops related to opportunities of Hubs for Circularity at regional or local level (e.g. Greece, Asturias -Spain, Belgium, Germany, Netherlands, Pays de Loire-France, Aarhus-Denmark).

⁷⁴ The members of Processes4Planet (including individual companies and European sector associations often composed of national associations) also reflected political objectives and relevant policies of Member States and regions from the very first stages of the drafting of these documents.

⁷⁵ <https://europeanclimate.org/content/uploads/2020/02/04-02-2020-climate-laws-in-europe-full-report.pdf>

CLIMATE LAW STATUS QUO

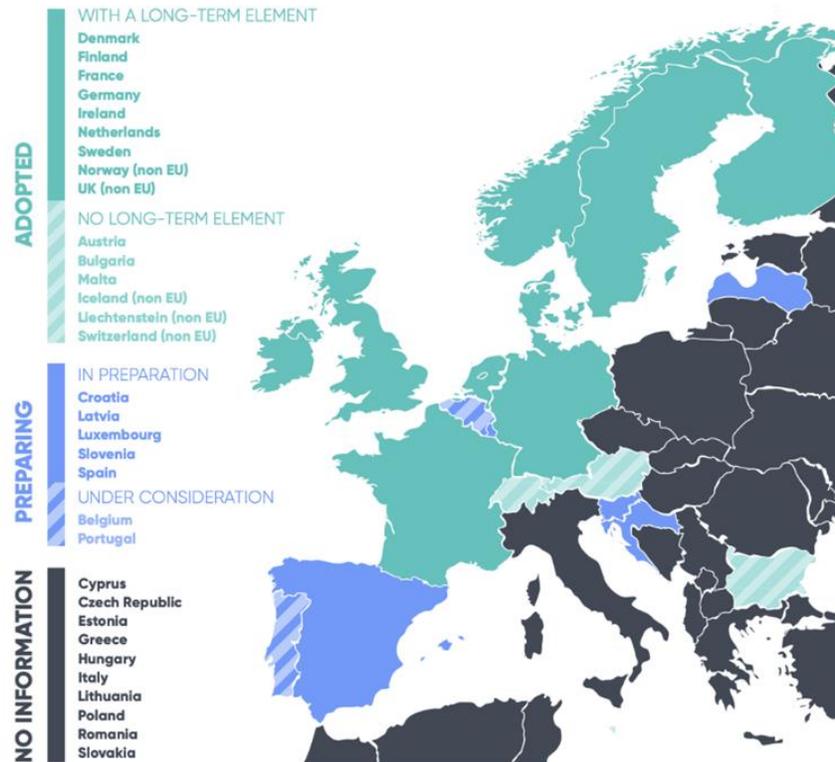


FIGURE 1: Geographic overview of the state of national framework climate laws in the EU

Source: Ecologic Institute research based on a range of sources (including legislative databases, direct legal texts, news reports and personal contacts)

Graph 10: Geographical overview of national framework climate laws in Europe (by the end of 2019)

As seen from the Graph 10, a handful of countries had already adopted such updates or laws by the end of 2019. Based on this research, Processes4Planet had a closer look at further developments within regulations of each individual country. Many other countries have adopted their national climate targets and regulations in the meantime, a majority of them establishing both, short and long-term targets. The adoption of circular economy related legislation into national frameworks seems to be taking a separate track. In some cases, measures to enable the circular economy are already part of national waste management regulations or are partly addressed in climate regulations. A non-exhaustive list of national (or regional) legislation on climate and circularity is given in Table 12.

Country	Legislation on Climate (non-exhaustive list)	Legislation on Circularity (non-exhaustive list)
Austria	Integrated National Energy and Climate Plan for Austria (2019). Climate and Energy Fund Act (2020).	Circular Economy Action Plan (2020).
Belgium	National Energy and Climate Plan (2019). More ambitious targets are included in the programmes of the newly elected Walloon and Brussels governments.	Waste-Resources Plan (Wallonia, 2018) / Flanders-Circular (Flanders, 2017) / Regional Programme Circular Economy Brussels (2016)
Bulgaria	National Climate Change Adaptation Strategy and Action Plan (2019).	Waste Management Act.
Croatia	Draft Climate Change Adaptation Strategy for the period to 2040 with a view to 2070.	Environmental Protection Act.
Cyprus	Draft Integrated National Energy and Climate Plan for the period 2021-2030.	Waste Law.
Czech Republic	Law on Protection of Air (2012). Law on Conditions of Greenhouse Gas Emission Allowance Trading (2012).	National Waste Management Plan (2015-2024). Law on Waste Management (in preparation 2019-2020, expected 2021).
Denmark	Climate law (2019)	Strategy for Circular Economy (2018)
Estonia	Climate Change Adaptation Development Plan until 2030. Estonian Environmental Strategy until 2030.	Estonian Environmental Strategy 2030.
Finland	Climate Change Act (2015). Update foreseen in 2021 with target for 2050 and emissions reduction targets for 2030 and 2040. Energy and climate roadmap 2050 (2014). Inclusive and competent Finland – a socially, economically and ecologically sustainable society' as its Government Programme (2019).	Finnish Roadmap to a Circular Economy (2019). A strategic programme for promoting the circular economy is being prepared (for 2020).
France	Loi énergie-climat (2019). Stratégie Nationale Bas-Carbone (SNBC) – (Projet 2020). Loi relative à la transition énergétique pour la croissance verte (2015).	Loi économie circulaire (2020).
Germany	Climate protection law (2019).	Circular Economy Act “Klimaschutzplan 2050”- Law on Closed Cycle Management and Waste (2012). German Closed Cycle Management Act.
Greece	National climate change adaptation strategy (2016).	National Waste Management Plan (NWMP) in 2015.
Hungary	The Second Climate Change Strategy of Hungary. National Sustainable Development Strategy (2007-2025/2050).	The Act on Environmental Protection. The Act on Waste.
Ireland	Climate Action Plan (2019).	A Circular Economy Policy and Action Plan will be developed in 2020-21.
Italy	Legge sul Clima 2020.	Rapporto sul l'economia circolare in Italia 2020.
Latvia	National Energy and Climate Plan 2021-2030. (NECP) and Strategy towards Climate-Neutrality 2050.	Latvian Waste Management Law.

Lithuania	The Strategy for National Climate Change Management Policy for 2013 – 2050.	National Environmental Protection Strategy.
Luxembourg	A climate roadmap "Generatioun Klima - Ambitiéis - innovativ - sozial gerecht" ("climate generation - ambitious - innovate - socially just"), composed of measures aimed at facilitating the energy and ecological transition (Feb 2020).	Circularity Dataset Initiative (2019) aims to develop an industry standard template for circular data on products.
Malta	National Adaptation Strategy – Low Carbon Development Vision.	The Environment Protection Act.
The Netherlands	The Climate Act and the National Climate Agreement (2019). Climate Plan & National Energy and Climate Plan (NECP) (2019).	Government-wide programme for a Circular Dutch Economy by 2050 (2016). Raw Materials Agreement (2017). Implementation programme 2019 – 2023.
Norway	Norwegian Government's strategy for green competitiveness.	Waste regulations.
Poland	National Strategy for Adaptation to Climate Change by 2020 with a vision to 2030 (2013). Development Strategy in the Area of the Environment and Water Management (2019).	Circular Economy Roadmap (2018).
Portugal	Roteiro para a neutralidade carbonica 2050 – R 262/2019.	Plano de ação para a economia Circular en Portugal – Resolução do Conselho de Ministros 12/2017, amended 07/2019.
Romania	National Strategy for Sustainable Development 2013-2020-2030.	Draft roadmap for Romanian circular economy policy from 2020 to 2030 in preparation.
Slovakia	Transition to Green Economy Process (2016). National strategy on climate change 2021-2030 (2018). Environmental Policy Strategy for 2030 (2018). Low-Carbon Strategy by 2030 with an outlook to 2050 (under preparation).	Waste Prevention Programme 2014-2018 (2014). Waste Management Programme for 2016-2020 (2015). Waste Prevention Programme for 2019-2025 (2018).
Slovenia	National energy and climate plan A Vision for Slovenia in 2050. Slovenian Development Strategy 2030.	Roadmap towards the circular economy in Slovenia (2018).
Spain	La Ley de Cambio Climático y Transición Energética (projet 2020).	Ley de Economía Circular (11-2019).
Sweden	Climate Act and Climate Policy Framework.	The Swedish Environmental Code.

Table 12 Non-exhaustive list of national (or regional) legislations on climate and circularity (10 April 2020, Processes4Planet)

The outcomes of the innovation activities of Processes4Planet will significantly contribute to the achievement of political objectives and targets of all Member States. Related industrial sectors have a crucial role to play to reduce the overall CO₂ emissions of countries, to help them achieve overall climate neutrality and to deploy circular business models at scale. But this role can only be fulfilled if indispensable technological and non-technological innovations reach full readiness.

2.4. Partner composition and target groups

2.4.1. Type and composition of partners

Accelerating the transformation towards the next generation of the European Process Industry requires driving the collaboration of a great variety of stakeholders to jointly share and develop knowledge and innovative solutions (directionality) and to mobilise investments.

Through its open and cross-sectoral approach, Processes4Planet is uniquely positioned to team-up the whole process innovation eco-system. Through the Association SPIRE, the private side of the partnership, the EU process industry will work together with the **public sectors** (EU, national and regional levels), other **industries** including **SMEs, civil society, academia, technology and research centres** as well as **funding and financing bodies** to deliver results and maximise impact.

Processes4Planet is **open to members from all the European countries** which can participate in Horizon Europe. The Association SPIRE, the private side, was created in 2012 with 28 founding members with headquarters based in nine EU countries and has grown to 163 members in 2020 with headquarters based in 22 EU countries. (Annex 4.5 provides a list of A.SPIRE founding list and a link to the membership list to date, which is updated regularly). However, many of our industries have industrial sites across Europe so P4Planet covers the full EU-27 and other countries, for example, Turkey. In addition, despite Brexit, parties from the United Kingdom are interested in engaging with Processes4Planet and the partnership would welcome an EU-UK agreement for continued excellent R&I collaboration under Horizon Europe. Stronger participation from Eastern Europe parties will also be pursued (See engagements activities in chapter 3.1).

The new Partnership will welcome newcomers including new process industry sectors, NGOs, more partners from Eastern countries, representatives of the regions and Member States (e.g.: innovation agencies or regional business development agencies) and new companies from different segments of the circular value chain (e.g. the energy sector or brand owners). Activities to engage newcomers are also described in chapter 3.

Refining and Pulp and Paper sectors are already in the process of joining the partnership and teaming up with the cement, ceramics, chemicals, engineering, minerals, non-ferrous, steel and water sectors. The sectors are represented both by their EU trade associations and individual companies, including SMEs. Conversations with the **Glass sector** and **Waste Management** are on-going, and the private side will strive to engage them in the partnership.

The direct participation of the trade associations is part the **unique P4Planet approach**. They represent the voice of a sector at European level and they will be key to connect to Member States and to broaden the voice of the new partnership. The commitment of European process industries to the objectives and roadmap of Processes4Planet is notably reflected by the very strong representation of big private entities in the partnership. Large-sized and intermediate process industries are a core element of many European industrial value chains. **SMEs** play a key role in each of the value chains (as suppliers, (sub-) contractors, customers of large enterprises or as material producers themselves) and are crucial in the creation of employment and wealth in our modern “knowledge- based” economies. SMEs developing R&I will be innovation providers to the larger industries and will find new market and growth opportunities by their involvement in the partnership. Other SMEs will also be key to provide specific solutions for industrial-urban symbiosis and the H4Cs (for example, on waste management related business).

Industries from other segments of the **circular value chain** are also welcomed in Processed4Planet and collaboration within our partnership on an individual companies’ basis will be very relevant to accelerate and enable the transitions. Companies from the textile, energy, digital and construction sectors and brand owners are already joining the partnership and participating in the development of the roadmap and overall strategy of P4Planet.

Academia and RTOs are key actors in the innovation ecosystem. Their engagement in P4Planet will be of utmost importance both in the development of key innovations (technological and non-technological) and in addressing the EU Skills Agenda. Their role is notably to help develop the innovations, engage further SMEs and develop a talented and skilled future workforce with easier access to the job market in close cooperation with all industrial actors.

Reaching the goal for Europe to become the first climate-neutral continent in the world requires a **systemic perspective**. The European Union is aiming at a massive change in the way industry and society produce and consume today. The availability of green energy at an affordable price is necessary to drive the electrification and energy efficiency of the process industry. The emissions reduction of the process industry will have a direct influence downstream in the value chain. The brand owners will require materials with specific eco-design specifications to be produced by the process industry. Citizens will need to change the way they consume and the way they manage their own waste. Regions and municipalities will need to manage waste in radically circular models. It will be necessary for everyone to “shift up the gear” to deliver the required transition.

P4Planet will pursue an efficient **alignment of efforts with other R&I partnerships and initiatives** to identify and address the mutual requirements that need to be tackled. This will include collaborations with Clean Steel, CBE, FCH, Climate KIC, EIT Raw Materials, SET PLAN #6 among others as described in section 2.3.

The expertise of **NGOs that are** active to support industries to reach the climate neutrality and circularity ambitions will provide a **link to society**. Participation of other **civil society actors** representing citizens and consumers can be very relevant in the Hubs for Circularity (H4C) where the link to social demands will happen at local level. This could include **labour unions, consumers’ associations** and other actors depending on the region, city or community.

The **collaboration and dialogue with the funding and financing bodies** will be a cornerstone for an efficient coordination of all R&I funding schemes and mechanisms (at EU, national and regional levels) along the TRL scale to reach the impact stage. Processes4Planet will work together with the European Commission (DG R&I, DG Grow, DG Clima, DG Ener, DG Environment and DG Connect), the EIB, the Member States, the regions, private foundations and other relevant financing stakeholders on the optimal blended financing approach to de-risk and trigger appropriate private investments (additionality).

More specifically, Processes4Planet also sees much value in connecting **local stakeholders** within and across regions to establish robust collaboration models delivering impact. The concept of **Hubs for Circularity (H4C)** is a major proposal for setting up new circular business and social models at regional level, with multiplication potential all over the European Union. The Hubs for Circularity will build on all the learnings and results of Processes4Planet projects and help to directly deploy circular economy at scale.

Setting up a “**European Community of Practice**”, as proposed in the Processes4Planet Roadmap, will be a cornerstone to support the Hubs for Circularity all over Europe. The collaboration with the funding and financing bodies will also seek to identify the appropriate schemes for the co-investment models of the H4Cs.

Main target groups for communication

TARGET GROUPS	RATIONALE	EXAMPLES
European Commission (EC)	<p>The EC is the public partner of the partnership.</p> <p>Our main objective is to ensure continuous alignment of the partnership with EU strategies and policies and to secure access to the most appropriate support mechanisms.</p> <p>The European Commission also supports the partnership by opening access to policy experts, knowledge, data and networking opportunities.</p>	<p><i>DG R&I, DG GROW, DG ENER, DG ENVI, DG CONECT, EASME, COMMISSIONERS</i></p> <p>...</p>
Public Authorities from Member States (MS) and Regions	<p>To successfully set up the co-programming model, to align innovation policies on a pan-European scale and ensure deployment all over Europe, it is crucial to install and maintain a dialogue with Member States and Regions.</p> <p>The Hubs for Circularity (H4C) is a novel and ambitious initiative defined in the Processes4Planet 2050 Vision and roadmap and aiming to deliver impact through geographic proximity. Regions have a pivotal role to play in making hubs a reality and connecting them to cities and communities.</p>	<p><i>Innovation & Research Ministries of MS, national/regional Innovation agencies, NCPs...</i></p>
NGOs & civil society (citizens)	<p>Processes4Planet will continue reaching out to NGOs and civil society organisations to get input from independent third parties representing citizens' interests.</p> <p>These organisations also have great impact in shaping future policies at all levels.</p>	<p><i>Carbon Market Watch, International Institute for Sustainable Development, Cambridge Institute for Sustainability Leadership (CISL), Ellen MacArthur Foundation...</i></p>
Financing Bodies & Foundations	<p>Processes4Planet will engage with all relevant financing bodies to ensure that the most efficient funding mechanisms are mobilised at the right stage of a given innovation programme along the TRL scale and that transitions between various schemes are properly managed.</p>	<p><i>EU, Member States, regions, foundations, Venture capital...</i></p>
Scientific Community	<p>A target group with impact in research & innovation and skills development. Scientific publications will be targeted to disseminate main achievements and get support and input from the scientific community. This community is represented within A.SPIRE membership through participating universities.</p>	<p><i>Science Business</i></p>
Other Partnerships & Initiatives	<p>Other Partnership & Initiatives are an important target group to create synergies and cross-fertilisation, to avoid double work and ensure the delivery of expected impacts in due time.</p>	<p><i>CBE, SET Plan, #6, Clean Steel, Digital partnerships...</i></p>

Table 13 Target groups for Processes4Planet communication

2.4.2. International dimension

Processes4Planet is confident that the available level of technological expertise and knowledge in the European Union (and in Horizon Europe associated countries) fulfils the highest standards and is a very solid foundation to deliver on its roadmap.

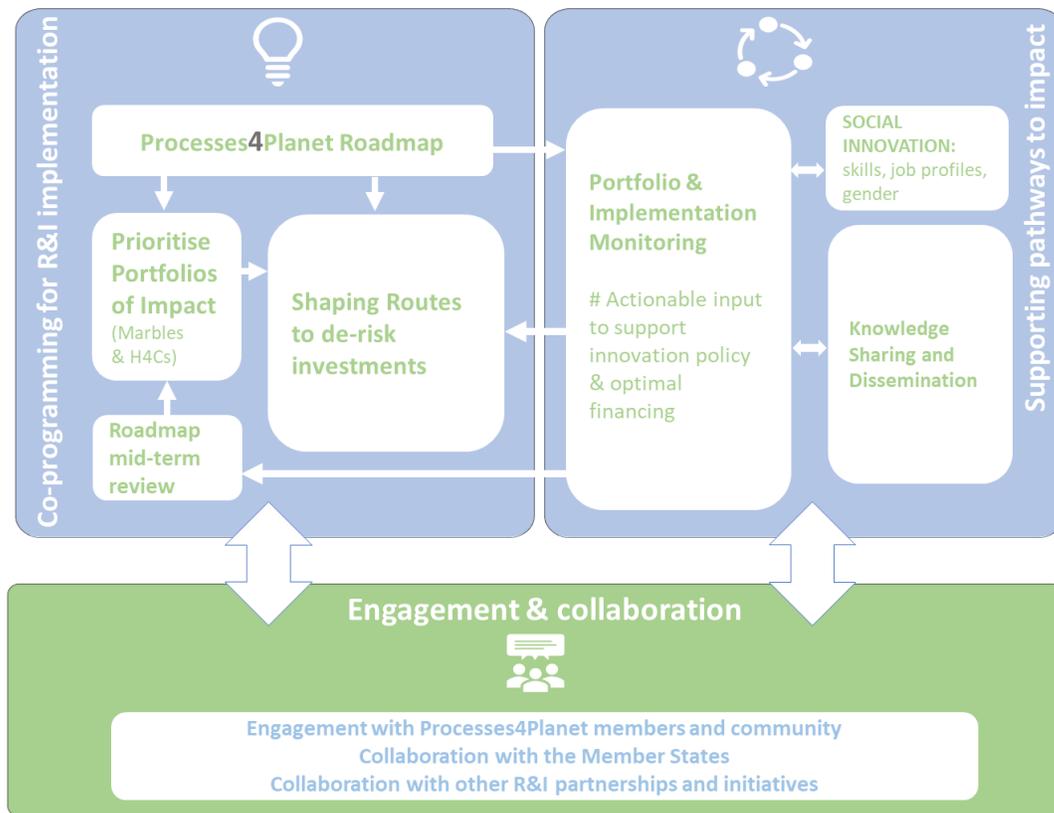
International cooperation with partners from third countries could be useful on an ad hoc basis for specific innovation programmes. If this need is identified, targeted calls for international partners could be organised. However, we should pay permanent attention to the competitiveness of European process industries and to the overall objective of the partnership to enhance the technological leadership of the European Union.

3. Planned implementation

3.1. Activities

This section describes the planned activities to manage and implement the Processes4Planet partnership and achieve success. (See Graph 11).

- **Co-programming for R&I implementation:** Activities aiming to define the routes to implement the Research and Innovation roadmap of Processes4Planet in alignment with the climate neutrality and circularity policies (EU, Member States, regions) and the global agreements.
The end goal is to deliver impact. Considering all the innovation areas and programmes defined in the 2050 roadmap, the co-programming process will define prioritised portfolios of impact to gear the implementation of the R&I needed through different routes to de-risk investments. Since Horizon Europe focuses on pre-competitive research (TRL3 to 7-8), it will also be very important to set a dialogue identifying the optimal combination of funds and financing schemes to unlock private investments and effectively reach the impact phase through the delivery of the Marbles or FOAK plants (TRL9) once the technical and economic feasibility of the innovative solutions is proven.
- **Supporting pathways to impact:** Activities supporting the paths to impact through:
 - 1) Providing actionable input for informed decision-making on innovation policy and financing along the co-programming processes considering the results of the monitoring process based on the portfolio and implementation monitoring that will consider the progress of projects and H4Cs and the learning and outcomes of the implementation of the partnership itself.
 - 2) Fostering specific actions and initiatives on social innovation that will directly benefit citizens by providing solutions to increase their access to green economy jobs. These actions will provide valuable input for the EU Skills Agenda including aspects related to gender parity (in education and at work).
 - 3) Knowledge and innovation transfer activities to cross-fertilise the results of the portfolio of projects and H4Cs (including dissemination and specific support to the network of H4Cs through a European Community of Practice).The findings of all the activities to support the pathways to impact will provide input for decision-making in the co-programming process. They will also facilitate the transfer of the results across sectors, projects and regions and into society.
- **Engagement and collaboration (transversal activities):** Activities aiming to create an open dialogue engaging the P4Planet's community, including members of A.SPIRE and the relevant stakeholders (public, private, civil society and other partnerships), to identify and develop synergies, alignments and coordinating actions. Co-programming, R&I implementation and the pathways of impact will be enriched through different mechanisms and engagement activities. The governance model proposed in section 3.3 explains the mechanisms (including a Feedback Mechanism and an Impact Panel) to ensure that all the activities fit together.



Graph 11: Implementation activities of the co-programmed partnership P4Planet



3.1.1. Co-Programming For R&I Implementation

This section explains the basis of the roadmap that will determine the co-programming activities to implement P4Planet’s R&I: the innovation areas and programmes, the Marbles (or FOAK new plants or new units in a plant) and the Hubs for Circularity. Then it explains how our roadmap embeds Horizon Europe and the blended financing for the co-programming and implementation process.

3.1.1.1. The Processes4Planet roadmap

P4Planet’s 2050 roadmap defines the cross-sectoral R&I strategy to transform the EU Process Industry to contribute its share to reach climate neutrality and a truly circular economy by 2050. All members of A.SPIRE have contributed to develop this roadmap with relevant contributions from the eight founding sectors of the partnership (cement, ceramics, chemicals, engineering, minerals, non-ferrous, steel and water). Two rounds of consultation with further stakeholders (including Member States, regions, NGOs, other sectors and partnerships among others) have been launched on-line and in ad-hoc workshops during 2018 and 2019. The new sectors invited to join the partnership have participated in these consultations. Moreover, those new sectors that are joining the partnership (refining and pulp and paper) will be invited to provide their further specific input in 2020.

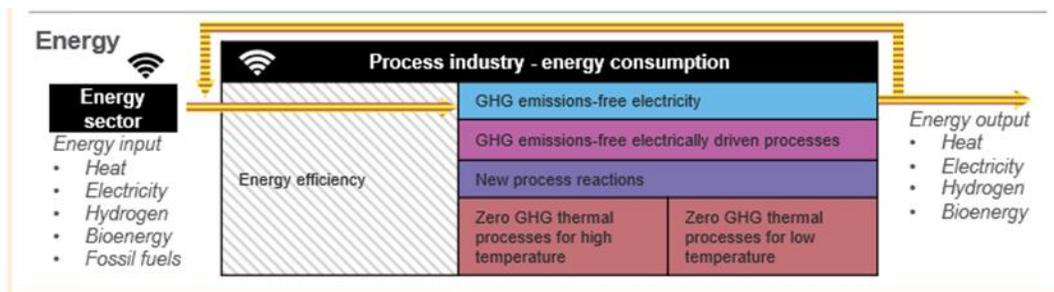
The roadmap sets up four transformation levers to reach its ambitions on climate neutrality, circularity (near zero landfilling & near zero-water discharge) and competitiveness: a) process innovation (energy mix including H₂, energy and resources flexibility and efficiency, electrification of industrial processes and CCU-CO₂), b) industrial-urban symbiosis, c) digitalisation, and d) non-technological innovation (framework conditions for market uptake, skills, etc.). 14 Innovation Areas have been identified that will lead to the achievement of the five specific objectives described in chapter 2 and shown in Table 14 below.

		Innovation areas													
		IA1	IA2	IA3	IA4	IA5	IA6	IA7	IA8	IA9	IA10	IA11	IA12	IA13	IA14
Processes4Planet		Renewable energy integration	Heat reuse	Electrification of thermal processes	Electrically driven processes	Hydrogen integration	CO2 capture for utilisation	CO2 utilisation in minerals	CO2 & CO utilisation in chemicals and fuels	Energy and resources efficiency	Circularity of materials	Industrial-urban symbiosis	Circular regions	Digitalisation	Non-technological aspects
Specific Objectives	SO1 Integrating Renewable Energy														
	SO2 Reduce emissions through CO/CO2 Capture and Use														
	SO3 Ensure full circularity and overhaul the use of waste														
	SO4 Moving towards commercially viable climate neutral and circular industry solutions														
	SO5 Fostering new skills & jobs and reducing barriers for market uptake														

Table 14 Innovation Areas to develop P4Planet’s Specific Objectives

Innovation Areas 1 to 9 tackle R&I related to CO₂eq abatements to meet the specific objectives 1 and 2 directly linked to P4Planet’s **Climate neutrality ambition**. These will result in CO₂ abatements linked to energy efficiency through electrification, renewable H₂ and CCU, and will allow assessment of which technologies are more effective in terms of abatement. The processes will need to be adapted to cope with alternative resources and other disruptive innovations to avoid GHG emissions (see Graph 12 below on energy flows). This will include:

- Electrification without GHG emissions which will require new solutions to deal with increasing fluctuations in the supply of electricity. A next generation of energy efficient technologies that drastically reduce energy consumption (like process intensification, enabled by 3D-printing of process equipment, and new separation technologies) is to be delivered.
- Technologies such as carbon capture and utilisation (CCU) routes and the upgrading of secondary resources can increase energy demand which should also be GHG emission free.
- Hydrogen, for which many new GHG emission-free production routes will be developed, will increasingly be used to provide the energy input to drive reactions, or act as a reactant or feedstock. As such, it also enables many CCU processes.

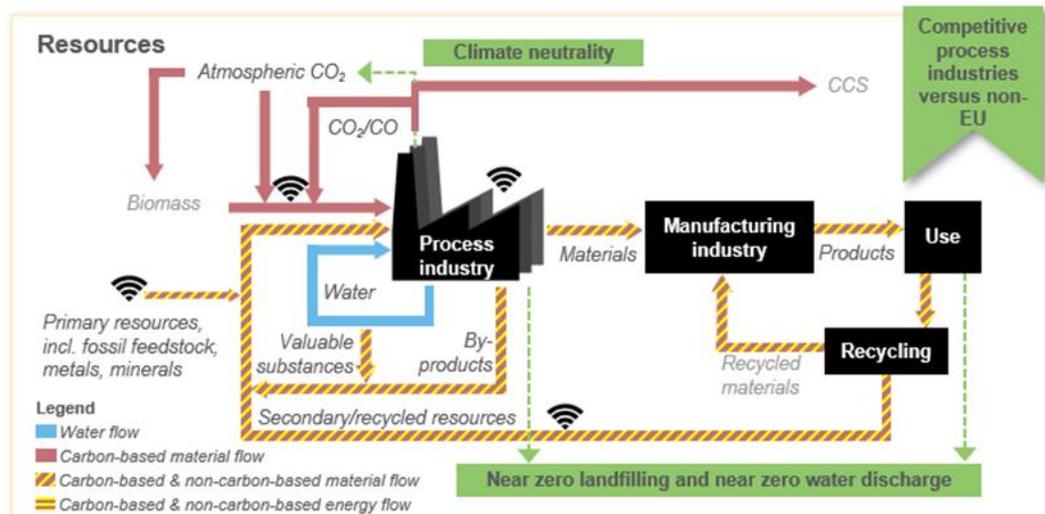


Graph 12: Energy flows of the process industries in 2050

Innovation Areas 6 and from 9 to 12 tackle R&I on several circular aspects to meet specific objective 3 directly linked with the partnership’s **ambition on circularity and resources efficiency**. These will result in closing the loops to avoid landfill through circular materials, higher use of secondary materials of which part will replace

virgin raw materials; and to avoid water discharge through the reuse and recycling of water and the recovery of water energy and solutes. The process industry is key to close the loops of waste-to-resources (see Graph 13 below on resources flows) of the circular value chains through various options which will be identified though best LCA results (reduction of overall environmental impacts) by:

- Developing circular business models extending product life and reducing material demand,
- Full recycling or even upcycling: keeping a resource in the same loop, e.g. recycling aluminium in the same product type (a main goal of the roadmap),
- Materials in waste water to be looped back into the processes as secondary resource,
- CCU: providing CO₂ as one of the primary resources (including biomass and carbon recycled from products such as plastics) for carbon-based materials or synthetic fuels,
- Developing flexible processes for an optimal use of the secondary resources and the primary resources that will still be needed (bio-based resources, virgin minerals or ores with low-carbon certification).



Graph 13: Resources flows of the process industries in 2050

Innovation Areas 11 and 12 tackle specifically **industrial-urban symbiosis** and the **Hubs for Circularity** thus addressing directly specific objective 3.

The Hubs for Circularity (H4C)

The Hubs for Circularity (H4C) will catalyse regional industry-society collaboration necessary to develop solutions within a local context (and address local barriers) by connecting various regional stakeholders. Without addressing this regional dimension, the technologies will fail to meet the ambitions in time.

A “Hub for Circularity” will be a point of industrial (large companies and SMEs) and public facilities within a particular industrial site, a region or a group of municipalities, achieving more circularity and carbon neutrality in their use of resources, while boosting the competitiveness of the EU process industry in the global landscape.

The H4Cs will be the place where demand-driven innovations will be demonstrated, facilitating industrial-urban symbiosis and circularity, whilst combining existing flows and installations. In the end, they are expected to provide demonstrations and help the Marbles roll out – but they are not themselves the demonstration units or Marbles.

Existing large industrial integrated sites will set up as H4Cs, attracting investments and fulfilling the ambitions of climate neutrality, circularity and competitiveness. Other smaller industrial sites will be triggered by these examples to move toward the establishment of their own H4C concepts. The H4Cs initiative will host hubs

with very different industrial realities learning from each other and sharing knowledge and solutions. The H4Cs should progress towards maturity and a self-sustainability stage.

The H4Cs will be large industrial sites operating at full scale and looking to exchange as much as possible in terms of water, heat, by-products, CO₂, wastes, and energy (renewable energy and H₂ integration), but also the urban waste streams. Synergies with other Partnerships (e.g. Clean Steel or Clean H₂) and initiatives (e.g. Climate KIC) to enable Industrial-urban Symbiosis and climate neutrality will be explored.

Attributes of a H4C include:

- **R&I led by the process industry** with the H4Cs taking place in areas with a relevant concentration of process industry.
- **Geographic proximity:** The H4Cs can be based in specific sites (industrial or smart cities) or cover wider areas (e.g. regions). In all cases, the H4Cs will connect the industry, the public sector, society, academia and financial bodies to develop solutions.
- **A Business to Territory plan** with a **co-investments model** to answer to the needs of society. These will reflect the demands and solutions of each H4C and will define how the different actors will collaborate to generate positive impact. It is the responsibility of each H4C to set up this strategic planning and associated agreements.
- **Nurture and foster circular resources streams** (energy, resources, data etc.) to close the loops within and across hubs. The H4Cs will interact with each other, as well as with other stakeholders such as the ports or the energy sector. While flows will be mostly related to the reintroduction of resources (and heat) from waste in the industrial processes, connections with the key product value chains⁷⁶ of the Circular Economy Action Plan within the European Green Deal will be relevant.
- **The transfer of knowledge and solutions** across hubs to scale up new circular business models across regions and to accelerate the transition between the different phases of progress of the hubs, which run from a starting level to a maturity level. At starting level, the sites/regions will need to set the conditions to become a hub and identify the demands of society. At intermediate level, the H4Cs will have a good inventory of demands and opportunities and stakeholders will be actively engaged in a hub-modus operandi. At advanced level, the H4Cs will focus on boosting synergies and maximising impact and will need support to accelerate the transition. At maturity level, the hubs will have reached an optimal level of transition towards climate neutrality and circularity and will be lighthouses to inspire other H4Cs. In the end, the H4Cs should reach the stage of self-sustainability. In all phases, they will need to have a continuous review of their Business to Territory plan and co-investment model.

The level of maturity of the symbiotic interactions to help drive the progress of industrial symbiosis projects and initiatives will be measured through the SRL (Symbiosis Readiness Level) scale from 1-to 9. This scale can apply to the innovations related to Industrial-Urban Symbiosis. A.SPIRE is doing further analysis of how this scale could apply to the H4Cs.

Innovation Areas 13 and 14 are cross-cutting and will heavily influence **competitiveness and growth**. Digitalisation will be linked to all the innovation areas and will especially influence the acceleration of innovations, the increase of competitiveness of the solutions developed, and the development of new business models.

The non-technological innovations of P4Planet will include aspects such as business models, innovations in the value chain, SMEs development through new business, skills for a renewed talented workforce (current and future employees; operators and high-level educated alike), new types of jobs for a revitalised labour market in the new green economy, recommendations to foster an industrial policy which strategically tackles

⁷⁶ The [Circular Economy Action Plan](#), released by the European Commission in March 2020, identifies seven key product value chains: Electronics and ICT, Batteries and Vehicles, Packaging, Plastics, Textiles, Construction and Buildings, Food, water and nutrients

the hurdles of the COVID and post-COVID context, and on the optimal framework and conditions to generate a market for, and protect the competitiveness of, climate-neutral and circular products. This is of outmost importance since the new solutions will increase costs (both CAPEX and OPEX) and affordability can be a significant barrier for parts of society to choose these new products. Raising awareness in society can improve acceptance, but even conscious citizens will opt for other products if they cannot afford them.

For all the Innovation Areas, and in line with the European Green Deal, the innovations developed by P4Planet's projects through circular design will aim at enabling circularity of materials and take out toxic or non-recyclable components, hazardous to health and environment. During the transition, the polluting, toxic and hazardous chemicals will be gradually removed out of the value chains and the environment and be stored in a safe sink or appropriately treated. On the other hand, the projects' solutions to reduce CO2 emissions should support the reduction of other types of emissions thus excluding solutions that would increase them. Projects should thus be designed ensuring that the solutions developed will enable progress towards climate neutrality and circularity which always consider there are no other negative effects for the environment.

A total of **36 Innovation Programmes** (See Table 15) have been identified in P4Planet's roadmap as the pathways of the different innovation areas to reach all the objectives. For each innovation programme, the full innovation cycle, from TRL/SRL 1 to 9 has been defined. Based on the current maturity level of the technologies, P4Planet's 2050 roadmap has identified the different milestones (2024, 2030, 2040 and 2050) by which the innovations can be ready, provided the right financial flow within Horizon Europe, and a blended financial approach to reach TRL9, is put in place in a timely manner.

According to the estimates in P4Planet's 2050 roadmap, several of the innovation programmes aim to deliver technologies ready for deployment by 2024. Most of the innovation programmes aim at having technologies ready for deployment by 2030. Only artificial photosynthesis is not expected to deliver any commercial technologies by that time. This is because this technology is less mature and requires more development. In 2040, most technologies are ready for deployment, and in 2050 all technologies in the roadmap are fully developed. Note that this analysis does not consider market readiness or commercial readiness levels.

			TRL9 projects, % of total			
Innovation area	IP	Innovation programme	2024	2030	2040	2050
Renewable energy integration	1a	Integration of renewable heat and electricity	32%	100%	100%	100%
Renewable energy integration	1b	Integration of bioenergy, waste and other new fuels	0%	60%	100%	100%
Renewable energy integration	1c	Hybrid fuel transition technologies	38%	100%	100%	100%
Renewable energy integration	1d	Flexibility and demand response	25%	75%	100%	100%
Heat reuse	2a	Advanced heat reuse	13%	38%	100%	100%
Electrification of thermal processes	3a	Heat pumps	15%	54%	100%	100%
Electrification of thermal processes	3b	Electricity-based heating technologies	0%	38%	100%	100%
Electrically-driven processes	4a	Electrochemical conversion	0%	31%	100%	100%
Electrically-driven processes	4b	Electrically driven separation	0%	60%	100%	100%
Hydrogen integration	5a	Alternative hydrogen production routes	25%	38%	75%	100%
Hydrogen integration	5b	Using hydrogen in industrial processes	11%	67%	100%	100%
Hydrogen integration	5c	Hydrogen storage	0%	75%	100%	100%
CO2 capture for utilisation	6a	Flexible CO2 capture and purification technologies	15%	54%	85%	100%
CO2 utilisation in minerals	7a	CO2 utilisation in concrete production	0%	50%	100%	100%
CO2 utilisation in minerals	7b	CO2 utilisation in building materials mineralisation	0%	50%	100%	100%
CO2 & CO utilisation in chemicals and fuels	8a	Artificial photosynthesis	0%	0%	50%	100%
CO2 & CO utilisation in chemicals and fuels	8b	Catalytic conversion of CO2 to chemicals or fuels	0%	13%	47%	100%
CO2 & CO utilisation in chemicals and fuels	8c	Utilisation of CO2 and CO as building block in polymers	0%	25%	63%	100%
CO2 & CO utilisation in chemicals and fuels	8d	Utilisation of CO to chemicals or fuels	0%	100%	100%	100%
Energy and resource efficiency	9a	Next-gen catalysis	10%	29%	81%	100%
Energy and resource efficiency	9b	Breakthrough efficiency improvement	14%	49%	100%	100%
Circularity of materials	10a	Innovative materials of the process industries	0%	25%	75%	100%
Circularity of materials	10b	Inherent recyclability of materials	0%	25%	75%	100%
Circularity of materials	10c	Upgrading secondary resources	5%	30%	98%	100%
Circularity of materials	10d	Wastewater valorisation	26%	44%	91%	100%
Industrial-Urban symbiosis	11a	Demonstration of Industrial-Urban Symbiosis	0%	67%	100%	100%
Circular regions	12a	European Community of Practice	33%	50%	75%	100%
Circular regions	12b	Development of Hubs for Circularity	16%	34%	72%	100%
Digitalisation	13a	Digital materials design	18%	100%	100%	100%
Digitalisation	13b	Digital process development and engineering	25%	100%	100%	100%
Digitalisation	13c	Digital plant operation	58%	100%	100%	100%
Digitalisation	13d	Intelligent material and equipment monitoring	73%	100%	100%	100%
Digitalisation	13e	Autonomous integrated supply chain management	32%	100%	100%	100%
Digitalisation	13f	Digitalisation of industrial-urban symbiosis	64%	100%	100%	100%
Non-technological aspects	14a	Integration of non-technological aspects in calls				
Non-technological aspects	14b	Human resources, skills and labour market	29%	52%	76%	100%

Table 15 P4Planet’s Innovation Areas and Programmes. Expected milestones

The Marbles: First-of-a-kind plants

The Innovation Programmes of the Processes4Planet roadmap identify innovative solutions to be developed through Horizon Europe calls up to TRL7-8. At this stage, the (prototype/system) demonstrators will typically test full equipment at small scale or the innovative parts of the equipment in operational conditions. The industry will then need to take these innovations to industrial scale for impact to be delivered. This will be done through the “Marbles”.

*A **Marble** is a First-of-a-Kind (FOAK) industrial large-scale facility (TRL9) that integrates a combination of technologies which, together, can deliver high impact.*

The **Marbles** will integrate a combination of innovations developed through Horizon Europe projects as well as enabling technologies (e.g. green electricity, H₂). All the Marbles will be FOAK plants (new plants or new units of a plant) and will confirm the impact potential at large/full scale in a competitive way, in line with the objectives on climate neutrality and circularity. Marbles can be built in companies located in or outside a H4C.

While the demonstrators at TRL7-8 developed through Horizon Europe projects will often be developed and tested with research and technology centres in their facilities, the Marbles will always be in industrial sites in order to test the innovation at real scale.

The portfolio of Marbles will cover all the Innovation areas of P4Planet’s roadmap. The sectors of the partnership are working on the identification and definition of a set of Marbles. So far, around 20 Marble concepts covering the full portfolio of Innovation programmes are under review focusing on areas such as CCU, electrification, heat, energy recovery, water, circularity, and digitalisation amongst others.

The Marbles will be launched at different stages in alignment with the milestones set in the roadmap, with Marbles expected to be launched by 2024, 2027 or 2030. Launching the Marbles will require further support

from different EU, national and private (including foundations) funding and financial schemes. An adequate blended financing approach should ensure an optimal financial flow to de-risk the full innovation cycle that will allow the subsequent scale up of the solutions and the further implementation, deployment and impact, once the technical and economic feasibility of the solutions is proven.

Attributes of the Marbles:

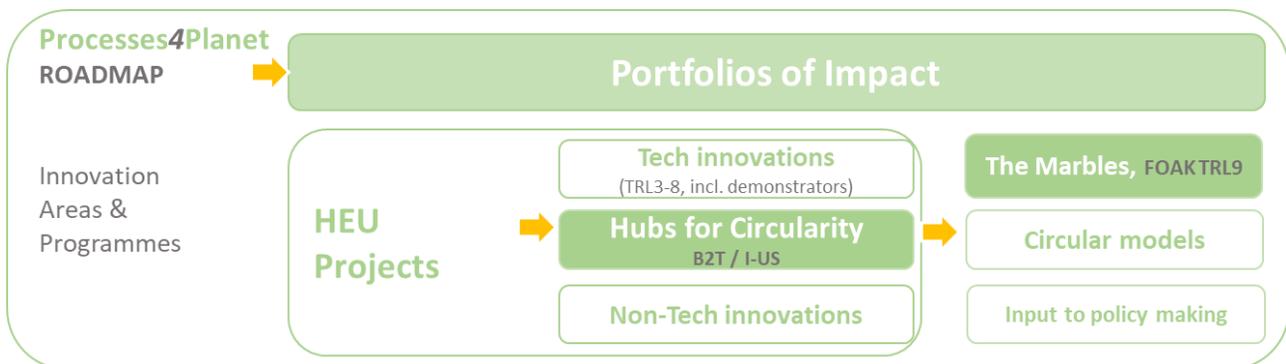
- Scale up at Technical Readiness Level (TRL) 9 after successful Innovation through P4Planet-Horizon Europe programmes.
- Lead to a significant measurable impact with respect to P4Planet’s and EU ambitions on climate, circularity and competitiveness.
- An Innovation that can be replicated to exploit the full potential of the transition to the first climate neutral continent.
- In time to meet the Ambition targets.
- Require significant investment.
- Can be mono- or cross-sectorial.
- Is connected with all elements of the value chain.

3.1.1.2. P4Planet’s co-programming model

P4Planet’s co-programming process will aim at prioritising portfolios of impact and shaping routes to de-risk investments.

Portfolios of Impact

Given the high level of ambition with regards to climate neutrality and circularity, no technology will be able to deliver the targets individually. P4Planet’s approach will be to **prioritise portfolios of impact**: groups of technologies that, combined, will have the capacity to deliver the expected impact. The portfolios will develop solutions to meet the specific objectives of the Partnership and will be linked to the Innovation Areas/Programmes of the roadmap. Both the FOAK plants (Marbles) and the H4Cs will be instrumental to integrate such solutions and trigger the transition to a climate neutral continent and a truly circular economy.



Graph 14: The portfolios of impact, a co-programming tool

The aim will be to support the portfolios of impact that can be developed through Horizon Europe projects and then integrated into FOAK plants (Marbles) through blended financing schemes so that the impact phase is reached. Alignments with the national policies will be sought. The support to the H4Cs will be instrumental to meet the circularity targets defined in national and regional policies and to scale up the transfer of circular models across sectors and borders. The learnings of the projects and the H4Cs and the results of the monitoring process will provide input for informed decision-making to be shared and discussed at the Partnership Board and with Impact Panel.

Mid-term review of the roadmap

A **review of the roadmap** will be performed at the mid-term of Horizon Europe, building on the portfolio and implementation monitoring of P4Planet's partnership as well as on a gap analysis and a GHG and circularity analysis. (See below on supporting pathways to impact). It will indicate which innovation programmes need to be further supported or which should be phased-out, either because they have successfully accomplished their mission and are in roll-out phase or because they have been proven to be unsuccessful.

Technology developments, especially in areas such as digitalisation, change very quickly. New needs appear in the context of new challenges faced by society, as the COVID pandemic is showing. The analysis will also assess if new Innovation Programmes need to phase-in and be included in the roadmap and considered in the subsequent work programmes of Horizon Europe.

It will also be used as a basis for extensive mid-term communication efforts on achieved outcomes and for a structured contribution to the mid-term review of the Horizon Europe programme and its partnerships by 2024.

Routes to de-risk Investments

For the portfolios of impact to deliver solutions in a timely fashion (as per the milestones identified in the roadmap), an optimal financial flow to de-risk the innovation investments up to TRL9 is needed. P4Planet's co-programming model will set a dialogue with the funding and financing bodies to shape and identify the optimal routes to de-risk investments.

- **Shaping Horizon Europe calls:** to deliver a portfolio of projects that implements P4Planet's R&I as per the innovation areas and programmes described in the roadmap 2050. This is the first route to de-risk the investments that will support innovations up to TRL 7-8. The co-programming process should lead to consensus of the private and public sides of the partnership meeting at the Partnership Board. The Feedback Mechanism will allow consideration of required alignments with the relevant stakeholders (e.g. Member States, civil society, other Partnerships etc.).
- **Defining the frame for an optimal blended approach.** A dialogue with the funders and financing players to achieve a good combination of schemes to de-risk the scale up of the innovations up to TRL9 will be set through the Impact Panel (See section 3.3 – governance). Based on the monitoring of the portfolio of P4Planet's projects, this will provide input and recommendations.
- **Co-investment models** that each **H4C** will need to develop in order to progress towards maturity and self-sustainability. The models should consider public and private investments to develop the needed solutions identified in the Business to Territory plan of each H4C. The blended funding and financing schemes could be useful for the H4Cs to achieve this.

Shaping Horizon Europe calls

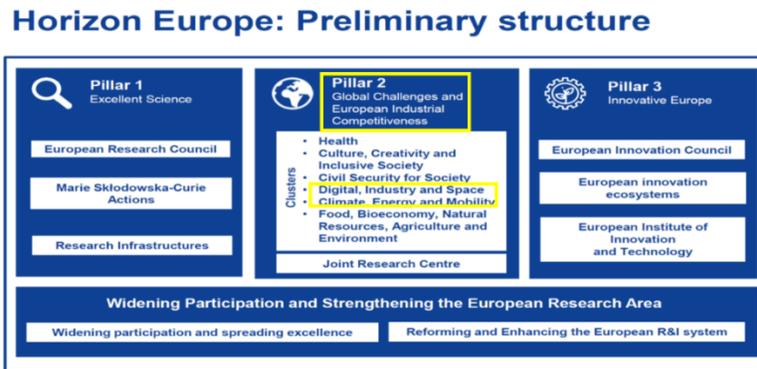
Processes4Planet is committed to actively participate in the preparation of the calls for proposals within Horizon Europe related to the achievement of the ambitions set in the roadmap and reflected in the objectives of this guidance document. The partnership will work **through all types of Horizon Europe actions** (and related calls for tenders), equivalent to the current Research and Innovation Actions (RIAs)⁷⁷, Innovation

⁷⁷ EU funding rate – 100%. Activities aiming to establish new knowledge and/or to explore the feasibility of a new or improved technology, product, process, service or solution. For this purpose, they may include basic and applied research, technology development and integration, testing and validation on a small-scale prototype in a laboratory or simulated environment. Projects may contain closely connected but limited demonstration or pilot activities aiming to show technical feasibility in a near to operational environment.

Actions (IAs)⁷⁸ and Coordination and Support Actions (CSAs)⁷⁹. Calls for **Lighthouse and flagship projects** (larger projects with higher budget within Horizon Europe) will be developed for some Innovation Programmes in order to deliver higher impact, earlier (2024, 2027 and 2030). Lighthouse projects will set a clear signal of the direction that industrial R&I should move. Flagship projects will demonstrate (up to TRL 7-8) the feasibility of system solutions with strategic potential and high impact. These will deliver the outputs of the technologies to be combined and integrated in the Marbles (FOAK new plants or new units in an established plant; TRL9).

The priority of the areas to tackle in each work programme will be assessed considering the state of the art of the innovations and the required milestones according to P4Planet’s roadmap (see Table 15 above; milestones, %). This will determine the portfolios of impact that will be clustered in relevant calls or groups of calls to develop a combination of solutions up to TRL 7-8. The results of the monitoring process (see below in this section) will provide further input for informed decision-making when developing the subsequent work programmes within Horizon Europe.

The general objectives of Processes4Planet (climate neutrality, circularity and competitiveness) and all the innovation areas and programmes are directly related to **Pillar 2** of Horizon Europe’s preliminary structure and more specifically to its **clusters no. 4** (Digital, Industry and Space) and **no. 5** (Climate, Energy and Mobility).



Graph 15: Links between Processes4Planet’s objectives and Horizon Europe structure (preliminary structure)

Future R&I activities of Processes4Planet relate to a broad range of **Intervention Areas** listed under several clusters. In some cases, we can identify a direct link with the innovation programmes and future P4Planet calls. In other cases, we identify connections that could lead to potential alignments with other Partnerships.

- **Cluster 4- Digital, Industry and Space:** direct link with “circular industries”, “low-carbon and clean industries”. The digital technologies areas are also very relevant to achieve Process Industry 4.0 with artificial intelligence, big data and cybersecurity being the most relevant aspects. P4Planet will include some specific calls addressing the digitalisation of the process industry to accelerate the innovation process and increase the cost-savings of innovations. Further alignments with the digital partnerships will also be pursued.
- **Cluster 5- Climate, Energy and Mobility:** direct link with “energy supply”, “energy systems and grids” and “energy storage” in terms of the connection with enablers of electrification and energy efficiency. There are also potential connections for the H4Cs with aspects related to buildings and industrial facilities and to communities and citizens.

⁷⁸ EU funding rate – 70%. Activities directly aiming at producing plans and arrangements or designs for new, altered or improved products, processes or services. For this purpose, they may include prototyping, testing, demonstrating, piloting, large-scale product validation and market replication.

⁷⁹ Accompanying measures such as standardisation, dissemination, awareness-raising and communication, networking, coordination or support services, policy dialogues and mutual learning exercises and studies.

- **Cluster 6- Food, bioeconomy, natural resources, agriculture and environment:** more indirect but relevant connections are identified for the development of solutions to control water pollutants and the use of bio-resources (energy mix, feedstock, valorisation of waste water).

The following graph shows the main connection of Processes4Planet innovation areas and programmes with the Areas of Intervention of Horizon Europe. Annex 4 identifies the detail of the links of each innovation programme.

Clusters	Areas of intervention	
Health	<ul style="list-style-type: none"> • Health throughout the life course • Non-communicable and rare diseases • Tools, technologies and digital solutions for health and care, including personalised medicine 	<ul style="list-style-type: none"> • Environmental and social health determinants • Infectious diseases, including poverty-related and neglected disease • Health care systems
Culture, creativity and inclusive society	<ul style="list-style-type: none"> • Democracy and Governance • Social and economic transformations 	<ul style="list-style-type: none"> • Culture, cultural heritage and creativity
Civil security for society	<ul style="list-style-type: none"> • Disaster-resilient societies • Protection and Security 	<ul style="list-style-type: none"> • Cybersecurity
Digital, Industry and space	<ul style="list-style-type: none"> • Manufacturing technologies • Advanced materials • Next generation internet • Circular industries • Space, including Earth Observation • Emerging enabling technologies 	<ul style="list-style-type: none"> • Key digital technologies, including quantum technologies • Artificial Intelligence and robotics • Advanced computing and Big Data • Low-carbon and clean industry • Emerging enabling technologies
Climate, Energy and Mobility	<ul style="list-style-type: none"> • Climate science and solutions • Energy systems and grids • Communities and cities • Industrial competitiveness in transport • Smart mobility 	<ul style="list-style-type: none"> • Energy supply • Buildings and industrial facilities in energy transition • Clean, safe and accessible transport and mobility • Energy storage
Food, bioeconomy, natural resources, agriculture and environment	<ul style="list-style-type: none"> • Environmental observation • Agriculture, forestry and rural areas • Circular systems • Food systems 	<ul style="list-style-type: none"> • Biodiversity and natural resources • Seas, oceans and inland waters • Bio-based innovation systems in the EU Bioeconomy

Graph 16: Main direct links between Processes4Planet’s objectives and Intervention Areas of Horizon Europe (preliminary structure)

Processes4Planet will also contribute to two of the current **Mission areas** in Horizon Europe:

- **Adaptation to climate change including societal transformation:** alignments with this mission will be explored (systemic solutions and international development in the field of climate change, water management, sustainable production and consumption and citizen engagement),
- **Climate-Neutral & Smart Cities** aim to develop systemic and transformative solutions for climate-neutral smart cities. Links and joint efforts can be established with the Hubs for Circularity.

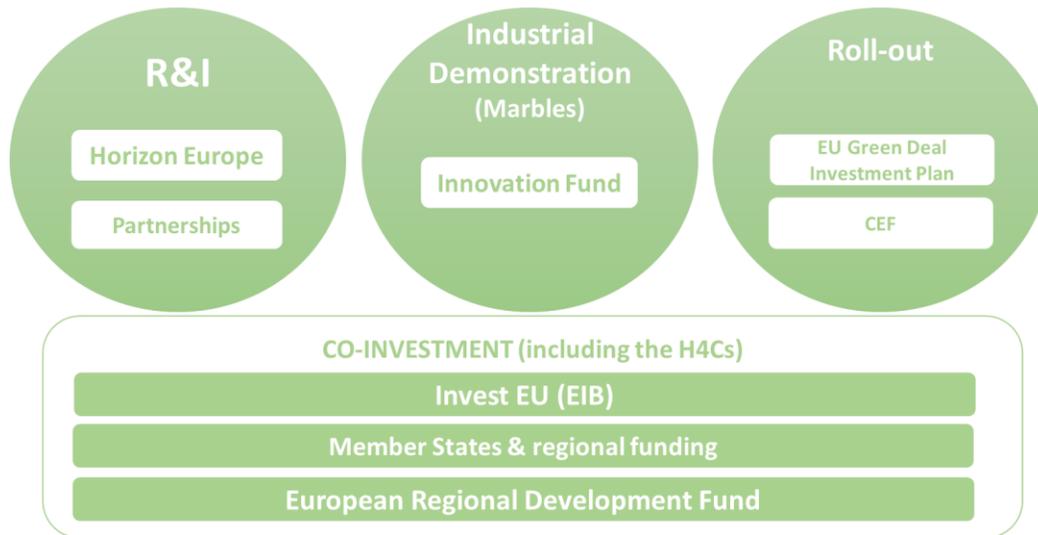
Defining the frame for an optimal blended funding and financing approach

The process industry can only deploy the innovations and deliver impact once they have developed large-scale demonstrators and first-of-a-kind plants at TRL9 (the Marbles). This last innovation phase requires high-level, high risk and long-term investments which are not supported by Horizon Europe. The process industries will need to use a blended finance approach to mobilise capital flows beyond Horizon Europe and develop the Marbles to reach the first-deployment phase. The analysis of P4Planet’s portfolio of projects and innovations will facilitate an informed dialogue with the public side (through the Impact Panel) on the best combination of schemes to cover the innovation funding gap and effectively de-risk the necessary private investments.

The Hubs for Circularity will also require specific co-investment models to scale up circularity and deploy solutions. Some investments will not be directly related to the process industry but can significantly contribute to achieving the goals of climate neutral and circular regions. For example, a H4C could identify the need to set up a specific infrastructure to sort out waste in a way they can provide resources to the process industry as opposed to sending waste to landfill. Each H4C should consider which resources are

available in each case (e.g. Member State, regional or structural funding).

Graph 17 identifies the main instruments that can be potentially used in a blended approach to move from proof of concept to roll out. In principle, the various schemes address the different stages of the path to impact. Nonetheless, the support is limited in comparison with the level of private investment needed. The process industry needs a higher intensity of support to unlock investments in the industrial demonstration phase (the Marbles).



Graph 17: Potential instruments for innovation development and H4Cs co-investments

Support from TRL1 to 3

This includes calls from pillar 1 of Horizon Europe as well as national instruments to support frontier research. P4Planet’s community can access those funds and provide recommendations to ensure that the right developments at TRL2-3 are in place on time to reach the milestones set in the roadmap.

Further support to R&I from TRL3 to TRL8

All EU and national/regional/private funding schemes are under consideration. This could include programmes such as LIFE or Interreg as well as other calls from Horizon Europe including calls that align with the Implementation Plan of SET PLAN #6. These can support further developments of innovations from P4Planet’s community in support of the SMEs, with value chain approaches or on the development of materials that will also require innovation in the industrial processes from an eco-design perspective. In this sense, P4Planet’s community will be open to provide input to regular calls of Horizon Europe on aspects related to innovation on materials and establish links with the partnership calls on innovative processes linked to such materials innovation. The H4Cs could benefit from these schemes to accelerate specific developments with a local or EU interest, which could later be transferred across hubs and regions.

Support for industrial scale demonstration (TRL9)

The **Innovation Fund** is the main instrument of the European Commission to support highly innovative projects that can bring significant emission reductions and that require higher levels of capital to scale up innovations, including the demonstration of FOAK and industrial symbiosis.

Roll-out investments

InvestEU will be able to provide additional investment support to projects financed by the Innovation Fund through loan guarantees or equity contributions. Several funding schemes can also provide support, notably

CEF Energy (Connecting Europe Infrastructure) for renewable energy infrastructure and the Industrial Infrastructure funds. The [European Green Deal Investment Plan](#) (notably through the ERDF and the Cohesion fund or the Just Transition Fund) will also be relevant. These schemes should be combined.

Cross-cutting schemes:

Other schemes should ensure support to additional costs and risks linked to innovation, to the demonstration of climate neutral and circular solutions, to SME development or to the H4Cs.

P4Planet projects will develop pilots and demonstrators in specific locations. Synergies with **national programmes** can be established to support the scale up of pilots and demonstrators. **The IPCEI (Important Projects of Common European Interest)** scheme covers all TRLs and it will further enable Member States to offer support to first industrial deployment (Marbles) through repayable advances, loans, guarantees or grants and by a more flexible approach to State Aid. IPCEIs are complementary to R&I partnerships. The selection of the Strategic Value Chain Low Carbon Emissions Industry as one of the six strategic value chains selected by the High-level Group on IPCEI is thus expected to unlock specific investments that can be used to help launch P4Planet's Marbles.

The **national and regional funds** will be especially relevant in the definition of the H4C co-investment models related to their Business to Territory Plans. As signalled by the High-level Group of Energy Intensive Industries, the **European Regional Development Fund (ERDF)** should be in line with the smart specialisation priority areas⁸⁰. This would enable the regions to further allocate resources to the H4Cs, fertilise their smart specialisation strategies and enable innovative SMEs development and growth.

Both, the H4Cs and SMEs can further benefit from the **Just Transition Mechanism** including: the InvestEU dedicated just transition scheme, EIB dedicated loan facility for the public sector and the Just Transition Fund, which will allocate an extra fresh funding of EUR 7.5 billion to mitigate the adverse effects of the climate transition by supporting the most affected territories and workers concerned. SMEs can also benefit from other schemes such as **COST**, InvestEU, **LIFE**, or funding from **EIC (European Innovation Council)** within Horizon Europe.

Co-investment models for the H4Cs

The Hubs for Circularity will also require specific co-investment models to scale up circularity and deploy solutions. The co-investment models will define how the public and private investments will be triggered to develop the innovative solutions identified in each Business to Territory Plan. Each H4C will be responsible to develop its own Business to Territory (B2T) plan and its co-investment model. The impact panel will further discuss the options available for appropriate co-investment models for the H4Cs.

Some investments will not be directly related to the process industry but can greatly contribute to achieve the goals of climate neutral and circular regions. For example, a H4C could identify the need to set up a specific infrastructure to sort out waste in a way they can provide resources to the process industry as opposed to sending waste to landfill. Each H4C should consider which resources are available in each case (e.g. Member State, regional or structural funding) considering the schemes of the blended financing approach, including tools such as the regional funds, Invest EU, State Aid or, potentially, the IPCEI scheme. The Just Transition Fund can also benefit those EU regions which are eligible under this scheme.

The co-investment models will also identify the private investments of industry and SMEs. The private leverage will apply to the H4Cs as well as to all the P4Planet's projects. Each H4C should consider how to best support innovative SMEs to find new opportunities to grow. From Horizon Europe, calls including cascade funding can provide flexibility to support specific initiatives within the H4Cs developed by SMEs and start-ups. Cascade funding would provide SME-friendly schemes simplifying the administrative procedures and

⁸⁰ "Masterplan for a Competitive Transformation of EU Energy-intensive Industries Enabling a Climate-neutral, Circular Economy by 2050", (High-Level Group on Energy-intensive Industries, 2019)

shortening the time to grant, thus allowing new small companies to participate, develop innovations in collaboration with their customers and find new business opportunities. The H4Cs could potentially benefit from the IPCEI scheme to boost investments and accelerate the transformation. In particular, SMEs could benefit from a more flexible approach to State Aid.



3.1.2. Supporting Pathways To Impact

3.1.2.1. Portfolio & Implementation Monitoring

An integrated monitoring of the performance of the projects and the H4Cs in the different innovation areas and programmes will be implemented⁸¹. Progress will be monitored for clusters of projects which contribute to a given technological (or non-technological) solution or to a given expected impact in the case of full implementation (climate, circularity, competitiveness & investments). The monitoring process will also cover the Hubs for Circularity, cross-sectoral activities and the impact of the partnership itself on the different types of members through environmental, social and economic KPIs.

Tools for monitoring can include:

- A Progress Monitoring Report (biannual) based on a survey of the projects and H4Cs to check if the innovations are on the correct trajectory towards achieving the ambitions and objectives.
- A GAP analysis to identify the funding gaps towards achieving the objectives can be issued before the mid-term review of Horizon Europe and the Partnerships.
- A GHG and Circularity Special report based on the state of the art of the process industry which will include recommendations to unlock investments to accelerate innovation and scale up.

The project portfolio and implementation will facilitate informed decision-making by:

- Screening the progress of the projects and the H4Cs towards the objectives,
- Identifying the state of the art of GHG emissions and circularity as well as the financing gaps,
- Setting the priority of the portfolios of impact along the Horizon Europe work programmes,
- Enabling Processes4Planet to make **timely adjustments in the prioritisation of the various Innovation Areas and Programmes**,
- Providing information to elaborate **recommendations and actionable input for the European Commission and the Impact Panel**,
- Helping create opportunities **for synergies between projects, innovation areas and programmes**, and between Processes4Planet and other partnerships or initiatives,
- Enabling the mid-term review of the roadmap and of the partnership including the assessment of the added value delivered and the need for a potential phasing out strategy or for a renewal of the partnership under the following EU R&I framework programme.

Input to support market uptake: regulations and standards

The delivery of expected impacts does not only depend on technological innovations. It will only take place if it is actively supported by an enabling regulatory framework, which should notably incentivise:

- The market uptake of climate-neutral circular solutions (incentives, standards, green procurement, etc.),
- An economically/environmentally sound and harmonised pan-European waste management (collection, sorting, transport, processing),
- Establishing a level-playing field between regions and sectors, and between climate-neutral and traditional solutions,
- A sufficient supply of affordable renewable energy,

⁸¹ Building on the outcomes of the SPRING project (Horizon 2020).

- A strong and sustainable investment landscape.

Recent communications from the European Commission in the framework of the European Green Deal⁸² are very encouraging, as they identify and address the regulatory bottlenecks listed above. Processes4Planet will formulate **recommendations related to the (potentially) required changes in regulations and incentives** to enable industrial-scale deployment, which will be communicated to the European Commission.

Consolidated recommendations and Actionable Input

Consolidated recommendations with actionable input will be published and regularly updated on the Processes4Planet website and widely shared. These will build on the conclusions of the monitoring process regarding the progress of the portfolios of impact and the optimal blended funding and financing needed to reach impact. Actionable input will include an analysis of which innovations are ready to be integrated in FOAK plants (Marbles) or in the H4Cs to scale-up climate neutral solutions and circular models and then transfer them to other sectors and regions.

Actionable input on the non-technological aspects that influence the delivery of impact will also be included in the consolidated recommendations to share with the Impact Panel. These will build on: the conclusions of the project HARMONI (in which seven A.SPIRE sectors have participated) in relation to standards and regulations; on the findings and developments on the project SPIRE-SAIS on skills for industrial-urban symbiosis with a consortium rooted in P4Planet's sectors; and on the developments of the future projects in regards to the roadmap's Innovation Action 14 which presents a holistic approach to non-technological innovation including framework conditions, market and consumers, common tools and the labour market. The specific actions related to social innovation are described below.

The recommendations will consider the conclusions of the open discussion with all the relevant stakeholders (including Member States, civil society and other partnerships) through the Feedback mechanism. The actionable input will be a key tool for the discussions with the funding and financing bodies through the Impact Panel to ensure the appropriate routes to de-risk the investments and reach the impact stage are set.

3.1.2.2. Social innovation: skills, new job profiles and gender balance

Skills and education are a bottleneck to develop, implement and unfold the full potential of new technological solutions within and across companies (e.g. industrial-urban symbiosis). Through Innovation Area 13, skills are an important element of P4Planet's non-technological innovation. The calls within Horizon Europe will consider skills and jobs as a transversal aspect to be worked by all the projects, in alignment with the EU Skills Agenda. The projects will identify the skills and jobs for the future, including digital, considering all levels of the industrial workforce (from operators to high-skilled profiles) and will deliver training and tools.

To bridge the gap between the fast-changing new skills demands of the companies and the training and education support, P4Planet will pursue the transfer of the projects' findings into actionable input that policy-makers (EU, national and regional), academia and other stakeholders can turn into new curricula, new upskilling pathways or include in the European Qualification Framework; thus contributing to the New Skills Agenda for Europe⁸³.

The partnership will seek collaborations with different stakeholders. The developments within the SPIRE-SAIS project (funded through ERASMUS+) on skills for Industrial -Urban Symbiosis will strongly contribute to one of the key initiatives of the Skills Agenda: the blueprint for sectoral cooperation on skills. The results of

⁸² COM (2019) 640, The European Green Deal - COM (2020) 102, A New Industrial Strategy for Europe - COM (2020) 98, A New Circular Action Plan for a cleaner and more competitive Europe.

⁸³ European Commission. (2016). Communication on new skills agenda, human capital, employability and competitiveness 2016. <http://www.ipex.eu/IPEXL-WEB/dossier/document/COM20160381.do>

the monitoring of P4Planet's projects and the input of all the sectors of the partnership will feed information for the SPIRE-SAIS consortium partners to consider.

Other actions include the connection with activities of the KICs on training for future skills; knowledge sharing and new digital learnings arrangements with A.SPIRE academia members; engagement in the future "Pact for Skills" of the European Commission with large-scale multi-stakeholders partnerships⁸⁴; and connection to other Horizon Europe schemes such as the Marie Curie Training Networks.

Dissemination of all the results of P4Planet's projects on skills and jobs to ensure they are considered by Member States in their respective skills mapping will also be a relevant activity. This could include a structured dialogue with the Member States through the Impact Panel.

The gender balance approach will overarch all P4Planet's activities, actionable input and dissemination related to social innovation. Research developed by Accenture⁸⁵ concludes that "employees' innovation mindset is six times higher in the most-equal cultures than in the least equal ones." The report also identifies that the global gross domestic product would increase by up to USD 8 trillion by 2028 if the innovation mindset in all countries were raised by 10%. Considering these findings, the report concludes that equality is the multiplier of innovation. This makes gender parity (access for males and females) in education, and especially in technological education, a critical building block for innovation.

3.1.2.3. Knowledge & Innovation Transfer

Dissemination and Communication

A.SPIRE will focus its efforts on the dissemination of achieved results and impacts, and on knowledge sharing activities. It will act as a single depository for information related to all Processes4Planet R&I projects.

The following dissemination and knowledge sharing tools and actions are on the agenda:

- An enhanced **knowledge sharing platform** where all members can openly share information and engage in networking. The platform includes an online brokerage area where members and non-members can submit their project idea, present their expertise, search for partners and build consortia⁸⁶. The platform also includes dedicated sections for the R&I projects and for the Hubs for Circularity open to all stakeholders.
- A.SPIRE will maintain a **Processes4Planet website**, which will include an "**outputs section**" (hosting the public results of projects and Hubs for Circularity), a **funding search functionality** giving access to all calls relevant to the process industries, as well as **education and training material**, links to published papers, demonstration pictures, technology reviews, etc.
- A free-of-charge service to host **dedicated project websites** (also accessible after the end of the project without time limit).
- A **quarterly newsletter to be** forwarded to more than 1 500 stakeholders and is accessible to the general public through free subscription on the Processes4Planet website. Participation in fairs and conferences to enable outreach to a wider number of stakeholders. This can include fairs such as INDTECH or conferences related to the Green Economy, the skills agenda or other relevant events for the objectives

⁸⁴ The "New Circular Action Plan for a cleaner and more competitive Europe" (COM(2020) 98 final, 11 March 2020) mentions that "the Commission will ensure that its instruments in support of skills and job creation contribute also to accelerating the transition to a circular economy, including in the context of updating its Skills Agenda, launching a Pact for Skills with large-scale multi-stakeholder partnerships, and the Action Plan for Social Economy."

⁸⁵ (Shook & Sweet, 2019)The report defines "Innovation mindset" as "a new way to measure an individual's ability and willingness to innovate". The analysis is based on an econometric model that analyses six key elements of the innovation mindset: purpose, autonomy, resources, inspiration, collaboration and experimentation.

⁸⁶ In addition to annual brokerage events organised by the association.

of the partnership.

- Organisation of workshops and other events to support the transfer of knowledge and innovative solutions across sectors, H4Cs and regions. These will often intend to engage the P4Planet’s community and are further described within the “Engagement and collaboration” section below.
- Activities to raise awareness and set an open dialogue with Members of the European Parliament will also be developed through ad-hoc activities in the frame of the Knowledge4Innovation Forum in the European Parliament and by involving the MEPs in our community engagement activities (see below) and, especially, in our stakeholders events.

All the dissemination and communication actions of Processes4Planet will target all the stakeholders described in Chapter 2 as well as the general public, through our website or social media. Events can take place face-to-face or virtually.

Specific support to Hubs for Circularity

Processes4Planet has the ambition to seed more than 15 Hubs for Circularity throughout European territory by 2030 through projects within Horizon Europe.

The deployment of Hubs for Circularity requires an active collaboration between public and private sectors at all levels, an enabling regulatory framework (notably on waste, permits, market uptake), as well as exchanges of information, lessons learnt and best practices. In order to support the Hubs to reach maturity and replicability, A.SPIRE will organise a **Community and H4C Forum** (yearly) and proposes to set up a **“European Community of Practice (ECoP)”**, led by A.SPIRE.

These two tools will be fundamental to facilitate the H4Cs in sharing knowledge and transferring solutions so that circularity can be scaled up across H4Cs and regions. The tasks of the ECoP will include:

- Synthesis of findings into generic learning/frameworks and keeping knowledge about state-of-the-art solutions updated,
- Enabling prioritisation of Industrial – Urban Symbiosis (I-US) projects,
- Definition of common performance metrics for Hubs for Circularity⁸⁷,
- Exchanges of information and knowledge (events, website, guidelines for the Business to Territory Plans promoting an inclusive approach and an active engagement handbook for industrial-urban symbiosis, other tools capturing the (non-)technological know-how from other regions),
- Connection and coordination with relevant “place-based” innovation and experimentation initiatives⁸⁸ from other R&I partnerships (e.g. Water Labs, the Transformation Hubs of EIT Climate KIC, Innovation Hubs of EIT Raw Materials, “Hydrogen Valleys” of FCH).

The A.SPIRE Advisory group is designing the best model to implement the ECoP. This could take the form of a permanent Working Group and collaboration with other stakeholders and initiatives. Other options are being considered. The roadmap identifies EUR 20 million will be needed, up to 2050, to build and develop the European Community of Practice that will connect the H4Cs through ad-hoc projects under Horizon Europe (e.g. CSAs).

The Kalundborg Symbiosis centre (Denmark) is an initiative of reference in regards industrial symbiosis and a lighthouse to inspire other regions. There are several other current initiatives that can become Hubs for Circularity such as the Smart Delta Resources (Netherlands), trilateral region of North Rhine Westphalia (Germany), Flanders (Belgium) and the Netherlands, Mo Industrial Park (Norway), and Industrial Green Tech

⁸⁷ For instance: savings of non-renewable primary resources, waste diverted from landfill/incineration, impact on CO₂ emissions, jobs and skills creation.

⁸⁸ “Place-based” innovation and experimentation initiatives are encouraged by the recently released “New Industrial Strategy for Europe”, COM(2020) 102 final.

(Norway). Other regions, like Asturias in Spain, share the goals of the H4Cs and are ready to start and develop their Business to Territory plan and move forward in their transition to become a circular region.

P4Planet will identify further sites, cities or regions that can become H4Cs considering their policies on climate neutrality and circularity and the level of concentration of process industries. A.SPIRE has created an ad-hoc H4Cs Task Force that will further develop how to map the potential areas for H4Cs and how to reach the relevant sites or regions in order to raise awareness on the opportunity to develop the H4Cs and contribute to further shape the concept. Conversations with DG R&I, DG Grow and JRC on the mapping are planned since there is an EU initiative on mapping following the proposal of the HLG-EII. P4Planet aims to establish synergies with this initiative. The H4C Task Force will also define how to structure the European Community of Practice to support the hubs.



3.1.3. Engagement and Collaboration

3.1.3.1. Engagement with Processes4Planet community

P4Planet engages with a wide and vibrant community that teams up industry, academia, research centres, public authorities (EU, national, regional), NGOs, other partnerships and initiatives as well as funding and financing bodies.

As well as all the dissemination activities described above, **workshops, brokerage events, dialogue tables, forums and** other types of interactive face-to-face or online events will be regularly organised in order to share and build knowledge, trigger discussions, get feed-back, build collaborations and facilitate cross-fertilisation of results that can boost the delivery of expected impacts.

We will strive to include interactive activities such as project pitches and presentations of Hubs' results, demo activities, or a P4Planet innovation award. The events will be face-to-face when COVID restrictions allow or online including webinars on the added value of membership (for newcomers), online brokerages, virtual meetups and innovation market places (with funders and investors).

Some of the activities will target a specific added value to the members of the association. However, a number of activities will be open to all stakeholders including:

- The **Community and H4C Forum**, which will gather all P4Planet's projects and H4Cs and will be open to all stakeholders. The Forum will be a space to share findings and to explore unique and constructive solutions to common problems capitalizing on the creative power of the group,
- Future editions of the **European Process Industry Conference**,
- **Side events or encounters with local / national representatives** back to back with Board meetings in different EU countries (e.g. Eastern Europe),
- Projects / H4Cs events back to back with larger industrial fairs,
- Activities organised in collaboration with the European Commission such as the R&I days.

A.SPIRE has created a Board of Directors **subgroup working on proposals to accelerate change and engage newcomers**. Initial proposals include:

- Engaging companies to actively contribute to P4Planet's objectives and support them to discover and assess paths to accelerate the transition towards climate neutrality and circularity with competitive returns on investment,
- Making more proactive pushes to create consortia, initiatives, projects and H4Cs,
- Discussions about the European Green Deal and how to connect with the different levels of decision-making to strengthen the paths from R&I to impact,

- Building up a relevant spectrum of ideas for cooperation tackling aspects such as digitalisation, sustainability and skills.

This would imply an active role for the A.SPIRE Board and the advisory group in the identification and interaction with stakeholders and in the definition of specific actions to accelerate change. By organising at least one Board of Directors meeting in a different European country every year (e.g. in Eastern Europe countries), the Directors of the Board and members of the Partnership Board will proactively establish direct contact with newcomers: regions, cities, industrial sites, academia and research centres and will engage companies to actively contribute to achieve the objectives of P4Planet. The proposals and conclusions of this subgroup to accelerate change will be shared with the Impact Panel (see section 3.3). This enables a more orchestrating role of A.SPIRE in addition to current activities.

3.1.3.2. Collaboration with Member States (and Regions)

A structured dialogue is needed to ensure alignment with **national/regional policies and R&I activities**. Some key objectives of these alignment activities are:

- **Consistency, additionality and efficiency in the use of public and private R&I resources** at the different phases of the innovation project (resource pooling); in particular, Member States and regions can play an important role in the testing/deployment phases of the innovation in synergy with Cohesion Funds and CEF investments,
- **Avoidance of double work** across R&I projects financed by the different levels of public authorities,
- **Proximity to EU citizens' needs and concerns** and higher **visibility and diffusion** of achieved outcomes, through continuous exchanges on planned activities and achieved progress,
- Dialogue about planned and/or desirable **developments of (national/regional) standards and regulations**.

3.1.3.3. Collaboration with other R&I partnerships and initiatives

A.SPIRE aims at **complementarity** of activities with other relevant R&I partnerships or initiatives⁸⁹. Collaborations will be established following a value chain approach (suppliers and customers) and the systemic approach (the eco-system), including:

- **Innovations requiring a sufficient and affordable supply of specific material or energy resources**, including critical raw materials, require collaboration with other initiatives focusing on the supply (production, transport, storage) of those resources. The existing collaboration through SET PLAN Action 6 can be the platform that gathers the dialogue between the energy sector and the energy intensive industries.
- **Innovations related to goods produced by our customers (manufacturing industries, contractors using materials supplied by process industries) and to the end-of-life of those goods (waste treatment)**, require collaboration along the value chain to implement a “circular-by-design” and life-cycle approach. For example, a potential collaboration on “circularity by design” is under discussion with Made in Europe.
- **Hubs for circularity** require collaboration to design and deploy circular business models.
- Innovations related to the **adaptation or co-creation of digital technologies** to make Process Industry 4.0 a reality. These innovations require a structural collaboration with digital partnerships.

Collaborations need to be based on a specific purpose and be feasible in terms of scope. The innovation eco-system is large and the number of initiatives and possibilities of collaboration is larger. The number of joint actions and working groups needs to be rationalised to be effective. P4Planet will assess the opportunities and will participate in those joint actions which will lead to the achievement of the partnership's objectives.

⁸⁹ Relevant partnerships and initiatives were identified under section 2.2. of the present Guidance Document.

The types of actions considered include: joint events to cross-fertilise projects' results, joint papers addressing innovation topics of common interest, joint calls or other joint collaborations through the European Community of Practice.

For **non-technological innovations**, the planned collaboration activities related to social innovation were detailed above (see Skills and jobs).

3.2. Resources

High ambitions require focused and effective efforts and higher-ambition leaders. Processes4Planet counts on its wide and diverse committed community to fulfil the ambitions and objectives of the partnership. At least ten leading sectors of the European Process Industry will be engaged in the implementation of the partnership's 2050 R&I roadmap developing solutions to tackle climate neutrality and real circularity and adhering to the objectives and KPIs described in chapter 2.

Private side, main commitments

Resources contributed by the private side will be:

1. In-kind contributions to the funded projects (on the basis of non-reimbursed eligible costs), with lower funding rates for higher TRLs.
2. In-kind contribution for additional activities foreseen in the SRIA not covered by Union funding.
3. Investments in operational activities that are spent beyond the work that is foreseen in the SRIA.

The commitment to the ambitions of P4Planet's sectors is frequently proven through the process industry undertakings on climate neutrality and circularity, including the Masterplan of the Energy-intensive industries transformation developed by the HLG on EII⁹⁰ and the respective roadmaps or strategic documents developed by the different P4Planet's sectors. The number of A.SPIRE members that have signed a pledge to achieve climate neutrality and zero-waste is growing which demonstrates the individual commitment of our industries to P4Planet's ambitions.

The private side commits to promote the acceleration of change through an ad-hoc Board subgroup that will set high-level discussions with industries on the further engagement to achieve the ambitions of the partnership. All A.SPIRE members will sign a MoU to confirm their engagement. This could take the form of Declaration of Honour.

Climate ambitions of Processes4Planet member companies

Processes4Planet industrial members are stepping up their ambition towards climate neutrality.

Chemical sector companies, such as Repsol and DSM, are aiming to achieve net-zero emissions by 2050, while Bayer is targeting carbon-neutrality in their own operations by 2030. Solvay has announced its Solvay One Planet strategy that will double the rate at which it reduces emissions, aligning its trajectory with the "well below 2°C" pathway. INEOS contributes to the many ambitious targets set out for the chemical industry in terms of energy efficiency, safety, emission reductions and innovation by conforming to ambitions of the Paris agreement. BASF claims to achieve CO₂-neutral growth by 2030. Clariant has set 2025 as the new target year by which it aims to have reduced its direct CO₂ emissions by 30%. Evonik's target is to cut emissions by 50% in absolute terms by 2025 (compared to 2008) by using alternative technologies and efficient production processes. P&G adopted its sustainability Ambition 2030 with objectives such as reducing the use of virgin petroleum plastic in packaging by

⁹⁰ High-Level Group on Energy-intensive Industries. (2019). Masterplan for a competitive transformation of EU energy intensive industries enabling a climate-neutral, circular economy by 2050. <https://doi.org/10.2873/854920>

50%, etc. Covestro 2025 ambition is to reduce their specific greenhouse gas emissions by 50% when compared to 2005. They place a strong focus on circular economy and want to be a creative force for its entire industry.

Steel sector companies: ArcelorMittal announced its European target to reduce CO₂ emissions by 30% by 2030 compared to 2018 and to be carbon neutral by 2050. Thyssenkrupp developed a comprehensive climate strategy with the clear aim of being fully climate neutral from 2050 onwards.

Waste sector: SUEZ aims to focus on 100% sustainable solutions and reduce GHG emissions by 45%, in line with a +1.5°C trajectory towards carbon neutrality in 2050.

The sustainability commitments of **cement industry companies** include reducing the carbon footprint of their products (applying a science-based target-setting methodology), increasing the use of secondary materials and fuels, enabling a circular business model. Cement and concrete companies are committed to leading the transition towards a carbon-neutral built environment by introducing more low-carbon products and solutions.

The **non-ferrous metals members** company Elkem seeks to reduce fossil CO₂ emissions by replacing fossil coal with biocarbon as a reduction agent in their smelting furnaces.

Minerals, engineering and ceramics also focus their efforts on the reduction of GHG emissions and establishing their strategies that are well in line with the climate neutrality ambitions of Processes4Planet.

From the point of view of the **implementation of the roadmap and the generation of impact, the private side commits** to actively contribute to co-programme the strategic R&I priorities of the Processes4Planet roadmap into calls within Horizon Europe based on the “portfolios of impact”, in alignment with the EU and national policies and with the calls of other partnerships.

The P4Planet community will develop the Innovation Programmes and its pathways of impact through projects funded by the European Commission and will leverage the funding by dedicating time, material resources and private investments directly through the projects or through further scaling up of the innovations. Through the allocation of the right resources, the members of the partnership will:

- Test portfolios of innovative solutions with high capacity of impact,
- Demonstrate climate neutral solutions in operational environments up to TRL 7-8, through Horizon Europe projects and H4Cs,
- Demonstrate Industrial-Symbiosis solutions and circular models up to TRL 7-8, through Horizon Europe projects and H4Cs,
- Launch more than 15 FOAK plants (Marbles, TRL9) to integrate the technologies developed through the portfolios of impact into a new plant or a unit in an established plant which can deliver high impact; provided the optimal blended financing is available to de-risk this last stage of innovation for the process industry, which requires long term and high-risk investments.

Full deployment and roll out is the next stage to be pursued by the industries of the 10⁹¹ P4Planet’s sectors once the technical and economic feasibility of the solutions is shown, but this is not within the scope of the partnership,

- Launch more than 15 Hubs for Circularity seeded by Horizon Europe calls and pursue their progress towards maturity,
- Support the H4Cs network through a Community of Practice and promote the transfer of the circular models across sectors and borders,
- Develop digital technologies to digitalise the EU process industry, accelerate innovation on climate neutrality and circularity and improve the competitiveness of the new solutions,

⁹¹ Two new sectors have expressed their interest to join A.SPIRE’s current eight sectors and be part of the P4Planet partnership. The applications are ongoing and conversations with other sectors have also been undertaken so the number of sectors could increase.

- Develop non-technological innovations delivering innovative business models, social innovation and actionable input for innovation policy and financing decision-making.

The industry will leverage the financial support from Horizon Europe and the blended financing with **private investments** all along the R&I cycle. The Processes4Planet roadmap has identified the need to invest EUR 33.8 billion up to 2050 in order to develop all the innovation programmes, including the non-technological (See investments to 2050 in chapter 2).

Investment needs (in million euro)						
Timing	TRL 1-3	TRL 4-6	TRL 7-8	TRL 9	Non-technological	Total
2020-2024	€1 692	€2749	€2 448	€1 300	€111	€8 300
2024-2030	€295	€1 372	€3338	€6 488	€47	€11 540
Subtotal 2030	€1 987	€4 121	€5 786	€7 788	€158	€19 840

Table 16 Investments needed to develop P4Planet’s innovations up to 2030

More than EUR 19 billion should be invested up to 2030 to reach TRL9. Of these:

- EUR 2 billion investment is needed to develop the innovations up to TRL3 by 2030. This amount is not considered in the private leverage calculation since this type of research is out of the scope of the partnership. For the same reason, the amount should be considered as a low estimation since not all the costs of RTOs in this initial research stage have been taken into account.
- **EUR 10 billion** investment is needed to move from **TRL 4 to 8 by 2030.**
- A further EUR 7.7 billion investment is needed to reach TRL9 and deliver the Marbles by 2030; the right funding from the appropriate schemes (NIF, Invest EU etc.) should de-risk and trigger the private investments required to reach this first-deployment phase. The amount considers all the innovation programmes of the roadmap up to TRL9. The list of Marbles is under definition and the amount of investment needed at this stage will be reviewed once the list is finalised. This could increase the current estimate.

Processes4Planet will aim at a leverage factor of 10 within the framework of HEU (up to TRL 7-8). If we consider the investments up to TRL9 (the Marbles), the private leverage factor could reach 18 considering the investments to reach the impact phase and depending on the further financial flow that could be allocated through the blended approach.

The calculations above include the R&I investments of the H4Cs in the frame of the Processes4Planet roadmap. As part of the non-technological investments, the roadmap identifies **EUR 125 million are needed to support the H4Cs** of which EUR 42.5 million would be required by 2030 and other EUR 63 million by 2050. The required investments will arise from a blended funding and financing approach. These include seed funding for the incubation of the H4Cs, which should represent a contribution of up to EUR 1.5 million each for two years to support the Business to Territory plans and the co-investment plans. Specific support for the H4Cs to develop towards maturity is estimated at an average of EUR 0.5 million per activity which could include: establishing a management of brokerage structures, mitigation of barriers for innovation and implementation of solutions, connecting the local stakeholders and developing business cases towards symbiosis and circularity that includes CO₂ abatement and climate neutrality goals.

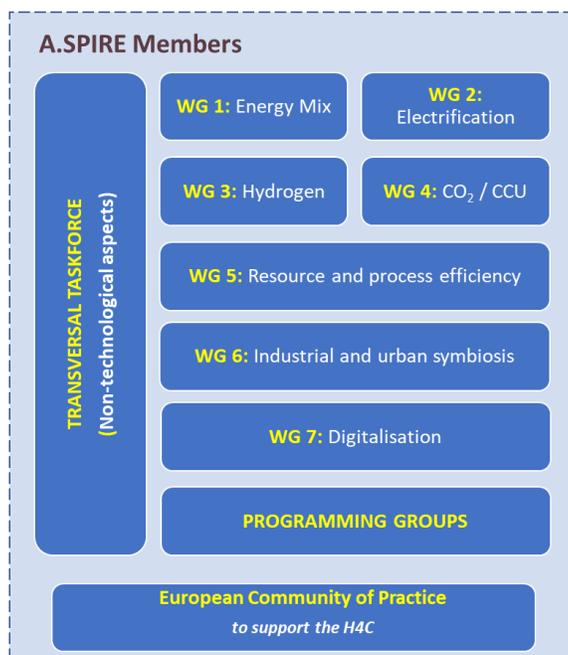
Each H4C should trigger further public and private investments through their Business to Territory plans and co-investments models. The potential investments of the H4Cs on infrastructure are not within the scope of the Partnership and have not been included in the calculations. Each H4C should include them in its individual co-investment plan.

Regarding the **implementation of the partnership** itself, the private side commits to:

- Manage the activities of P4Planet’s partnership, from the private side, through a dedicated team (A.SPIRE office) and its Executive Director.
- Act in an open, transparent and inclusive manner, welcoming newcomers and reducing barriers for participation.
- Manage the association through its governance structure as legally established in its Statutes, in particular the General Assembly and the Board of Directors.

Provide **in-kind contributions** to implement the co-programming activities of P4Planet through its advisory and working structure: The Advisory Group, the European Community of Practice to support the transfer of knowledge, tools and innovation across the H4Cs⁹², and the programming groups or ad-hoc task forces.

The composition of the A.SPIRE Working Groups and Taskforces is represented in Graph 18. It is however flexible and subject to future adaptations depending on future needs.



Graph 18: Working Groups/Taskforces of Processes4Planet (subject to adaptations)

In total, around 270 people are currently directly contributing to the management and implementation of the partnership with a time dedication that varies from 5% to 15% of their time annually. It should be emphasised that these contributions are delivered by each participant to the various Groups on top of his/her duties for his/her company or organisation. It is estimated that the related **in-kind contribution** represents **more than 400 Person Months/year on average**. This figure will increase during intense periods of activity of the partnership. During the periods to develop the Horizon Europe work programme or the review of the roadmap, the in-kind contributions are expected to be higher. As a reference, the in-kind contributions to prepare P4Planet’s roadmap have been estimated in 800 Person Months /year. Annex 4.4 provides a full overview of the in-kind contributions of A.SPIRE members in the development of Processes4Planet roadmap, and of the involvement of further stakeholders.

- Monitor and manage the portfolio of projects according to their capacity of impact to assess:
 - The needed changes in P4Planet’s roadmap and subsequent Horizon Europe calls considering progress,
 - The phasing out of the Innovation Programmes,

⁹² A.SPIRE will further define the structure of the European Community of Practice and potential changes in its Advisory Structure in its Internal Rules, once its new Statutes have been approved by its General Assembly.

- The turning point in which the partnership should exit the R&I framework programme, once all the ambitions of P4Planet's 2050 roadmap have been reached and the transition to climate neutrality and real circularity is in place,
- Private sector companies will also participate in projects that help the association to provide further services to the Processes4Planet Community. This is notably the case of the current SPIRE-SAIS project (skills for industrial-urban symbiosis) and CIRC@LEAN, and others which could be initiated in the future. The private side is committed to foster the required upgrading of skills.

Regarding **outreach and the connection to society**, the private side commits to:

- Support the projects and H4Cs to disseminate and communicate their outcomes, share knowledge and transfer solutions across sectors and borders.
- Participate in an open dialogue with other Partnerships, initiatives, sectors, Member States, regions and civil society through the **Feedback Panel** and other related activities (See section 3.1 above). The organisation of ad-hoc co-programming workshops to prepare the calls of Horizon Europe will also be pursued.
- Mobilise P4Planet's community to turn the findings on skills and jobs into specific academic curricula or other training programmes that considers gender balance aspects to support a better access for citizens to jobs in the green economy and to support industry in having an adequately skilled current and future workforce.
- Raise the awareness of citizens on climate-neutral and circular products and involve civil society through the H4Cs and the Feedback mechanism.

Regarding **innovation policy and financing**, the private side is committed to:

- Participate in a structured dialogue of the industry with the funders and financing bodies (EU, national and regional levels) through the **Impact Panel**, providing them recommendations and actionable input:
 - On innovation policy to enable lead competitive markets for climate neutral and circular products,
 - On the optimal blended funding and financing approach to support the FOAK plants (Marbles, TRL9) and the H4Cs to effectively reach the deployment and impact stage.
- Further pursue alignments with the Member States through:
 - Direct contact with Member States. Some are already contacting A.SPIRE to know more about the future partnership and the 2050 roadmap (e.g. Germany and Poland). A.SPIRE is providing information and offering bilateral online meetings to discuss alignments with their policies and the potential of development of H4Cs in their country.
 - A.SPIRE will also contact the permanent representations in Brussels of countries where participation in P4Planet's activities can be increased (e.g. Eastern Europe countries). Proposals for collaboration include the organisation of ad-hoc webinars to engage further companies and RTOs from their countries and raise awareness of the added value of engaging with the partnership.

Public side, main commitments

The main commitment of the public side is to provide the needed support and means **for the process industry to reach its ambitions** on climate neutrality, real circularity and competitiveness. This implies the allocation of the necessary resources for the development of the portfolios of impact up to TRL9 so that the impact stage is effectively reached.

An open and transparent dialogue between the public and the private sides will be fundamental. As the promoters of the European Green Deal, the Circular Economy Package, the Industrial EU policy, the Skills Agenda and other relevant policies, the public party is in the unique position to be able to provide the private side with relevant information in a timely manner to fulfil the objectives of the partnership.

From the point of view of the **implementation of the roadmap and the generation of impact**, the public side commits to:

- Set up P4Planet’s calls in the regular work programmes of Horizon Europe based on portfolios of impact that respond to the milestones identified in P4Planet’s roadmap (2024 and 2030). The prioritisation of the portfolios of impact and the calls should be reached through consensus with the private side.
- Strongly support for the Processes4Planet Innovation Programmes within Horizon Europe in order to support the development and demonstration of the innovations listed up to TRL 7-8.
- Mobilise resources beyond Horizon Europe through an optimal combination of funding and financing schemes to de-risk the innovations up to TRL9 so that the impact phase is reached. At EU level, this involves an optimal alignment of programmes such as the Investment Fund, Invest EU etc. (see section 3.1). Furthermore, the Partnership aims at mobilising further resources from Member States and regions. Many EU Member States policies (see section 2.3.2) are aligned with P4Planet’s three ambitions what should allow further deployment of resources in specific locations for “the Marbles”. Many regions have defined their smart specialisation strategies in alignment with the “climate neutral region” or “zero-waste region” goals and synergies will be pursued by means of co-investment models through the Hubs for Circularity.
- Specific support to the H4Cs⁹³, through EU programmes and resources according to the feasible schemes.
- Beyond public support for innovation and investment, an enabling regulatory framework must be created to ensure that the expected impacts are delivered on the ground. In particular, it is crucial to facilitate the establishment of Hubs for Circularity and to facilitate market uptake for climate neutral and circular solutions. This future framework is clearly much described in the EU Green Deal and other related recent communications from the Commission, which now have to be implemented into enforceable legislation. The public side commits to effectively turn the actionable input provided by A.SPIRE into specific measures or actions to the full extent possible.

Regarding the **implementation of the partnership itself**, the public side commits to:

- Contribute and ensure a good co-programming process with the relevant stakeholders. The public side will be responsible to organise the Partnership Board as well as the Impact Panel meetings which could take place back to back with the Partnership Board.
- Through the Impact Panel, the public side commits to an open and structured discussion on the optimal blended funding and financing approach to ensure the appropriate financing flow up to TRL9 in order to de-risk the private investments. The public party will coordinate with the EU funders and financing bodies and with Member States when innovation policy arrangements need to be set in regard to the agreements met by the Impact Panel.
- The public party will organise the Feedback panel through ad-hoc workshops, meetings or other formats to reach alignments with Member States policies, with other partnerships calls, and with civil society. The private side will support in the organisation by mobilising its network and providing content when relevant.
- Support to develop a mapping of the EU sites where there is a wider potential for the H4Cs due to the strong presence of process industry. Special support is needed to connect with Member States and regions where H4Cs could have a special role for a just transition towards climate neutrality and circularity (e.g. regions in Eastern EU countries).
- Specific support to set up and develop the European Community of Practice to support and connect the Hubs for Circularity network, through dedicated CSAs, a dedicated tender targeting the P4Planet community or A. SPIRE or other potential schemes.
- A transparent approach, providing the private side with timely information on the developments of the

⁹³ A H4C label for a set of quality criteria for the Business to Territory and Co-investment plans would notably set a common framework while providing room for each H4C to address its own geographical needs when matching demand and solutions.

EU R&I programmes relevant to the achievement of the ambitions and to the fulfilment of the private side commitments.

- The public party can also provide a very useful contribution by reaching out to Member States and regions to support co-programming, help facilitate the establishment of Hubs for Circularity and raise awareness on regulatory conditions for market uptake of innovations. As a means to kick this off, a workshop in autumn 2020 organised by the European Commission involving Member States and other funding and financing bodies, in preparation for the future Impact Panel would be welcomed. A.SPIRE will be happy to collaborate in its organisation.

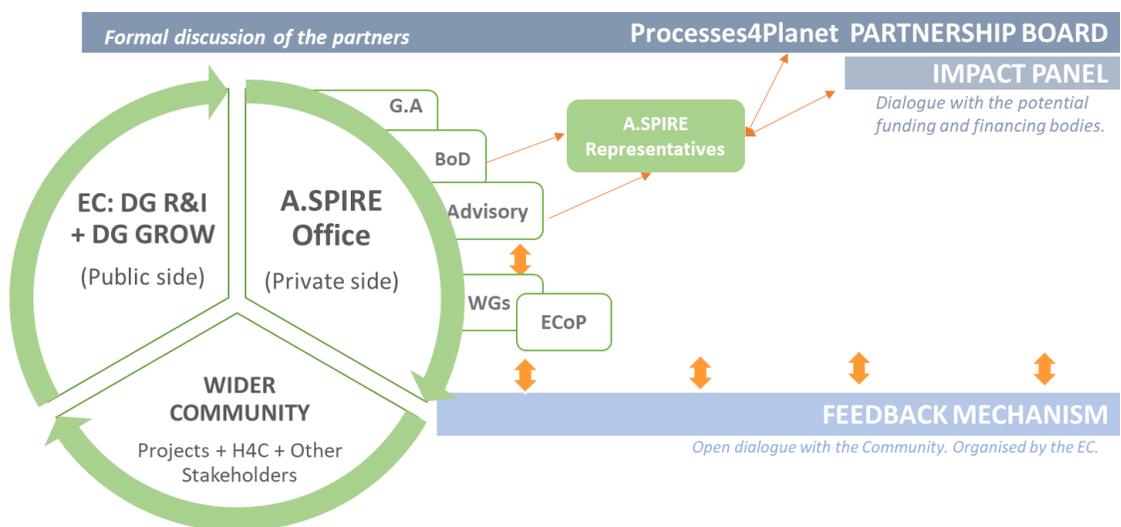
3.3. Governance

Between 2012 and 2020, the partnership association A.SPIRE has grown from 28 members (with headquarters in nine different EU countries) to 163 members (with headquarters in 22 EU countries). In reality, many of the industrial members have production sites across Europe. This allows us to claim that **Processes4Planet will already cover the 27 Member States of the European Union⁹⁴**.

The partnership association A.SPIRE currently focuses its efforts on integrating new sectors as well as newcomers from regions, NGOs and other stakeholders. The release of the 2050 Vision document has triggered great interest among new stakeholders, which has significantly developed the membership. The Refineries and Pulp and Paper sectors have confirmed their willingness to join A.SPIRE. Nonetheless, applications are still ongoing at this stage. From A.SPIRE we are strengthening our efforts to bring the Waste Management sector on board. Processes4Planet is committed to build on this momentum as it is strengthened by the dynamic around the EU Green Deal.

Processes4Planet Governance Model

The proposal for the governance of this partnership includes three key fora for discussion (see Graph 19) with different purposes and levels of interaction: the Partnership Board, the Impact Panel and the Feedback Panel.



Graph 19: Governance model of Processes4Planet co-programming partnership

⁹⁴ It is also to be noticed that, despite Brexit, A.SPIRE has retained a core of members from the UK which remain engaged in activities and look forward to a comprehensive EU-UK agreement on R&I collaboration under Horizon Europe.

P4Planet's PARTNERSHIP BOARD

This is the body where the Private Partner (A.SPIRE) and the Public Partner (European Commission) formally meet to establish discussions and meet agreements.

GOAL: to discuss the priorities, the topics and the strategic development of the Partnership.

WHO: The partners of the Partnership that are committed to develop R&I and to deliver solutions.

From the public side, the two DGs leading the Partnership: DG R&I and DG Grow and the chair of SET PLAN #6 to represent Member States (currently Finland). The Commission will invite other DGs or EU agencies (e.g. EASME) when relevant.

From the private side:

- Representatives from A.SPIRE Board of Directors.
- Representatives from A.SPIRE Advisory Group.

A flexible composition of the Partnership Board representatives from the Private Side. A.SPIRE will define a long list of Partnership Board representatives (to be published on the European Commission website). The maximum number of participants from the private side will be agreed with the Commission to ensure all P4Planet's sectors are represented and a balance is met for the participation of industry and RTOs. For the sake of continuity and consistency in the discussions, a core group will participate in all the Partnership Board (PB) meetings. The agenda of the PB tackles aspects of different nature (strategy, Horizon Europe calls, monitoring etc.) which will require different types of expertise or the participation of people who are directly involved in specific actions. A.SPIRE will flexibly include these experts from the long list in the relevant PB meetings.

WHAT: Discussions will focus on the preparation of P4Planet's portfolios of impact for the Work Programmes of Horizon Europe and to analyse the results of the portfolio of projects and the H4Cs, where the technological approach is prominent. However, the non-technological aspects and strategic dialogue are important and needs to be strengthened in the partnership board.

The partnership board will discuss different aspects of P4Planet implementation which will range from more strategic aspects (future thinking) to the development of calls and topics, the progress of the projects towards impact, the investments leverage, and the funding levels (including SMEs).

HOW: A good planning of the Partnership Board meetings will be setup in order for the public and the private sides to effectively prepare input in a timely manner. The private side mobilises a large number of in-kind contributors, which requires time to prepare and discuss before the partnership board meeting takes place.

The public and the private side should strive for consensus on the list and content of the calls to be launched. At least 50% of the topics in each call should respond to the proposal of Processes4Planet sectors and all should pursue the implementation of P4Planet's roadmap.

THE IMPACT PANEL

The Impact panel is a **space for a structured and informed dialogue on impact** with the potential financial "investors" and funders.

GOAL: Formal discussion with the funding and financing bodies to define paths to move from R&I to impact through an optimal blended funding and financing approach to support the Marbles (FOAK demonstrators) and the H4Cs.

WHO: P4Planet's Partnership Board members will meet with the different funding and financing bodies.

- Public partner (DG R&I and DG Grow),
- Representatives of A.SPIRE (Board & Advisory Group),

- Member States / Regions,
- EU representatives of the different funding and financing schemes (as described in chapter 3.1: IF, Invest EU etc.),
- Private financing foundations or entities, including, for example, venture capital or others,
- The European Investment Bank,
- Other bodies that can be identified as relevant to support the Marbles and H4C investments (e.g. private foundations).

WHAT: Discussion on the optimal combination of funds and financing schemes to facilitate the launch of the Marbles (TRL9) and to trigger the private investments, including the H4Cs, that will lead to impact. The expected results are: the Marbles will be supported by the different schemes and a good financial flow will trigger the industrial investments for deployment; further tools for co-investment models for the H4Cs will be identified to accelerate their progress and transition towards competitive climate neutrality and circularity.

HOW: These meetings will take place back to back with the Partnership Board meetings; at least once a year or when needed. A.SPIRE will provide a document to the impact panel with recommendations based on the conclusions of the portfolio monitoring: the progress of P4Planet’s portfolios of impact and H4Cs and their readiness to move to TRL9 (Marbles) or to SRL9 (H4Cs maturity). Bilateral meetings will also be considered when relevant.

THE FEEDBACK MECHANISM

Organised by the European Commission, the feedback panel is an **open dialogue mechanism** to meet alignments across initiatives and with society.

GOAL: To provide a holistic perspective on the environmental, social and economic challenges that nurtures the participation of all stakeholders and that fosters alignments and synergies across partnerships and other stakeholders.

WHO: The Public side will organise the meetings of this panel which will include representatives of:

- Public partner (DG R&I and DG Grow),
- Representatives of A.SPIRE (Board & Advisory Group),
- EU R&I Partnerships,
- Other EU and international initiatives,
- Other members of the value chain (e.g. energy sector),
- Civil society representatives (NGOs, private foundations, etc.).

It will be important that this panel gathers the relevant stakeholders of the circular value chain relevant to achieving the objectives of P4Planet’s roadmap. These are described in chapter 2, section 2.2 (Alignments with other R&I Partnerships and Initiatives at EU level) and in section 2.4 (Partner composition and target groups).

WHAT: Discussions of the feedback panel will focus on:

- Alignments across roadmaps and across the Horizon Europe calls of the different partnerships and initiatives (including the KICs). This could include identifying potential joint calls, cross-fertilisation of projects’ results and synergies through other potential actions when relevant,
- The perspective of civil society. Of special relevance will be the data that NGOs can provide in regard to climate neutrality, circularity, competitiveness and growth. NGOs should ensure the data provided is objective and supported by clear evidence,
- Alignments with the policies of EU Member States and regions in regard to climate neutrality and circularity.

As a basic principle, feedback through open dialogue will be welcomed while the decisions on the specific proposals for P4Planet's calls in the Horizon Europe work programme, and the negotiation in the Partnership Board, will be defined by the private side of the partnership.

HOW: The feedback panel will meet once a year in ad-hoc workshops or events. Furthermore, the A.SPIRE advisory group and the Board of Directors can invite members of the feedback panel to their meetings on an ad-hoc basis, when relevant.

Involvement of the public party in the development of Processes4Planet

A collaborative approach between the private and public partners of Processes4Planet has been adopted to shape the future partnership. This approach built on the relationship established over past few years between A.SPIRE and the European Commission in the framework of the SPIRE public private partnership⁹⁵, the predecessor of P4Planet. This has included interactions between representatives of the association and of the Commission. These interactions were the opportunity for open and challenging exchanges with the objective of a successful and impactful implementation of the future partnership.

The main concern has been to make sure that the Processes4Planet's R&I strategy and intervention logic match the unprecedented level of ambition set by the EU and its Member States as well as the global climate neutrality targets. It is the duty of Processes4Planet to make sure that its innovation agenda matches a very high level of ambition while formulating pathways which make full sense from an industrial standpoint and do not get lost as a paper exercise.

Since the release of the European Commission proposal for a Partnerships' Portfolio, discussions between private and public partners have also focused on the broadening of the scope of Processes4Planet as a co-programming Partnership. Agreements have been met at roadmap level (notably the approach to materials from a circular and cross-sectoral perspective) and in the definition of the intervention logic by setting the tree of problems-objectives-KPIs that the Partnership will focus on and by defining the governance model for the future partnership.

DG R&I has developed several reviews and reports to support the developments of the new partnership with informed data. The following can be highlighted:

- **In July 2017**, the European Commission released the mid-term review of the Partnerships, including SPIRE.
- **In October 2018**, DG R&I released the P4P report on "Low-Carbon Process Industries through Energy Efficiency and Carbon Capture & Utilisations" which analysed all SPIRE projects to date; and organised a validation workshop in Brussels.
- **In 2019**, DG R&I worked on a Policy report on Industrial Symbiosis in order to evaluate the progress made so far and address required future developments. The report provided great input to sustain and improve the Processes4Planet Innovation Areas on Industrial-Urban Symbiosis and to shape the proposal related to the H4Cs.
- **Feedback from the R&I Days in September 2019:** This event was led by DG R&I and all participating stakeholders could provide useful input to shape the future Horizon Europe programme and the future

⁹⁵ From the public side, the SPIRE cPPP is led by DG R&I (currently Directorate Prosperity) while DG ENER is also part of the contractual arrangement; both respectively allocate EUR 850 million and EUR 50 million to implement SPIRE 2030 roadmap through dedicated SPIRE calls for projects. Both the Commission and A.SPIRE have kept a continuous dialogue and close collaboration to implement the SPIRE cPPP. Through a dedicated 'SPIRE team', DG R&I is in charge of following the SPIRE projects and the progress of the partnership; it also organises the SPIRE Partnership Board meetings. The Commission has also been represented in the SPIRE PB and in other meetings by representatives from other services, in particular DG ENER, DG GROW, DG CLIMA and EASME.

partnerships, including P4Planet. Besides the relevance of many of the sessions, two sessions were especially relevant for P4Planet: “Together we are cleaner: Industry for a zero waste economy” on 24 September, with the participation of Pierre Joris as President of A.SPIRE; and “Human centred Artificial Intelligence” on 25 September with the participation of Àngels Orduña, Executive Director of the association.

DG R&I has also been key in the organisation or implementation of some key meetings that have supported both the development of P4Planet’s roadmap and facilitating access to newcomers:

- **13 December 2018, Katowice:** Co-organisation of the SPIRE workshop in COP24, Katowice, with the further participation of DG Clima, DG Regio, MEP Pieter Liese and NGOs; and organisation of side meeting with Polish industry and RTOs (FOR NEWCOMERS).
- **4 July 2019,** Meeting with the regions on the hubs for Circularity.
- **5 July 2019,** SPIRE Meeting with Germany and France: review of the roadmap and the H4Cs.
- **9 October 2019,** participation in the H4Cs workshop in the European Week of the Regions.
- **15 November 2019,** DG R&I organised a process industries New Stakeholders’ meeting that gathered representatives from sectors including Refineries, Glass, Pulp and Paper, and Waste Management and other parties such as NGOs, labour unions, etc. This event gave potential newcomers the opportunity to learn about the goals and ambitions of Processes4Planet and about the opportunity of joining the new partnership (FOR NEWCOMERS).
- **12 December 2019:** Participation of Peter Dröll (Director of Prosperity Directorate) and Jürgen Tiedje (Head of Unit of RTD F3 – Sustainable Industry Systems) in A.SPIRE BoD meeting: discussion about the KPIs and the industrial commitment.
- **23 January 2020,** Meetings with representatives of the Polish Association for Entrepreneurship, in Brussels (FOR NEWCOMERS).

A.SPIRE has followed up on all the activities to engage newcomers mentioned above. After each meeting, the association has:

- Followed up with all participants by thanking them for their participation, providing all the documents shared during the meetings and providing further information on how to get engaged in the activities of Processes4Planet,
- Inviting the participants to the webinars on the added value for Europe of the New Partnership,
- Individual follow up by mail and bilateral meetings when needed to further answer the specific questions of some members.

As a result, Central Mining Institute from Poland has joined the partnership and we are currently exploring further options to engage further parties even during the COVID context. Two new sectors (refining and pulp and paper) are in the process of joining our partnership and other sectors (glass and waste management) could follow. Other parties are still considering their option to join. This is the case of the NGOs Carbon Market Watch and Zero Waste, for example, which need to further assess the added value for them to join. All the parties will be invited to new webinars or to future stakeholders’ events (face-to-face or online) to continue exploring the opportunity for them to join.

The Association SPIRE has also participated in the conversations of the HLG on Energy-intensive industries for the development of their transformation masterplan⁹⁶ led by DG Grow. The Association has also been represented in the workshops of the Strategic Value Chain on low-carbon industry, linked to the IPCEIs, which could be key to support the development of the Marbles (FOAK). The participation in these discussions has ensured the alignment with all the EII sectors, most of which (if not all) will be part of the new partnership.

⁹⁶ High-Level Group on Energy-intensive Industries. (2019). Masterplan for a competitive transformation of EU energy intensive industries enabling a climate-neutral, circular economy by 2050. <https://doi.org/10.2873/854920>

Representatives from DG R&I participated in all key workshops related to the Processes4Planet 2050 Vision and Roadmap (See annex 4.3) for the description of the process to develop the roadmap. Some of these events actually involved from three to five Directorate Generals of the European Commission each, including DG R&I, DG Clima, DG Ener, DG Grow, DG CONNECT and DG ENER.

The drafting of the present Guidance Document to set the intervention logic and implementation strategy of the future P4Planet partnership was also the opportunity for successive iterations between the private and public partners. Both DG R&I and DG Grow have been deeply involved in the discussions (meetings and by mail) which have taken place through March and April 2020 while previous interactions, including also DG Environment, had taken place from November 2019.

In the forthcoming months, this active collaboration will continue, notably through a joint review of the KPIs and of the future partnership contract and through joint work on the first calls of Horizon Europe based on the 2050 roadmap.

3.4. Openness and transparency

The purpose of Processes4Planet Partnership is to develop enabling technologies and solutions for process innovation along the value chain that are required to reach long term sustainability for Europe in terms of climate neutrality, real circularity and global competitiveness of the process industry.

Processes4Planet will be based on the principles of **openness, inclusiveness and transparency** in all its activities and in regard to stakeholders participation.

Open and inclusive participation

Throughout its lifetime, Processes4Planet will be **open** to attract a diversity of newcomers widening the base of stakeholders that: serve the purpose and objectives of the partnership as described in the current document and in P4Planet's 2050 roadmap, provide an Added Value for Europe and are allowed to fully participate in Horizon Europe, according to the rules of participation of the programme⁹⁷. Membership will be rejected only in the exceptional case when the criteria above are not met.

All the relevant stakeholders for the process innovation eco-system and the circular value chain, including civil society, may participate in the new Partnership by becoming members of A.SPIRE (the private side) through: the payment of a membership fee and the signature of a MoU⁹⁸ engaging them to the purpose and objectives of the partnership.

Following the unique cross-sectoral principle of P4Planet, those sectors that belong to the process industry or delivering solutions that will enable the transformation of the process industry may join as sectors. In such cases, the sectors will need to be represented by their EU trade association and by companies within the sector. On the other hand, any industry stakeholder (companies, clusters, trade associations at local or national levels etc.) from other sectors is welcome to become a member on an individual basis. Stakeholders that do not develop R&I directly can join as Associate members. These can include, for example, representatives of the regions or the Member States (e.g. through their innovation or development agencies) NGOs, foundations etc. All stakeholders that develop R&I directly can join either as industry members or as research members (RTOs).

The **inclusive approach** of P4Planet, ensures that any member can join any working group or task force and can participate in all activities regardless of the category of membership. Nothing prevents each and every

⁹⁷ This includes stakeholders based in the European Union, the European Free Trade Area, candidate countries, associate countries and any other entities that the EU allow to fully participate in Horizon Europe.

⁹⁸ The document is under definition. It could take the form of a Memorandum of Understanding or of a Declaration of Honour.

member of A.SPIRE contributing to discussions aiming to shape the R&I strategy for better industrial processes in the European Union. It is the choice and freedom of every member to adjust its participation according to its own objectives and constraints.

P4Planet activities and measures will include a range of options to remove barriers of participation. An SME can be part of the A.SPIRE Board of Directors representing other member SMEs. This measure has recently been implemented by A.SPIRE and it is highly valued. Some of the partnership activities (conferences, workshops, brokerage events etc.) will take place in Eastern and other EU countries to open opportunities to local stakeholders to engage. Online webinars or other formats will be delivered to allow for an even more open and inclusive participation by any interested stakeholder in whichever EU Member State, or even outside the EU, they are based, thus breaking participation barriers linked to travel costs.

Proactive recruiting

Processes4Planet will use its sectors and network to invite new members to join the partnership. A.SPIRE (the private side) will share an “AddedValue Package” to all its members so that they can act as ambassadors of P4Planet and engage newcomers. The EU trade associations of all P4Planet sectors will be key to engage further companies from their sectors. Besides the distribution of the AddedValue Package, A.SPIRE will participate in their workshops or relevant meetings (General Assembly, Board, etc.) to discuss the benefits of joining the partnership. The national trade associations or other multiplier partners will also be very relevant to further reach out to potential stakeholders in countries where participation is lower. The contacts with the Permanent Representations in Brussels will also serve this purpose.

Our continuous membership campaign will also include a monthly webinar on P4Planet’s AddedValue for Europe, participation in the kick-off meetings of P4Planet’s projects, participation in fairs or the organisation of workshops and ad-hoc side meetings in different EU countries, and all the activities launched by the Board subgroup to accelerate change (See section 3.1 – engagement and collaboration).

The information on how to become members and the membership fees per category will be publicly and transparently available on the website as well as the full list of partnership members. New Members will be welcomed on an on-going basis throughout the lifetime of the partnership. The H4Cs and their regional stakeholders will also be welcomed as members in the Partnership. Special conditions or a special fee to support the European Community of Practice may be considered.

The network A.SPIRE relies on for the proactive recruiting policy for P4Planet includes, among others:

- A.SPIRE members (150+)
- CEFIC (chemicals)
- CEMBUREAU (cement)
- CEPI (Pulp & Paper)
- CERAME-UNIE (ceramics)
- ESTEP/EUROFER (steel)
- EPRA / CONCAWE (Refining)
- EUROMETAUX (non-ferrous metals)
- EUROPEAN ALUMINIUM (non-ferrous metals)
- High-Level Group on Energy Intensive Industries
- IMA-EUROPE (minerals)
- SET PLAN #6
- Strategic Low Carbon Value Chain and the potential new Alliance on Low-carbon industries
- SusChem ETP
- Water Europe (water)
- Knowledge4Innovation
- The Hubs for Circularity

Transparency and accessibility

A dedicated online platform will make information on P4Planet accessible to its members. Different online working spaces will be provided for the working groups, task forces, Board, Advisory group and General Assembly. This should facilitate the work of the different groups for specific activities and objectives. All the resolutions of the BoD will be equally shared with all A.SPIRE members as well as all other relevant information.

All the information and dissemination tools (website, newsletter, social media etc.) and activities (events, workshops, webinars etc.) described in section 3.1 will give full and non-discriminatory access to all the information on the P4Planet Partnership, its projects and its H4Cs. This will include access to the key documents developed in the framework of the partnership (roadmap, guidance document, progress monitoring reports, project brochures, position papers etc.). The results and findings of the projects will be published on the website to the extent intellectual properties (IP) considerations allow.

Regular activities open to all stakeholders will be regularly organised such as the Community and H4C Forum and others. Participation will be free upon registration which will be opened online. Other activities, including thematic workshops or working groups will be addressed to all the members of the partnership and some could be open to further stakeholders through a registration fee.

All P4Planet calls will follow the common rules of participation of Horizon Europe and will be equally open to all eligible stakeholders. The responsibility of the publication of the calls and the selection of the projects will be on the public side. The private side will not intervene in the evaluation of the proposals and will not issue Letters of Support to proposals for the topics shaped directly through the partnership in order to ensure the maximum transparency. Nonetheless, the private side will be happy to provide information on the roadmap for the evaluators to better assess if the proposals will lead to the achievement of the ambitions and objectives. This will not include specific references to stakeholders, but rather objective data on the ambitions, targets and innovation programmes that clarify the goals and targets the selected projects need to provide solutions for.

Openness and transparency in the definition of common priorities

The Innovation Areas and Programmes of the Processes4Planet 2050 roadmap will point the pathways to follow in order to deliver the different innovations and solutions. The Vision and the roadmap have undergone four public consultations, of which two were online and two were stakeholders workshops (See full description of the process to build the roadmap in annex 4.3). The roadmap will be completed in 2020 with the input of the new members of A.SPIRE, including the new sectors Refining and Pulp and Paper. Several new members have already participated in previous stakeholder consultations.

Consultation activities through the Feedback Mechanism or other ad-hoc interactions with the different stakeholders will take place during the lifetime of the partnership in order to identify common vision alignments when setting the priority portfolios of impact of the biannual work programmes of Horizon Europe and the review of P4Planet's roadmap in 2024 (See section 3.1. for the full description and potential calendar of the activities). In order to ensure transparency and added value to the partnership, the open dialogue with the different stakeholders will be based on specific support documents for informed discussion (e.g. the results of the periodic monitoring reports or experts' documents such as reports, white papers etc.). The feedback of the different stakeholders will be summarised and shared with all the participants. The main outcomes of these joint developments with the various stakeholders will be publicly shared on the website.

4. ANNEXES

4.1. Links of Processes4Planet Roadmap Innovation Programmes to Horizon Europe Intervention Areas

Processes4Planet ROADMAP			HORIZON EUROPE
2050 TECH DRIVERS	INNOVATION AREAS	INNOVATION PROGRAMMES	RELATED INTERVENTION AREAS
Energy Mix & Hydrogen	Integrating renewable energy carriers	a/ Integration of renewables b/ Integration of bio-energy waste and other new fuels c/ Competitive hybrid transition to low- carbon industrial energy supply	Low-Carbon and Clean Industries Emerging Enabling Technologies Key Digital Technologies Energy Supply Energy Storage Energy Systems and Grids
	Enhancing energy flexibility and diversity	a/ Flexibility and demand response	Key Digital Technologies Low-Carbon and Clean Industries Energy systems and grids Buildings and Industrial Facilities in Energy Transition Energy Storage
	Enhanced utilisation of different grades of heat	a/ Heat exchange optimisation	Low-Carbon and Clean Industries Energy Systems and Grids Buildings and Industrial Facilities in Energy Transition Energy Storage
	Integration of hydrogen production, use and storage	a/ Alternative routes for the production of hydrogen b/ Introducing no emission hydrogen in the industrial processes c/ Storage of hydrogen	Emerging enabling technologies Low-Carbon and Clean Industries Energy Supply Energy Systems and Grids Buildings and Industrial Facilities in Energy Transition Energy Storage
Electrification	Electrification of heating processes	a/ Electricity to upgrade waste heat b/ Other electricity-based heating processes	Low-Carbon and Clean Industries Emerging Enabling Technologies Buildings and Industrial Facilities in Energy Transition Energy Supply Energy Storage Energy Systems and Grids
	Electrification to directly drive processes	a/ Electrochemical conversion b/ Electrically-driven separation	Low-Carbon and Clean Industries Emerging Enabling Technologies Buildings and Industrial Facilities in Energy Transition Energy Supply Energy Storage Energy Systems and Grids

CCU - CO/CO2	Capture & purification of CO₂	a/ Flexible CO ₂ capture and purification technologies	Low-Carbon and Clean Industries Emerging Enabling Technologies Circular Industries
	CO₂ to minerals	a/ CO ₂ valorisation during concrete production b/ Circular construction materials by re- carbonation c/ Natural materials mineralisation (e.g. olivine carbonating CO ₂)	Manufacturing technologies Emerging Enabling Technologies Advanced Materials Circular Industries Low-Carbon and Clean Industries Emerging Enabling Technologies
	CO₂ valorisation to chemicals, polymers & fuels	a/ Direct utilisation of sunlight (Artificial photosynthesis) b/ Catalytic conversion of CO ₂ (excl. photocatalytic and direct use in polymers) c/ CO ₂ (and CO ₂ /CO) to polymers d/ CO captured from industrial waste gases to chemicals and fuels	Manufacturing technologies Emerging Enabling Technologies Advanced Materials Circular Industries Low-Carbon and Clean Industries Energy Supply Energy Storage
Resources Flexibility	Disruptive processes for optimised use of virgin and secondary resources	a/ Advanced catalysis providing resource flexibility and lower energy inputs through alternative chemical pathways b/ Complete reuse of water and valorisation of the materials contained c/ Innovative processes to maximise use of secondary raw materials d/ Breakthrough process design for improved energy and resource efficiency	Low-Carbon and Clean Industries Advanced Materials Circular Industries Key Digital Technologies Manufacturing Technologies Buildings and Industrial Facilities in Energy Transition Seas, Oceans and Inland Waters Bio-based Innovation Systems in the EU Bioeconomy Circular systems
	Minimising the environmental footprint of materials	a/ Higher functionality materials b/ Inherent product recyclability materials	Low-Carbon and Clean Industries Advanced Materials Circular Industries Buildings and Industrial Facilities in Energy Transition Bio-based Innovation Systems in the EU Bioeconomy Circular systems
Industrial- Urban Symbiosis	Process technologies for Industrial- Urban Symbiosis	a/ Demonstration of Industrial-Urban Symbiosis b/ Waste valorisation including recycling	Circular Industries Low-Carbon and Clean Industries Emerging enabling technologies Key Digital Technologies Energy systems and grids Buildings and Industrial Facilities in Energy Transition Communities and Cities Energy storage Bio-based Innovation Systems in the EU Bioeconomy Circular systems
	Business models & demonstration of Industrial- Urban Symbiosis	a/ Communities of Practice b/ Development of Hubs of Circularity	Circular Industries Low-Carbon and Clean Industries Key Digital Technologies Energy systems and grids Buildings and Industrial Facilities in Energy Transition Communities and

			Cities Energy storage Bio-based Innovation Systems in the EU Bioeconomy Circular systems
Digitalisation	Digitalisation of process/product R&D	a/ Towards digitally supported design of environmentally benign high-performance materials b/ Towards digital process development & engineering	Key Digital Technologies AI and Robots Manufacturing technologies Circular Industries Low-Carbon and Clean Industries Advanced Materials Buildings and Industrial Facilities in Energy Transition Circular systems
	Digitalisation of plants	a/ Optimised plant operations control towards highest quality products and fully energy, resource efficient and environmentally friendly plants b/ Intelligent sensors and sensor networks, data processing and equipment monitoring to assess the state of equipment and materials	Key Digital Technologies AI and Robots Manufacturing technologies Circular Industries Low-Carbon and Clean Industries Energy Systems and Grids Buildings and Industrial Facilities in Energy Transition Bio-based Innovation Systems in the EU Bioeconomy
	Digitalisation of connected processes and supply chains	a/ Towards fully autonomous scheduled production processes and integrated supply chains b/ Towards fully connected process industries – scheduling across plant networks/sites/ industries/ municipalities - industrial symbiosis	Key Digital Technologies AI and Robots Manufacturing technologies Circular Industries Low-Carbon and Clean Industries Energy Systems and Grids Buildings and Industrial Facilities in Energy Transition Communities and cities Bio-based Innovation Systems in the EU Bioeconomy Circular systems

4.2. Proposed KPIs

 <p>CLIMATE</p> <p>GENERAL OBJECTIVE 1</p> <p><i>Developing and deploying climate neutral solutions</i></p>	<p>SPECIFIC OBJECTIVE 1</p> <p><i>Integrating renewable energy</i></p>	<p>KEY PERFORMANCE INDICATORS</p> <p>KPI 1 CO₂eq emission reduction by integration of renewable energy & energy efficiency**, measured through a relevant* number of demonstrators**</p>
	<p>SPECIFIC OBJECTIVE 2</p> <p><i>Reduce emissions through CO/CO₂ capture and use</i></p>	<p>KPI 2 CO₂eq emission reduction through CO₂ Capture and Use, measured through a relevant* number of demonstrators**</p>
 <p>CIRCULARITY</p> <p>GENERAL OBJECTIVE 2</p> <p><i>Closing the energy and feedstock loops</i></p>	<p>SPECIFIC OBJECTIVE 3</p> <p><i>Ensure full circularity and overhaul the use of waste</i></p>	<p>KPI 3 Waste**** reduction, measured through a relevant* number of demonstrators**</p> <p>KPI 4 Secondary materials use intensity, measured through a relevant* number of demonstrators**</p> <p>KPI 5 Water reused/recycled through energy and solute recovery, measured through a relevant*- number of demonstrators**</p> <p>KPI 6 Number of H4Cs seeded through P4Planet projects across EU regions / sites</p>
	<p>SPECIFIC OBJECTIVE 4</p> <p><i>Moving towards commercially viable climate neutral and circular industry solutions</i></p>	<p>KPI 7 Number of Marbles (first-of-a-kind plants at TRL9)</p> <p>KPI 8 Private investment level (leverage)</p> <p>KPI 9 Number of significant innovations developed</p> <p>KPI 10 CAPEX & OPEX reduction through the innovations</p>
 <p>COMPETITIVENESS AND CROSS-CUTTING</p> <p>GENERAL OBJECTIVE 3</p> <p><i>Global leadership in climate neutral and circular solutions accelerating innovation and unlocking public and private investment</i></p>	<p>SPECIFIC OBJECTIVE 5</p> <p><i>Fostering new skills & jobs and reducing barriers for market uptake</i></p>	<p>KPI 11 Impact on SMEs through projects and H4Cs</p> <p>KPI 12 Number of new jobs and job profiles</p>

4.3. Process to develop the Processes4Planet Roadmap

Dating back to 2017, when the mid-term review of Horizon 2020 and partnerships was taking place, A.SPIRE launched several activities to review its impact and to picture the next generation of European Process Industry. From then, the dialogue and collaboration of A.SPIRE's members have intensified to develop the new Processes4Planet 2050 Vision and Roadmap.

- **5 July 2017:** Brainstorming event about the future of the Process Industry by mid-century.
- **19-21 September 2017:** The first European Process Industry Conference gathered more than 240 stakeholders to imagine the potential future of the process industry and society.
- **February 2018:** The Vision Group of representatives from the eight Industrial Associations of SPIRE's sectors along with member companies and RTOs is established.
- **July 2018:** An internal consultation with all members.
- **September 2018:** SPIRE 2050 Vision's draft released. It outlined SPIRE's new value proposition and three main ambitions.
- **2 October 2018:** SPIRE 2050 Vision's Workshop gathers more than 120 stakeholders to discuss and validate the strategic document.
- **29 October 2018, Vienna:** A joint workshop during the INDTECH Conference, with SPIRE, FoF and EeB partnership representatives and representatives from DG RTD, Member States and industry.
- **28 November 2018:** A dinner debate in the European Parliament with A.SPIRE members, high-level representatives from DG R&I, other stakeholders and MEP Dan Nica designated as the Horizon Europe Rapporteur.
- **13 December 2018, Katowice:** SPIRE workshop in the COP24 event together with representatives of EP, EC, MS and NGOs.
- **Early 2019:** Creation of seven new Working groups to develop the Processes4Planet roadmap.
- **26 March 2019:** The roadmap exercise is kicked-off with A.SPIRE's Working groups.
- **May 2019:** IRIAG workshop aiming to identify links and coherence across different WGs.
- **11 September 2019:** SPIRE Working Groups' Day gathers WGs representatives and Board members to boost the level of innovation in the roadmap.
- **September 2019:** The Processes4Planet Roadmap booklet is shared with key stakeholders such as the EC, Member States, regions, new sectors, etc. Internal online consultation open to all members.
- **22 October 2019:** The Processes4Planet roadmap draft is released and an online consultation for stakeholders is launched.
- **3 December 2019:** Stakeholders' workshop attended by over 140 stakeholders to discuss the roadmap and identify gaps, potential synergies across sectors, partnerships and regions.
- **December 2019:** Review meeting by the Advisory Group (IRIAG) and A.SPIRE's BoD.
- **March 2020:** Release of a pre-final version of the roadmap document.
- **Upcoming: May - July 2020:** New sectors to be incorporated into the roadmap.

4.4. A.SPIRE Members & Stakeholders involved in the Processes4Planet Roadmap

A.SPIRE 2050 Vision and Processes4Planet Roadmap are the result of an intense in-kind contribution of A.SPIRE's members and of fruitful dialogue with a large number of stakeholders that are relevant to achieve our objectives and to generate synergies, such as:

- European Commission representatives (DG R&I, DG ENER, DG GROW, DG CLIMA, DG CONECT and DG ENVI),
- MEPs (specially representatives of the ITRE Committee),
- Member States, regions and cities representatives,
- NGOs,
- Other partnerships,
- Other sectors and interested stakeholders.

4.4.1. Participation in RoadmapEvents

EVENTS	Members	Stakeholders
EU Process Industry conference: A Look to the Future; 19-21/08/17	162	47
Task Force Brainstorming Meeting; 5/07/2017	29	0
Workshop 2017	59	12
Sustainable Process Industry Strategy Towards 2050; 02/10/2018	90	31
Kick Off WGs; 26/03/19	113	4
IRIAG Roadmap Workshop; 29/05/19	27	4
WGs Day; 11/09/19	104	7
European Week of the Regions (H4C); 09/10/19	20	15
Roadmap Online Consultation; 20/11/19	25	4
Stakeholder Event; 03/12/19	110	30
TOTAL NUMBER OF PARTICIPATIONS	739	154

4.4.2. A.SPIRE Members' In-Kind Contribution

A.SPIRE MEMBERS IN-KIND CONTRIBUTION (n° of people)						
	BoD	IRIAG	WGs	Transversal Task Force	2018 Vision Group	Industry Associations
INDUSTRY	6	13	61	1	4	5
SMEs		0	6	1	0	0
RTOs	4	14	110	3	0	4
I.ASSOC	8	12	9	1	13	11
ASSOC		1	1	0	0	0
Others			9	3	3	2
TOTAL	18	40	196	9	20	22

The 16 chairs and co-chairs from IRIAG are also counted in the WGs list. The total n° of persons provided their "in kind-contribution" is **271**.

4.4.3. Stakeholders and Members involved in the creation of roadmap

Figure 1. By sector and type of organisation

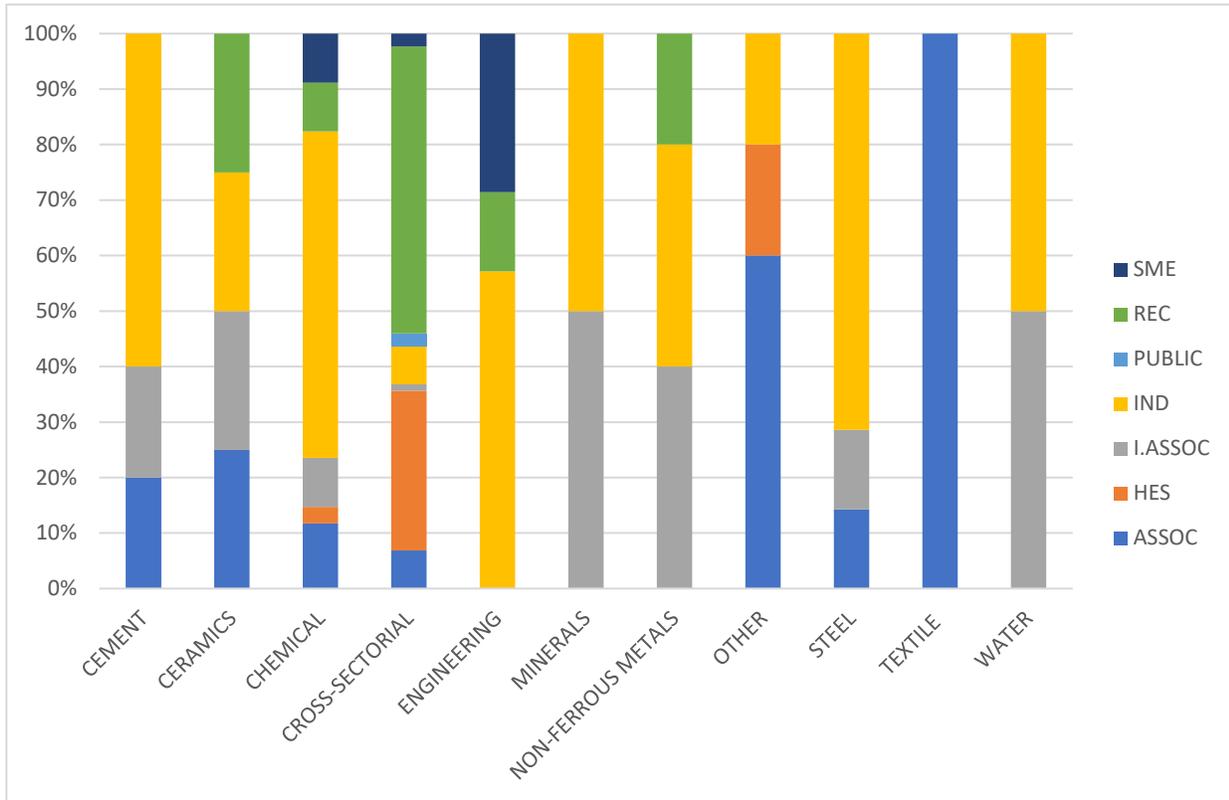
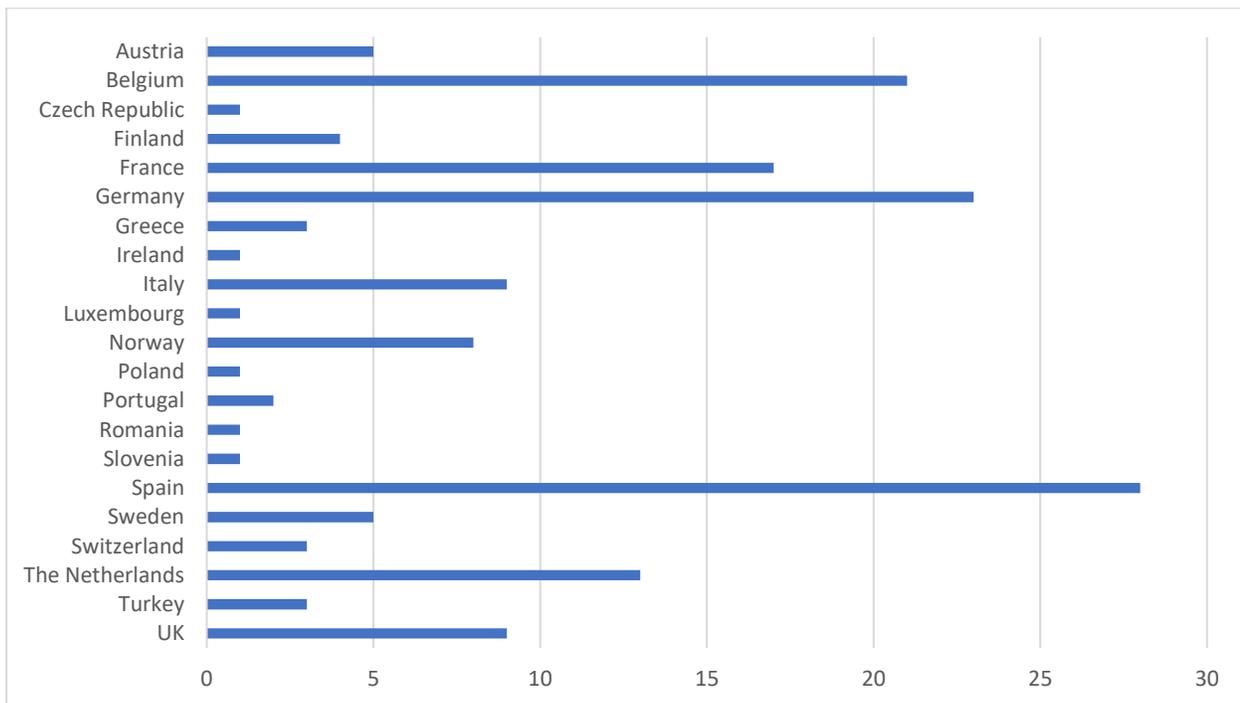


Figure 2. Number of organisations per country



4.5. Evolution of A.SPIRE membership from 2012 to 2020

4.5.1. A.SPIRE Founding Members



4.5.2. A list of current members of A.SPIRE can be found [here](#).

4.6. Abbreviations

A.SPIRE	Association of Sustainable Process Industry through Resource and Energy Efficiency
AI	Artificial Intelligence
BBI-JU	Bio-based Industries Joint Undertaking
BoD	Board of Directors
CAPEX	Capital expenditures
CCUs	Carbon Capture and Use
CEF	Connecting Europe Facility
CO₂	Carbon Dioxide
CSA	Coordination and Support Actions
DG CLIMA	Directorate-General of Climate Action
DG ENER	Directorate-General of Energy
DG ENVI	Directorate-General of Environment
DG GROW	Directorate-General of Internal Market, Industry, Entrepreneurship and SMEs
DG R&I / DG RTD	Directorate-General of Research and Innovation
EC	European Commission
ECoP	European Community of Practice
EIC	European Innovation Council
EIIs	Energy Intensive Industries
EIT	European Institute of Technology
ERDF	European Regional Development Fund
EU	European Union
EU-28	The Member States of the European Union on July 1 st 2013
FCH	Fuel Cells Hydrogen
FOAK	First-of-a-kind
GDP	Gross domestic product
GHG	Greenhouse gas
H4C	Hub for Circularity
HEU	Horizon Europe Multiannual Financial Framework 2021-2027
IA	Innovation Area or Innovation Action
IP	Innovation programme
IPCEI	Important Project of Common European interest
IRIAG	Advisory Group of A.SPIRE
KICs	Knowledge and Innovation Communities
MS	Member States

NGOs	Non-governmental Organisations
OPEX	Operating Expenses
P4Planet	Processes for Planet
PPM	Project Portfolio Monitoring
PPP	Public Private Partnerships
R&I	Research and Innovation
RIA	Research and Innovation Action
RTOs	Research and Technology Organisations
SET-Plan	Strategic Energy Technology Plan
SRL	Symbiosis Readiness Level
TRLs	Technology Readiness Levels
WG	Working Group

4.7. Glossary

CAPEX	Capital expenditures consist of the funds that companies use to purchase major physical goods or services that the company will use for more than one year. A company might incur CapEx to increase or improve its fixed assets, for example.
Capital intensive sectors	The term "capital intensive" refers to business processes or industries that require large amounts of investment to produce a good or service and thus have a high percentage of fixed assets, such as property, plant, and equipment (PP&E). Companies in capital-intensive industries are often marked by high levels of depreciation. Capital-intensive industries need to mobilise massive financial resources from capital markets and need a high volume of production to provide an adequate return on investment.
Circular Economy	A circular economy aims to maintain the value of products, materials and resources for as long as possible by returning them into the product cycle at the end of their use, while minimising the generation of waste. The circular economy offers an opportunity to reinvent our economy, making it more sustainable and competitive. This brings benefits for European businesses, industries, and citizens.
Clean Technologies	Methods of reducing the negative environmental impact of conventional technologies such as coal power or natural gas on the planet or ecosystems or that optimise the use of natural resources. Clean technology is also referred to as cleantech, green technology, and Greentech.
Climate-neutral	Climate-neutral also refers to climate-neutrality and Carbon Neutrality, which includes those activities without creation of greenhouse gases. Carbon neutrality means having a balance between emitting carbon and absorbing carbon from the atmosphere in carbon sinks. Removing carbon dioxide from the atmosphere and then storing it is known as carbon sequestration. In order to achieve net zero emissions, all worldwide greenhouse gas emissions will have to be counterbalanced by carbon sequestration. A carbon sink is any system that absorbs more carbon than it emits. The main natural carbon sinks are soil, forests and oceans. According to estimates, natural sinks remove between 9.5 and 11 Gt of CO ₂ per year. Annual global CO ₂ emissions reached 37.1 Gt in 2017. To date, no artificial carbon sinks are able to remove carbon from the atmosphere on the necessary scale to fight global warming. The carbon stored in natural sinks such as forests is released into the atmosphere through forest fires, changes in land use or logging. Therefore, it is essential to reduce carbon emissions in order to reach climate neutrality (EU Parliament, 2019).
Digitalisation	The adoption and integration of digital technologies (IoT, AI, Blockchain, Ultra-high definition, VR/AR and KETs) to allow: an opening up of new opportunities for businesses; to boost the development of trustworthy technology, to foster an open and democratic society, to enable a vibrant and sustainable economy and to help fight climate change and achieve the green transition.
Energy Intensive Industries	EIIs produce goods and materials that enable reduction of emissions in other sectors of the economy, including transport, construction and power generation.
EU Emission Trading Scheme (EU ETS)	EU ETS is a cornerstone of the EU's policy to combat climate change and its key tool for reducing greenhouse gas emissions cost-effectively. It is the world's first major carbon market and remains the biggest one. The EU ETS limits emissions from more than 11 000 heavy energy-using installations (power stations and industrial plants) and airlines operating between these countries and covers around 45% of the EU's greenhouse gas emissions.
Hubs for Circularity (H4C)	H4C are regional initiatives (involving regional stakeholders and driven by a facilitator) that aim to eliminate landfilling and contribute to climate neutrality through circularity and proximity. The initiatives also address regional demands (public and private), such as

	infrastructure needs or health and safety. This territorial approach has a direct impact on competitiveness, on improving logistics, creating jobs and opportunities for new businesses in decentralised areas.
Marbles	A Marble is the first-of-its-kind (FOAK) large scale application of one or more new technologies, integrated in the value chain, and deployed by the process industry.
Materials	The intermediary products developed by the process industries.
OPEX	Operating expenses are the costs a company incurs for running their day-to-day operations. These expenses must be ordinary and customary costs for the industry in which the company operates. Companies report OPEX on their income statements and can deduct OPEX from their taxes for the year in which the expenses were incurred.
Process industries	The family of companies that are active in the transformations and formulations of raw materials using continuous and batch processes into materials or intermediates with new enhanced properties and functionalities.
Symbiosis Readiness levels (SRL)	Level of maturity of symbiotic interactions to help drive the progress of industrial symbiosis projects and initiatives.
Technology readiness levels (TRL)	<p>TRL 1 – basic principles observed</p> <p>TRL 2 – technology concept formulated</p> <p>TRL 3 – experimental proof of concept</p> <p>TRL 4 – technology validated in lab</p> <p>TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)</p> <p>TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)</p> <p>TRL 7 – system prototype demonstration in operational environment</p> <p>TRL 8 – system complete and qualified</p> <p>TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)</p>
Upcycling	Note that where the word “recycling” is used in this document it refers to upcycling (keeping a resource in the same loop, for example the recycling of aluminium with the same quality) as well as downcycling (using a material in a lower value application, for example the use of ground bricks on tennis courts). The word recycling in this document does not refer to energy recovery (burning the waste to generate heat and/or electricity). This choice is made as the distinction between upcycling and downcycling is not always clear cut. In this document, for the process industry, the goal is to upcycle (recycle towards high value applications) where possible.

4.8. Bibliography

- A.SPIRE, & Borge del Rey, L. (PNO). (2019). *Progress Monitoring Report 2019*.
- A.SPIRE. (2019). SPRING project. Retrieved April 23, 2020, from <https://www.spire2030.eu/spring>
- A.SPIRE, Tello, P. , & Weerdmeester, R. (PNO). (2019). *SPIRE Roadmap 2030*.
- Barreira, A. (IIDMA), Lazaro, L. (Real I. E., Institute), M.-O. (Ecologic, Rüdinger, A. (IDDRI), Sina, S. (Ecologic I., & Torney, D. (Dublin C. U. (2020). Climate Laws in Europe - Good practices in Net-Zero Management. *Eco Logic, February*.
- Bazzanella, A. M., & Ausfelder, F. (2017). Low carbon energy and feedstock for the European chemical industry. *DECHEMA*, 168. www.dechema.de
- Cerame Unie. (2013). *Paving the way to 2050 - The Ceramic Industry Roadmap*. 10(11), 50–53.
- Club of Rome. (2019). *Climate Planetary Emergency*. Retrieved April 21, 2020, from <https://clubofrome.org/impact-hubs/climate-emergency/>
- McKinsey Company. (2019). *Imagining construction's digital future*. Retrieved April 21, 2020, from <https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/imagining-constructions-digital-future#>
- De Wit, M., Hoogzaad, J., & Von Daniels, C. (2020). Circularity Gap Report 2020. *Circle Economy*, 69. <https://www.circularity-gap.world/>
- European Commission. (2018). A Clean Planet for all - A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy. In *Com(2018) 773*. https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_en.pdf%0Ahttps://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_en.pdf?utm_campaign=AktuellHållbarhet-Direkten_181129_Username&utm_medium=email&utm_source=Eloqua&elqTrackId
- European Commission. (2020). *A New Industrial Strategy for Europe*. https://ec.europa.eu/info/sites/info/files/communication-eu-industrial-strategy-march-2020_en.pdf
- European Commission. (2016). *Communication on new skills agenda, human capital, employability and competitiveness 2016*. <http://www.ipex.eu/IPEXL-WEB/dossier/document/COM20160381.do>
- European Commission. (2012). *A policy framework for climate and energy in the period from 2020 to 2030*. 2014, 1–18.
- European Commission. (2019). The European Green New Deal. *COM(2019) 640*, 24. <https://doi.org/10.2307/j.ctvd1c6zh.7>
- European Commission. (n.d.). *Ecodesign Your Future*. <https://doi.org/10.2769/38512>
- European Commission. (2020). White Paper On Artificial Intelligence - A European approach to excellence and trust. In *COM(2020) 65*. <https://doi.org/10.1017/CBO9781107415324.004>
- European Commission. (2020). Annex: A new Circular Economy Action Plan For a cleaner and more competitive Europe. In *COM(2020) 98 final*. <https://doi.org/10.1017/CBO9781107415324.004>
- European Commission. (2020). *A new Circular Economy Action Plan For a cleaner and more competitive Europe EN*. <https://doi.org/10.1017/CBO9781107415324.004>
- Eurostat. (2019). Record recycling rates and use of recycled materials in the EU. *Eurostat News release, March*. <https://ec.europa.eu/eurostat/documents/2995521/9629294/8-04032019-BP-EN.pdf/295c2302-4ed1-45b9-af86-96d1bbb7acb1>

Eurostat. (2018). Circular material use rate - Calculation Method. In *Statistical Office of the European Communities*.

http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=cei_srm030

Gerbert, P., Herhold, P., Burchardt, J., Schönberger, S., Rechenmacher, F., Kirchner, A., Kemmler, A., & Wünsch, M. (2018). Klimapfade für Deutschland. *BDI - Bundesverband Der Deutschen Industrie e. V., BCG - The Boston Consulting Group, Prognos*, 286. <https://bdi.eu/publikation/news/klimapfade-fuer-deutschland/>

High-Level Group on Energy-intensive Industries. (2019). *Masterplan for a competitive transformation of EU energy intensive industries enabling a climate-neutral, circular economy by 2050*. <https://doi.org/10.2873/854920>

Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). *What a Waste 2.0 A Global Snapshot of Solid Waste Management to 2050* (Urban Deve). World Bank Group. <https://openknowledge.worldbank.org/handle/10986/2174>

Oberle, B., Bringezu, S., Hatfield-Dodds, S., Hellweg, S., Schandl, H., Clement, J., Cabernard, L., Che, N., Chen, D., Droz-Georget, H., Ekins, P., Fischer-Kowalski, M., Flörke, M., Frank, S., Froemelt, A., Geschke, A., Haupt, M., Havlik, P., Hüfner, R., ... Zhu, B. (2019). *Global Resources Outlook 2019: Natural Resources for the future we want*. United Nations Environment Programme.

OECD. (2019). *Global Material Resources Outlook to 2060: Economic Drivers and Environmental Consequences*. <https://doi.org/https://doi.org/10.1787/9789264307452-en>.

Shook, E., & Sweet, J. (2019). *Equality = Innovation Getting to Equal 2019: Creating a culture that drives innovation*. 36. https://www.accenture.com/_acnmedia/Thought-Leadership-Assets/PDF/Accenture-Equality-Equals-Innovation-Gender-Equality-Research-Report-IWD-2019.pdf#zoom=50

United Nations. (2020). *Sustainable Development Goals - Sustainable consumption and production*. Retrieved April 21, 2020, from <https://www.un.org/sustainabledevelopment/sustainable-consumption-production/>

Wyns, T., Khandekar, G., & Robson, I. (2018). *Industrial Value Chain: A Bridge Towards a Carbon Neutral Europe*. September, 1–90.