SPIRE PROGRESS MONITORING REPORT 2018

Sustainable Process Industry through Resource and Energy Efficiency

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EXECUTIVE SUMMARY

Now four years into the Horizon 2020 programme, SPIRE is in full flight, bringing together process industries, academia, and expert organisations to deliver the SPIRE2030 Roadmap. In total, SPIRE calls from 2014 to 2017 have funded 77 projects, of which six have finished and 71 are currently running.

The current report analyses the 76 projects (out of 77) that have started before 2018, with **a combined budget of €500 million** (€439 million coming from the EU), and participation from 781 organisations, including 521 private companies.

In 2017, SPIRE funded 23 new projects under nine dedicated Horizon 2020 calls, **expanding the SPIRE portfolio by over 40%.** These new projects involve 287 organisations (of which more than one third are SMEs) based in 26 countries and have a **combined budget of €166 million.** Fourteen of the funded projects under 2017 calls are Innovation Actions (IA), six are Research and Innovation Actions (RIA) and three are Coordination and Support Actions (CSA). The 2017 round has resulted in a more balanced SPIRE project portfolio, with an even number of RIA and IA projects that together account for 90% of all projects.

Thirteen of the 2017 projects concern the **circular economy,** with half of them exploring the use of alternative feedstocks in industrial processes. Nine concern **process efficiency,** exploring optimisation as well as breakthrough approaches, and the remaining two projects concern **enabling activities** to enhance the impact of SPIRE through improved standardisation and addressing regulatory issues.

Overall, the project portfolio addresses three of the four components of the SPIRE2030 Roadmap effectively (Feed, Waste2Resource and Process), but Applications remains comparatively underfunded, with no specific calls addressing this area to date. However, there is an even balance of process efficiency and circular economy projects, with particular strength in process optimisation and alternative feedstock projects.

All eight SPIRE sectors are active in projects, often collaborating on cross-sectoral innovations, with an average of three industries participating per project and each SPIRE sector participating in at least 16% of the projects. Projects also take advantage of the SPIRE framework to share information and collaborate on innovation.

SPIRE is on track to meet its contractual target to leverage private investment. **For every euro invested by the EU, we estimate that private companies have invested €7–10.** The EU has contributed almost €439 million to SPIRE projects from 2014–2017, while private companies have invested between €3–4.3 billion in developing and implementing innovations connected to the SPIRE2030 Roadmap.

In terms of creation of new skills and job profiles, SPIRE is on track to surpass its contractual target. Analysis of a sample of SPIRE projects shows at least **17 new (skilled) job profiles** being developed compared to the overall SPIRE target of 10. The majority of these new profiles should emerge in the job market within the next five years. In addition to developing new types of jobs, SPIRE projects and companies are creating jobs connected to the SPIRE2030 Roadmap investments. Eight projects reported that **86 highly skilled jobs** will be created during the course of their projects, and 20 companies reported that **438 highly skilled jobs** have been created.

SPIRE projects are disseminating the knowledge they have gained and strengthening the skills of the European workforce. Projects in the SPIRE sample reported that they had developed or were developing **14 new university courses and 13 training resources,** as well as supporting 169 PhDs and 178 Degrees. In addition, 20 of the projects reported that they had hosted a total of **106 dissemination events,** involving 41 participants per event on average.

The SPIRE SME community has grown rapidly since the inception of the cPPP in 2014 and is now estimated to comprise **258 SMEs** (255 of which participate in projects). The typical SPIRE project now involves four SMEs, and SMEs account for **28% of project participation and 26% of EU project funding received,** outperforming the requirement of 20% SME participation in Horizon 2020.

SPIRE is having a positive impact on the performance of SMEs, helping them to find new customers, access new markets, and improve competitiveness. Analysis suggests that SPIRE SMEs tend to outperform EU28 SMEs of equivalent size on average in terms of turnover and employment growth. **SPIRE SMEs reported more than 25% growth in turnover as a group,** double the increase experienced by EU28 SMEs on average.

The 76 SPIRE projects with a start date before 2018 are developing **74 major innovations,** based on an analysis of general project data, exceeding the 2020 contractual target of 40 innovative systems and technologies. At a more granular level, a sample of 48 projects reported that they were **developing 221 'significant innovations',** namely smaller technologies, processes, methods, tools, and products of exploitable value that are associated with their major innovations: an average of 4.6 significant innovations compared to 4.1 reported last year.

SPIRE is also **accelerating time-to-market** for innovations, with an average reported **saving of 29 months.** Within a sample of SPIRE projects, 65% intend to patent exploitable results with 18 patents filed, two granted and plans to apply for a further 60.

The SPIRE community is **working hard to disseminate innovations and knowledge.** Forty-four percent of surveyed projects reported plans to publish results, 79% reported that their results were broadly transferable to other sectors, and **40% were contributing to European standards,** with 16 projects contributing to standardisation documents, 10 making proposals for standards to an existing group, and three setting up a new standardisation group.

On average, SPIRE projects reported that their innovations had the potential to make significant improvements in energy and raw materials efficiency in line with SPIRE's contractual targets: **36% reduction in fossil energy consumption (30% target), 30% reduction in CO_2e ('up to 40%' target), and 25% reduction in non-renewable primary raw material consumption (target 'up to 20%').**

All in all, the results of this Progress Monitoring Report show that SPIRE is providing outstanding added value to the European Union by committing investments in Europe, promoting jobs, delivering technologies for sustainable industrial processes and society, and generating knowledge on energy and resource efficiency that is highly transferable across sectors and borders.

The breakthrough innovations developed by SPIRE projects under Horizon 2020 are setting the basis to move towards the next generation of European process industry. Moving from SPIRE2030 roadmap to SPIRE 2050 Vision under Horizon Europe will provide a quantum step forward in tackling climate change advancing the circular economy goals for the planet and society.

SPIRE

Sustainable Process Industry through
Resource and Energy Efficiency

The 2018 Pogress Monitoring Report (PMR) from SPIRE underlines the tremendous progress that our Public Private Partnership has achieved already in its short life. Launched at the end of 2013, SPIRE has brought together eight of the most important industry sectors in Europe and successfully established an unprecedented level of cross-sectorial cooperation and dialogue between them. Across the whole SPIRE community, including small and large companies, academia and research and technology organisations, a functioning trust relationship that is cross-sectorial, cross-discipline and cross-border has been nurtured. These strong and growing cooperative relationships represent the true and significant added value that SPIRE is bringing to industrial research and innovation in Europe. Together we can deliver the best sustainable solutions that our society requires.

Daniel Gauthier

Chairperson of the Board of Directors, A.SPIRE aisbl

The results of SPIRE projects in resource and energy efficiency are already delivering the breakthrough innovations that are needed to move towards the 'next generation' of European Process industry. SPIRE's 2018 PMR highlights our capacity to generate significant environmental, economic and societal impact through the added value our Horizon 2020 projects bring. The SPIRE community works together, building on each other's knowledge and enabling faster scale-up, to deliver better and more solutions for European citizens. SPIRE's work is helping to accelerate the transition to a circular and low-carbon economy ensuring jobs and growth for future generations.

Àngels Orduña

Executive Director, A.SPIRE aisbl

TABLE OF CONTENTS

1. INTRODUCTION: THE SPIRE cPPP

This report reviews the progress of the SPIRE contractual Public-Private Partnership (cPPP) from 2014–17 in relation to its objectives under the European Union's Horizon 2020 research and innovation programme, and in terms of the added value it provides to our economy, environment and society.

Launched in December 2013, SPIRE supports research and innovation (R&I) that promotes **S**ustainable **P**rocess **I**ndustries in Europe through **R**esource and energy **E**fficiency. SPIRE brings together companies, world-leading universities and research organisations involved in the following European sectors: cement, ceramics, chemicals, engineering, minerals and ores, non-ferrous metals, steel, and water. A.SPIRE is the European Association that manages SPIRE, working closely with the European Commission, member organisations, and the industry associations that represent the SPIRE sectors.

As a cPPP, SPIRE provides an enhanced framework for EU-funded R&I, deploying a strategic roadmap to deliver key economic and societal goals. The **SPIRE2030 Roadmap** was developed by the SPIRE sectors in conjunction with other energy-intensive industries, EU Member States, the European Commission, and the wider public.[1] It sets out a strategy to deliver SPIRE's contractual objectives to develop innovations that can reduce emissions by up to 40%, energy consumption by up to 30%, and raw material consumption by up to 20% in European process industries.[2] It focuses activity in four key areas:

1. **FEED**, investigating the optimal valorisation of existing and alternative feedstocks in process industries, including biomass and greenhouse gases;
2. **WASTE2RESOURCE**, looking to 'close the loop' through the avoidance, valorisation, re-use and recycling of waste streams, within and across industrial sectors;
3. **PROCESS**, providing innovative solutions for more efficient processing and new energy systems in process industries, including industrial symbiosis;
4. **APPLICATIONS**, delivering new processes and materials for market applications that boost energy and resource efficiency downstream of industry in value chains.

With €1.8 trillion turnover in 2015, the process industries account for more than 56% of industrial value added in the EU and around 10% of all economic activity. They provide 6.3 million direct jobs in the EU and a further 19 million indirect jobs. SPIRE sectors in the EU reduced their energy consumption by 22% from 1991 to 2016 while also significantly reducing emissions and increasing production. See Annex V for further data on process industries and SPIRE.

SPIRE takes a distinctly cross-sectoral approach to innovation, promoting systemic resource and energy efficiency within and between European industry sectors, covering the innovation chain from research to market demonstration. This promotes bottom-up and goal-oriented innovation. It also provides a framework for R&I projects to collaborate on common goals, share knowledge, and better communicate success.[3] This type of approach will be critical to delivering mission-driven R&I under Horizon Europe.

SPIRE is currently revising its strategic roadmap to create **SPIRE 2050 Vision** with an increased level of ambition to move *'towards the next generation of process industries - enhancing our cross-sectoral approach in research and innovation'*. This vision foresees an integrated and digital European process industry, fostering a 'well-below 2 °C' scenario for our planet and a fully circular society in Europe with enhanced competitiveness and impact for jobs and growth. Our ambition is to boost investments in Europe, generating global competitiveness for EU Process Industries, as well as better jobs and welfare for our citizens. Conversations with a wide spectrum of stakeholders, including the European Commission, policymakers, and society are again key to shape the future and meet EU and global goals.

Endnotes

1 https://www.spire2030.eu/sites/default/files/pressoffice/spire-roadmap.pdf

2 http://ec.europa.eu/research/industrial_technologies/pdf/spire-contractual-arrangements_ en.pdf

3 The value of cPPPs is widely recognised by R&I projects. A comprehensive survey on Low Carbon Process Industries commissioned by the European Commission in 2017 (which included all SPIRE projects), found that 70% of projects rated PPPs as Helpful or Very Helpful to the advancement of their innovations. https://publications.europa.eu/en/publication-detail/-/publication/df9afa95-025d-11e8-b8f5-01aa75ed71a1/language-en

2. MAIN ACTIVITIES AND ACHIEVEMENTS IN 2017

2.1 Implementation of calls for proposals evaluated in 2017

SPIRE funded 23 new projects in 2017 under nine calls. The projects involve 287 organisations—over a third of which are SMEs—and have a combined budget of €166 million. The EU contribution to the projects is €144 million, with private companies receiving over half, and research organisations and universities receiving a fifth each. Recipients of funding are based in 26 countries. Fourteen of the funded projects are Innovation Action (IA) projects, six are Research and Innovation Action (RIA) projects, and three are Coordination and Support Action (CSA) projects. The focus on IA projects has balanced the SPIRE project portfolio, which now has an even number of RIA and IA projects, collectively accounting for 90% of the portfolio.

Thirteen (57%) of the projects funded in 2017 concern the circular economy, with half of these exploring the use of alternative feedstocks, such as CO2, in industrial processes. Nine (39%) of the projects concern process efficiency, exploring optimisation as well as breakthrough approaches, such as electrolytic routes to steel. The remaining two projects (9%) concern enabling activities that enhance the impact of SPIRE through improving standardisation and addressing regulatory bottlenecks to the uptake of innovation. There were no calls in 2017 that directly concerned Applications, which remains a comparatively underfunded aspect of the SPIRE2030 Roadmap.

Twenty-two of the projects started last year (along with a project that received funding in 2016), and one started in 2018 (CO2EXIDE, which is not considered in this PMR). Meanwhile, three projects finished in 2017, taking the total number of completed projects to six. Overall, 2017 has seen the SPIRE portfolio expand by over 40%, with 71 projects running out of 77 total SPIRE projects funded by calls from 2014 to 2017. The enlarged portfolio addresses all the main blocks of the Roadmap, with the exception of Applications, and is well balanced between RIA, IA, and CSA projects.

Call	Project	Type	Category	Participations
CIRC-01-2016-2017	FiberEUse	IA	Circular Economy	23
CIRC-01-2016-2017	PlasticCircle	IA	Circular Economy	22
CIRC-01-2016-2017	ECOBULK	IA	Circular Economy	32
CIRC-01-2016-2017	ZERO BRINE	IA	Circular Economy	23
CIRC-01-2016-2017	CIRC-PACK	IA	Circular Economy	23
CIRC-01-2016-2017	PolyCE	IA	Circular Economy	20
EE-17-2016-2017	ETEKINA	IA	Process Efficiency	12
SPIRE-07-2017	SUPREME	IA	Process Efficiency	20
SPIRE-07-2017	ENSUREAL	IA	Process Efficiency	13
SPIRE-07-2017	Morse	IA	Process Efficiency	9
SPIRE-08-2017	ICO2CHEM	RIA	Circular Economy	6
SPIRE-08-2017	Carbon4PUR	RIA	Circular Economy	15
SPIRE-08-2017	RECODE	RIA	Circular Economy	14
SPIRE-09-2017	NOVUM	IA	Process Efficiency	10
SPIRE-09-2017	DEMETO	IA	Process Efficiency/Circular Economy	16
SPIRE-09-2017	PORTABLECRAC	IA	Process Efficiency	8
SPIRE-09-2017	ECCO	IA	Process Efficiency	13
SPIRE-10-2017	SIDERWIN	RIA	Process Efficiency	13
SPIRE-10-2017	OCEAN	RIA	Circular Economy	10
SPIRE-10-2017	CO2EXIDE	RIA	Circular Economy	12
SPIRE-11-2017	SPRING	CSA	Enabling Activities	6
SPIRE-12-2017	HARMONI	CSA	Enabling Activities	10
SPIRE-13-2017	SCALER	CSA	Circular Economy	7
TOTAL				**337**

Table 1: *SPIRE projects funded under 2017 calls. RIA = Research and Innovation Action; IA = Innovation Action; CSA = Coordination and Support Action. Some organisations participate in numerous projects, so the number of participations (337) exceeds the number of participants (287).*

2.2 Mobilisation of stakeholders, outreach, and success stories

Mobilisation of stakeholders & outreach 2017

The SPIRE Association has embraced the call for Openness from the Research, Science and Innovation Commissioner, Carlos Moedas. Testimony to this openness is the fact that the SPIRE Newsletter reaches more than 1,500 stakeholders with news about SPIRE projects, representing an outreach of 70% of the wider Spire Community – the stakeholders interested and/or involved in SPIRE, but that are not members of the A.SPIRE Association.

The **First EU Process Industry Conference,** held on 19-21 September 2017, welcomed members and non-members of the association and hosted the SPIRE projects' day. The conference explored the next generation of process industries and the future landscape of European R&I. Five DGs of the European Commission participated in the conference: RTD, ENER, CONNECT, GROW and CLIMA. Representatives of Member States were invited to participate in all sessions with the aim of strengthening the alignment of the SPIRE2030 Roadmap and future strategy with European policies across borders. Representatives of other PPPs were also invited and a relevant collaboration with the Big Data cPPP (BVDA) was established for the session on the digital transformation of process industries.

Mobilisation of the wider SPIRE Community is also strengthened through SPIRE's collaboration in institution-driven activities, such as DG RTD's **PPPs' Info-Days** (October 2017), which included a SPIRE brokerage event, and the **PPPs' Impact Workshop** (May 2017). A wider outreach has been achieved through the participation of SPIRE speakers (Managing Board members, R&I Advisory Board members and the Executive Director) in more than 50 events across Europe, including Eastern European countries (Estonia and Slovakia) and Turkey. Furthermore, two Thematic Workshops (Industrial Symbiosis, and New Business Models for the Process Industry) were held, specifically addressing the members of the Association.

Success stories

The following success stories are three examples of inspiring projects within the SPIRE portfolio that could have significant impact across the EU, environmentally and economically.

REE4EU. Over the last 20 years there has been an explosion in demand for Rare Earth Elements (REE), which are used in a growing number of modern applications, such as laptops, mobile phones, and electric vehicles. The EU is 100% dependent on imports of REE, which are mainly mined in China, causing significant damage to the environment and human health. The REE4EU project aims to demonstrate that it is possible to recover REE from waste instead, supplying the whole EU REE value chain, delivering resource independence for the EU, and massively reducing environmental impacts. The project, which began in 2015, is on track to demonstrate extraction of REE and alloy production at pilot scale for the first time, with the potential to enable 90% REE recovery, as well as reduce material consumption by 90%, and halve emissions and energy consumption across the EU's REE value chain.

SOLPART. Energy-intensive industries, such as the minerals sector, require a large amount of heat for their processes. This is currently produced by burning fossil fuels, which contributes significantly to emissions in the EU, and is expensive for the sectors, with fuel bills typically accounting for 30-40% of plant operational costs. The SOLPART project is developing a revolutionary new approach that seeks to heat industrial processes in the minerals sector using only the sun. The project, which began in 2016, is making good progress and plans to demonstrate a high-temperature solar reactor for the first time at pilot scale next year, which could reduce emissions by 40% in the lime and cement sectors, and slash plant running costs by 20% through providing access to a free source of natural heat.

DEMETO. Starting in 2017, the new DEMETO project aims to demonstrate a chemical recycling technology that could transform our relationship to plastic, decoupling production from primary resources, and allowing us to recycle plastic waste back into basic chemical raw materials that can be used to make new virgin-grade plastic. Using an internationally patented technology, the project hopes to demonstrate for the first time at pilot scale a new depolymerisation process using microwaves that could recycle PET plastic waste streams in the EU infinitely, closing the loop, while reducing emissions by 40%, and energy consumption by 60%.

2.3 Governance

The Partnership Board supports the implementation of the cPPP, fostering dialogue between the public and private partners to define strategic research and innovation activities in key sectors of the European economy. Three meetings of the Partnership Board for the SPIRE cPPP were organised in 2017, involving the relevant Commission services (DG RTD, DG ENER, and supporting agencies) and representatives from the private side of the SPIRE cPPP nominated by A.SPIRE aisbl. The Partnership Board has a mandate to discuss the progress of the cPPP and the Multi-Annual Work programmes, as well as propose Roadmap updates (if necessary), and ensure mutual collaboration.

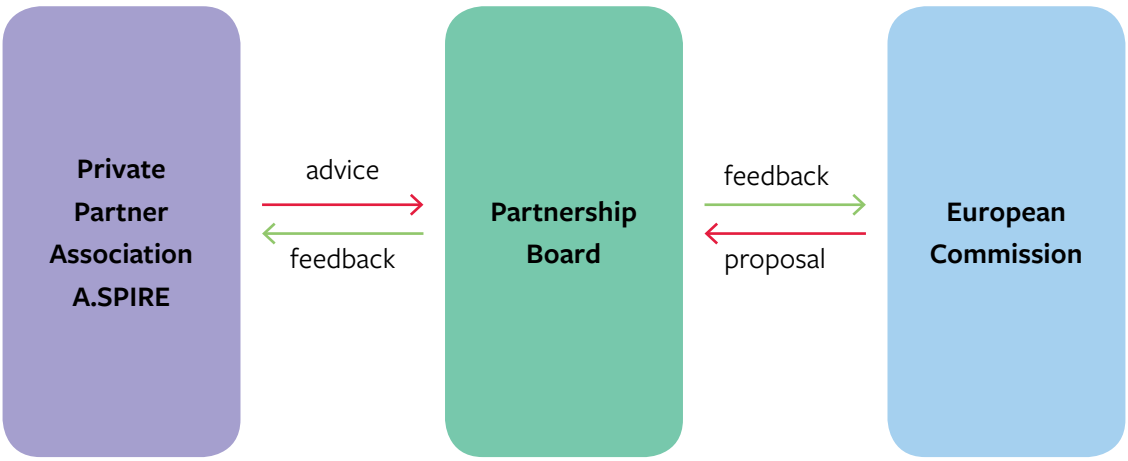


Figure 1: *Governance structure of SPIRE.*

The main topics addressed at the Partnership Board meetings were as follows:

- Status of grant agreements and implementation procedure in relation to SPIRE 2016 calls;
- Preparations for Work Programme 2018-2020, based on priority areas for industrial partners and EU and global challenges;
- Major events and activities such as Info Days, the Impact Workshop, brokerage events and other conferences that have been highly attended by stakeholders;
- The mid-term review of cPPPs under Horizon 2020, and the results of the progress monitoring report for 2016, and
- Major policy developments, which may contribute to the support and success of the SPIRE cPPP, or to the mobilisation and commitment of the private partners.
- Developments related to the next European research and innovation programme for 2021 to 2027 (Horizon Europe), including missions and the future of partnerships.

3. MONITORING OVERALL PROGRESS SINCE THE LAUNCH OF THE cPPP

This section reviews SPIRE's progress from 2014-17, based on data gathered from projects and companies via two separate questionnaires. Forty-three projects and 100 companies completed responses, which is 57% of projects and 19% of companies in SPIRE. Not all questions were mandatory, and some additional projects and companies provided partial responses, so sample sizes vary (which is noted throughout accordingly). For further information on data and statistical methods, see Annex I.

3.1 Achievement of the goals of the cPPP

Four years on since its launch, SPIRE is now in full flight, bringing together process industries, academia, and expert organisations to deliver the SPIRE2030 Roadmap. So far SPIRE has funded 77 projects, of which 76 started before 2018 and have a combined budget of €500 million (€439 million of which comes from the EU), and participations from 781 different organisations (including 521 private companies). As a whole, the project portfolio addresses three of the four blocks of the SPIRE2030 Roadmap effectively, but Applications remains comparatively underfunded, with no specific calls addressing this area to date. There is an even balance of process efficiency and circular economy projects, and particular strengths in process optimisation and alternative feedstocks.

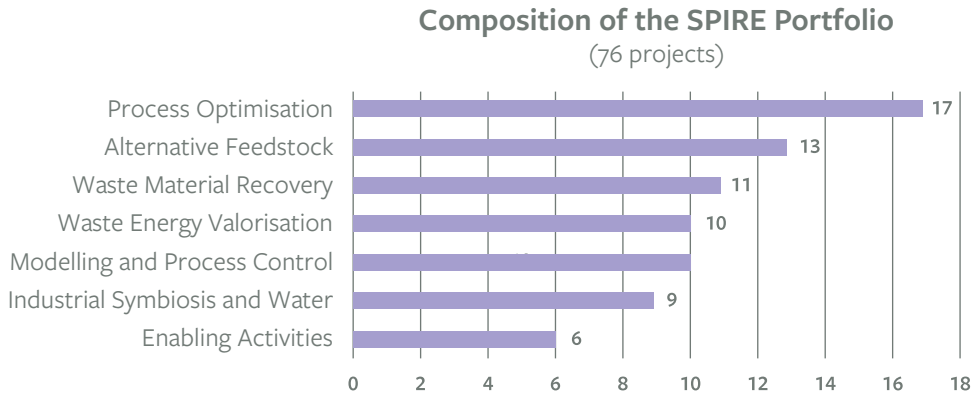


Figure 2: *Number of SPIRE projects by topic. All projects with a start date before 2018 have been included, including six now completed projects. For the classification of each project, please see Annex II.*

All eight SPIRE sectors are active in projects, often collaborating on cross-sectoral innovations. Indeed, a sample of 43 projects reported an average of three industries participating per project (including non-SPIRE sectors), with each SPIRE sector participating in at least 16% of the projects. Industrial symbiosis projects, such as EPOS and SCALER, as well as CSA projects, such as HARMONI and SPRING, are especially cross-sectoral. Projects are also taking advantage of the SPIRE framework to share information and collaborate on innovation. For instance, three SPIRE projects (SAMT, STYLE, and MEASURE)[4] have produced joint recommendations on sustainability assessment; three projects (INSPIREWATER[5], ReWaCEM, and SPOTVIEW) recently held a joint workshop on efficient water management; and two projects (EPOS and SHAREBOX) are working on a CEN Workshop Agreement setting out best practice in industrial symbiosis.[6]

3.2 Progress Achieved on KPIs

3.2.1 Mobilised private investment

Our analysis suggests that SPIRE is on track to meet its contractual target of leveraging private investment worth 5–10 times the EU contribution to SPIRE projects by the end of Horizon 2020, and is outperforming 2014 baseline values in this area (based on FP7 projects). The EU has contributed almost €439 million to SPIRE projects until the end of 2017 during Horizon 2020, and we estimate that companies involved in SPIRE have invested €3–4.3 billion in developing and implementing innovations connected **to SPIRE projects and to SPIRE2030 Roadmap** over this period. This would mean that for every euro invested by the EU, private companies have invested €7–10. [7]

To date, the budgeted contribution of private companies **to SPIRE projects** in Horizon 2020 is €56 million. Eighteen out of 43 projects we surveyed, however, reported additional private expenditure worth more than €9 million in total, with average additional expenditure exceeding €0.5 million for over-budget projects. Based on these data, we estimate that private expenditure exceeds budgets in 24–39 out of 76 SPIRE projects, with additional expenditure in the region of €12–20 million.[8] On this basis, we estimate that companies have in fact contributed around €69–76 million to SPIRE projects to date during Horizon 2020.

In addition to this project expenditure, 64% of large enterprises and 45% of SMEs we surveyed (from a sample of 77 companies) reported that since becoming involved in SPIRE they had invested outside of SPIRE projects in innovations that advance the SPIRE2030 Roadmap. These innovations included integrated process control systems, efficient furnaces, water treatment facilities, waste heat recovery systems, and various pilot plants. Respondents reported that these wider investments were worth €461 million, with an average investment of €21 million for large enterprises (that provided figures), and an average €2.9 million for SMEs (that provided figures). On average, the SMEs reported that they were investing 49% of their R&I budget on areas connected to the SPIRE2030 Roadmap, and large enterprises 28%. Based on these data, we estimate that 77–153 SMEs and 132–180 large enterprises have made Roadmap-relevant investments **outside of SPIRE projects,** worth around €3–4.2 billion in total, which is well over the 2014 baseline value in this area of €2.3 billion.[9]

Summing companies' estimated project expenditure and wider investment, and comparing the figure to the EU's total financial contribution to SPIRE projects, we estimate that the leverage factor for SPIRE as a whole is currently 7–10. Given the approximate nature of this estimate, we have also calculated the weighted average leverage factor for a company in our sample based purely on declared investments and known population values, rather than inferred parameters.[10] This was found to be 8.3, based on data from 71 companies, representing over 13% of the companies involved in SPIRE.

Budgeted private contribution to SPIRE projects	€56 million
Estimated over-budget private contribution to SPIRE projects	€12–20 million
Estimated wider private investment on SPIRE2030 Roadmap	€3–4.2 billion
Total EU contribution to SPIRE projects	€439 million
Estimated Leverage Factor	**7–10**

Table 2: *Estimated leverage factor of SPIRE to date in Horizon 2020, defined as the total contribution of private companies to SPIRE projects and the SPIRE2030 Roadmap (since becoming involved in SPIRE during Horizon 2020 until the end of 2017) versus the EU contribution to SPIRE projects with a start date before 2018 in Horizon 2020. For further information, see Annex III.*

3.2.2 New skills and job profiles

SPIRE is on track to surpass its contractual target of developing 10 highly skilled new job profiles during Horizon 2020. A sample of 31 projects reported 17 new job profiles under development (0.55 per project), and a sample of 44 companies reported 21 new profiles (0.47 per company) in relation to wider SPIRE2030 Roadmap investments. Eighty-eight percent of the projects, and over 40% of the companies, estimated that jobs matching the profiles would emerge within 5 years. Reported profiles include Industrial Symbiosis Manager, 3D Design Expert, and Laser Operator. These samples only capture a fraction of SPIRE's activities, so the total number of new job profiles being developed in the cPPP is likely to be significantly higher.

Examples of New Job Profiles			
Solar Heat Expert	Industrial Symbiosis Manager	Digital Architect	Process Intensification Manager
3D Design Specialist	Simulation and Optimisation Expert	LCA Engineer	Laser Operator
Industrial Catalysis Expert	Membrane Reactor Specialist	Process Modelling Expert	Feedstock Purification Expert
Machine Learning Expert	Bioprocess Engineer	Plasma Reaction Engineer	Hydrogen Facility Attendant

Table 3: *Selection of new highly skilled job profiles being developed within SPIRE by projects and companies. Job titles have sometimes been simplified based on descriptions provided by the survey respondents. For a full list, please see Annex VI.*

In addition to developing new types of jobs, SPIRE projects and companies are creating job positions connected to the SPIRE2030 Roadmap. Eight projects (from a sample of 43) reported that 86 highly skilled jobs will be created during the course of their projects, and 20 companies (from a sample of 79) reported that 438 highly skilled jobs have been created in relation to their wider SPIRE2030 Roadmap investments undertaken during Horizon 2020 since becoming involved in SPIRE (including investments that deploy technologies at a commercial scale, such as a new factory to manufacture solar grade silicon with innovative processes). About three quarters of these 438 jobs were reported by large enterprises that comprised about half of the companies that reported they had created jobs.

As well as creating jobs and job profiles, SPIRE projects are disseminating knowledge and strengthening the skills of the European workforce. Projects in our sample reported that they had developed or were developing 14 new university courses and 13 training resources, as well as supporting 169 PhDs and 178 Degrees: an increase per project on every metric since last year. Courses included advanced STEM Degree modules, as well as Massive Open Online Courses (MOOCs), covering issues such as CCU, machine learning, and industrial symbiosis, at institutions such as DTU, UGent, EPFL, KU Leuven, and TU Delft. Twenty of the projects reported that they had hosted a total of 106 dissemination events, involving 41 participants per event on average. In addition, 28 companies from a sample of 55 reported that their wider SPIRE2030 Roadmap investments involved training and enhancing skills in the workforce.

3.2.3 Impact on SMEs

While SPIRE does not have contractual targets concerning SMEs, it is surpassing 2014 baseline values for SME participation (based on FP7 projects), and our analysis suggests that SPIRE SMEs tend to outperform EU28 SMEs when it comes to turnover and employment growth, in part due to the benefits of participation in the cPPP.

The SPIRE SME community has grown rapidly since the inception of the cPPP in 2014, and is now estimated to comprise 258 companies (255 of which participate in projects). On average, a SPIRE project now involves 4 SMEs, and SMEs account for 28% of project participations, with 26% of EU project funding going to SMEs. This exceeds the 2014 baseline value for SME participation by over five percentage points and contributes to the EU's target of at least 20% participation across Horizon 2020. We estimate that 91% (±8%)[11] of SPIRE SMEs are small or medium sized, based on data from 105 companies. This contrasts with the EU in general, where Micro SMEs account for 93% of the SMEs community. We further estimate that 35% (±8%) of SPIRE SMEs are less than 10 years old, 60% (±8%) are less than twenty years old, and 90% (±8%) are less than 40 years old. Based on more comprehensive data, it is evident that SPIRE SMEs are distributed across at least 24 different European countries.

Analysing a sample of approximately 15% of the SPIRE SME community we found that the SMEs reported that they had increased their number of employees considerably more on average than EU28 SMEs of equivalent size. While employment levels have been fairly flat for EU28 SMEs on average, SPIRE SMEs in our sample reported a weighted average increase of almost nine new employees in this period; well over the minimum 2014 baseline value of two new employees per enterprise.

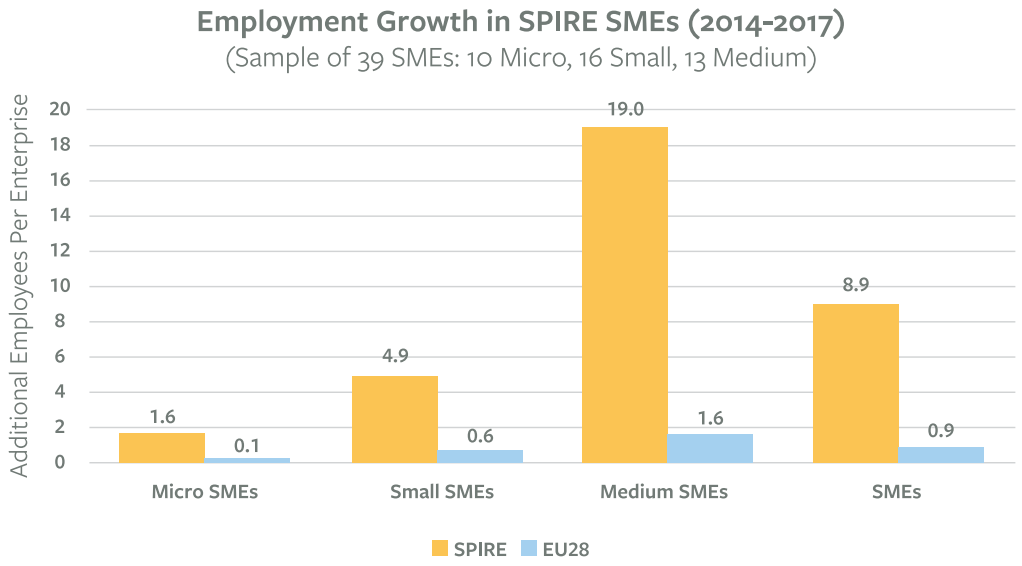


Figure 3: *Change in number of employees per SPIRE SME from 2014-17 compared to the EU average. SPIRE SME values are self-reported and sometimes approximated. The EU28 averages are derived from the EU's annual SME assessment reports, dividing the increase in jobs from 2014-17 in each size category by the number of enterprises in that size category in 2017. The SPIRE and EU values for all SMEs in the final column have been weighted to match the composition of the SPIRE SME population.*

Similarly, analysing a sample of over 10% of the SPIRE SME community we found that the SMEs reported more than 25% growth in turnover as a group, which was double the increase experienced by EU28 SMEs as a whole over this period (based on a weighted reference scenario using GVA figures and controlling for growth in the EU28 SME population). This result significantly exceeds the 2014 baseline value in this area, which assumes a 16% increase in SMEs' sales.

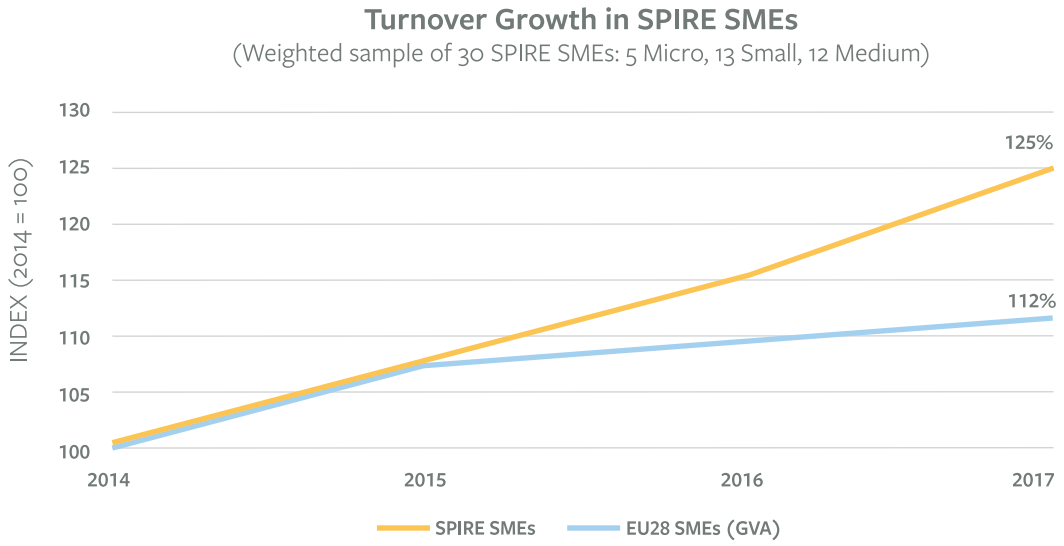


Figure 4: *Turnover growth in SPIRE SMEs from 2014-17 compared to EU28 SMEs. SPIRE SME values are self-reported and sometimes approximated. The EU28 reference group was constructed using data from the EU's annual SME reports, and is equivalent to all 2014 EU28 SMEs remaining open throughout the period and taking their share of GVA growth each year as the population of SMEs expands. Assuming a consistent ratio of sales to intermediate consumption, GVA growth measured proportionally is used as a proxy for turnover growth. Both data sets were weighted to reflect the composition of the SPIRE SME community as a whole, and use nominal euro values.*

We should bear in mind that the sample data are self-reported and often approximate, and the statistics may deviate from the true population values for all SPIRE SMEs. Furthermore, it is important to stress that we cannot precisely determine the extent to which SPIRE is causally responsible for the SPIRE SMEs' superior performance. Nevertheless, while there may be a range of wider factors at play too, it is evident that SPIRE has had a significant positive impact on the SMEs' performance, insofar as it helps them (and large enterprises) find new customers, access new markets, and improve competitiveness.

Based on data from over 15% of SPIRE SMEs, 77% reported that SPIRE had had a 'Positive' or 'Very Positive' effect on their turnover to date, and 96% anticipated a 'Positive' or Very Positive' effect over the next five years. Over 35% commented on the value of SPIRE in terms of raising visibility and making new contacts, with 38% reporting that they were in contact with over 10 new organisations through SPIRE, and 28% reporting they were in contact with 6–10 new organisations. Fifteen percent of the SMEs had already won new business through SPIRE contacts, adding over €190,000 to annual turnover on average. Indeed, one reported that SPIRE had increased the value of the business by 10-15% already, and another reported that SPIRE-related business accounted for 100% of 2017 turnover. These findings speak to the particular benefit of coordinating R&I through PPPs, insofar as it provides SMEs with wider opportunities to network with larger enterprises and win new business.

3.2.4 Innovations

Project data suggest that SPIRE is on track to meet its contractual target of developing 40 innovative systems and technologies that advance the sustainability of European process industries during Horizon 2020, and is performing well against 2014 baselines concerning innovation (based on FP7 projects).

The 76 SPIRE projects with a start date before 2018 are developing **74 major innovations** according to an analysis of data from CORDIS.[12] Breaking these down into the categories in SPIRE's Contractual Agreement, 12 primarily concern alternative feedstocks, 11 primarily concern closing the loop, 27 primarily concern CO2 abatement, 10 primarily concern novel materials, four primarily concern water efficiency, and 10 primarily concern industrial symbiosis. This exceeds the targeted number of innovations in each category, except in the case of water efficiency, which should be addressed in future calls (although water efficiency is often a consequence of innovations classified under other categories, so it is better addressed than this might suggest). While not all projects will necessarily succeed in developing their major innovations, the number under development well exceeds the 2020 target with three years of calls to go, so it seems reasonable to assume that the target will be met.

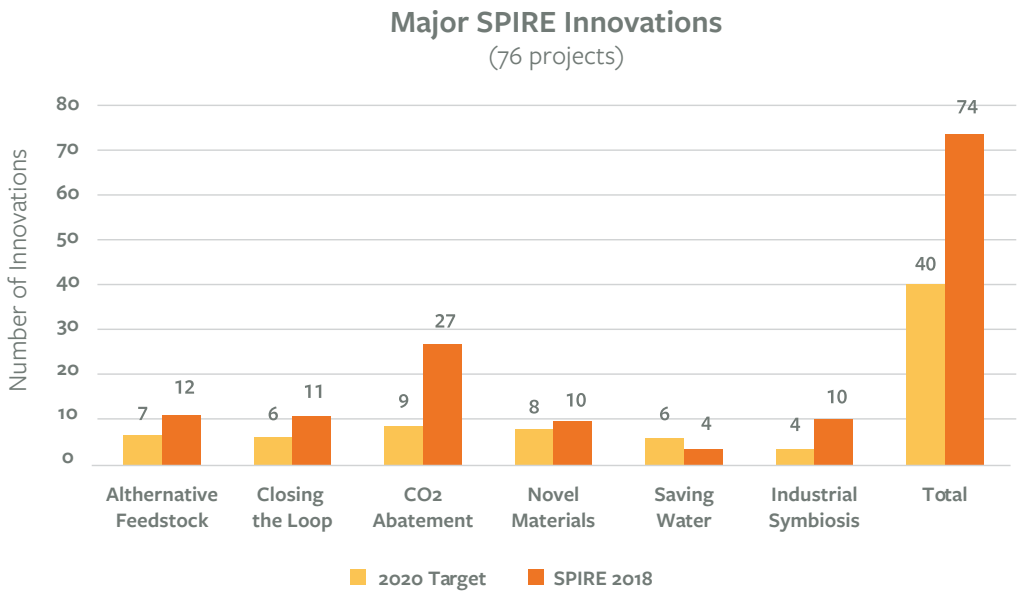


Figure 5: *Number of major innovations being developed by SPIRE projects with a start date before 2018, categorised according to the taxonomy in the SPIRE Contractual Agreement, and compared to the target in each of these categories. Major innovations were identified based on survey data from this year and last, as well as information available on project websites and CORDIS.*

At a more granular level, a sample of 48 projects reported that they were developing 221 **'significant innovations',** which are the smaller technologies, processes, methods, tools, and products of exploitable value that are involved in delivering their over-arching major innovations.[13] Given that this sample only accounts for 63% of SPIRE projects, we expect that the total number of significant innovations being developed is considerably higher. Innovations reported include catalysts, membranes, heat exchangers, reactors, recycling methods, carbon capture methods, products made from alternative materials, process control IT systems, and data platforms and tools, such as material passports and industrial symbiosis sectoral blueprints.

On average, projects reported 4.6 significant innovations each: slightly more than in the previous year (4.1). Innovations were reported by all types of SPIRE projects, with waste material recovery projects reporting the highest average number per project (8.2) and enabling activity projects reporting the lowest (3). Over two fifths of the reported innovations concerned either process optimisation or alternative feedstocks, which are major aspects of the SPIRE2030 Roadmap. Some of the reported innovations could be classed as Applications (i.e. new products, tools, and materials that improve environmental performance downstream in other sectors, such as the automotive industry, or construction industry), but such innovations were a small minority, reflecting the comparative underfunding of this aspect of the Roadmap to date.

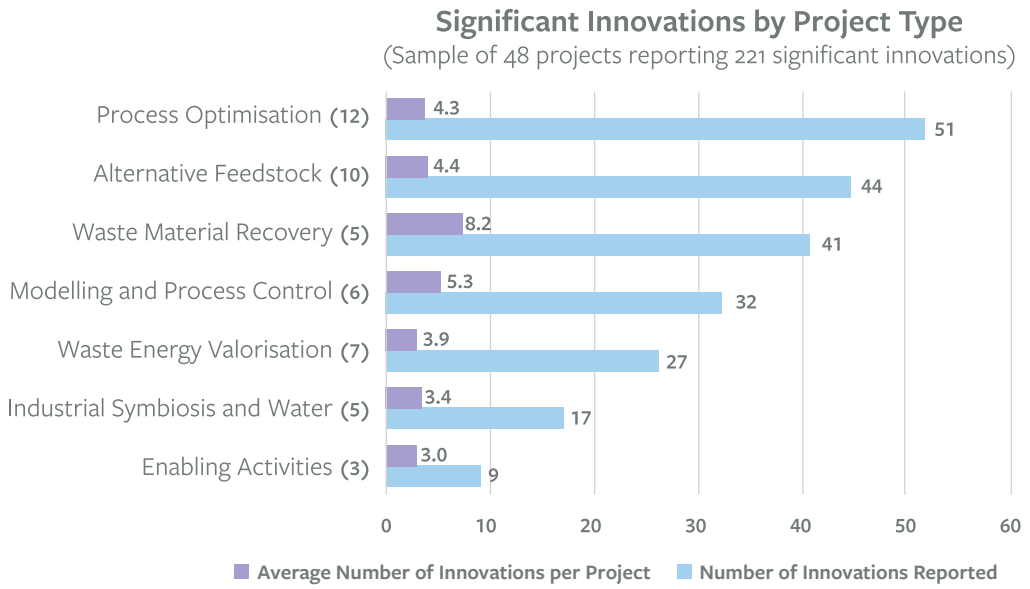


Figure 6: *Number of significant innovations reported by different types of SPIRE project. The number of projects in each category that responded is noted in brackets.*

Projects self-reported that, by the end of 2017, their significant innovations with a Technological Readiness Level (157 of the reported 221) ranged from TRL 2–7, with a mean TRL of 4.7. On average, projects self-reported that they had already increased the TRL of these innovations by 1.2 TRL points since the start of their project (with RIA projects reporting larger increases than IA projects), and they expected a further increase of 1.4 TRL points by the end of the project. Projects also reported that participants planned to invest in taking almost 50% of innovations (with a TRL) up to a higher TRL after the end of the project, which exceeds the 2014 baseline value in this area by almost 20 percentage points.

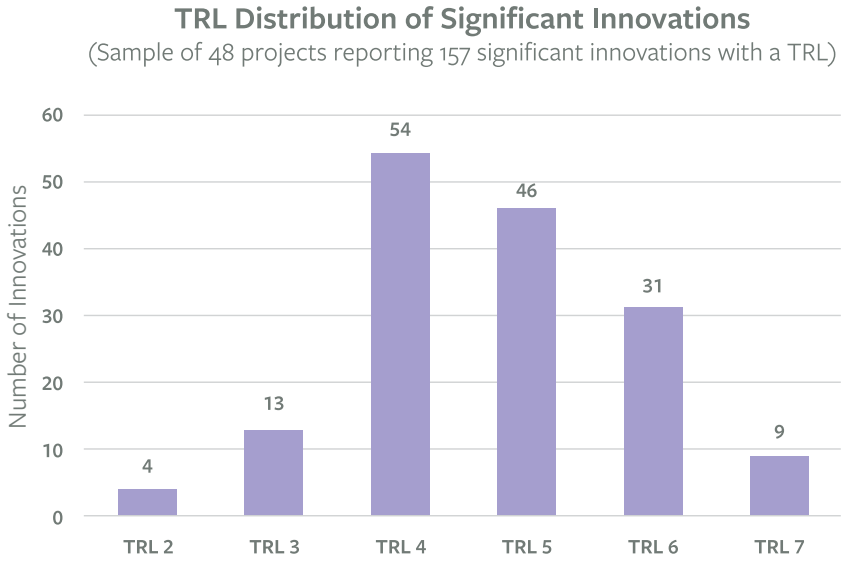


Figure 7: *Current TRL spread of significant innovations (with a TRL) reported by a sample of 43 SPIRE projects. TRL values are self-reported.*

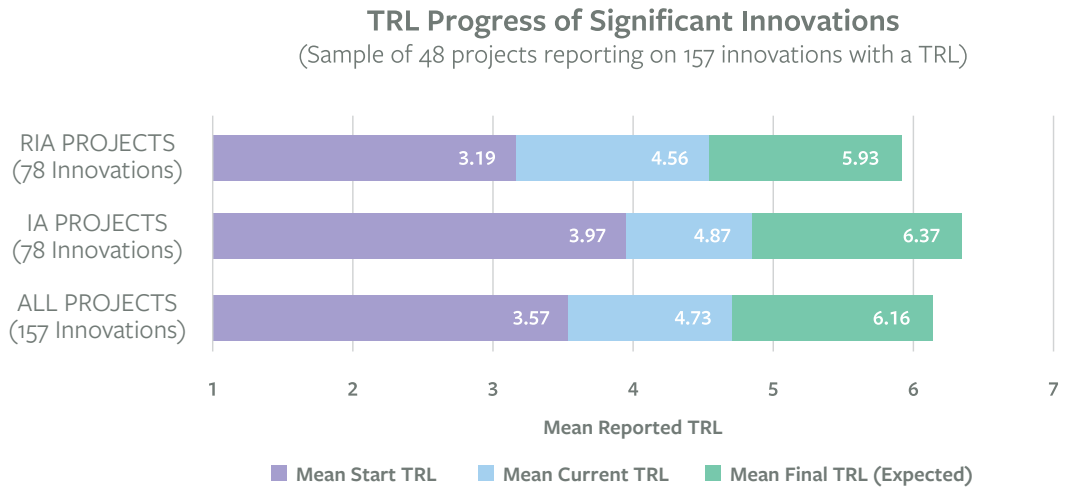


Figure 8: *Mean TRL progress of significant innovations (with a TRL) being developed by different types of SPIRE project. TRL values were self-reported. RIA = Research and Innovation Action; IA = Innovation Action. 'All projects' also includes one CSA project (Coordination and Support Action) that reported one method innovation with a TRL.*

As well as advancing the TRL of a large number of significant innovations, SPIRE is performing well in terms of exploiting and commercialising results. Over half of 43 projects reported that SPIRE accelerates the time it takes to bring innovations to market, with respondents anticipating an average saving of 29 months. Sixty-five percent of the projects expressed their intention to patent exploitable results, reporting that they had applied for 18 patents, and planned to apply for a further 60, with two patents already having been awarded. On average, projects in the sample were pursuing 1.8 patents, which exceeds the EU's Horizon 2020 target of three applications per €10 million funding (based on the average EU contribution to a SPIRE project). In addition, 87% of the non-CSA projects in the sample reported that consortium members had plans to exploit project innovations, with 3.7 organisations having developed a business plan for this purpose per project on average.

Finally, it is evident that the SPIRE community is working well to disseminate knowledge concerning innovations and latest best practice for wider transference of results. Forty-four percent of surveyed projects reported plans to publish results, and 79% reported that results were broadly relevant to other sectors. In addition, 40% reported that they were contributing to European standards, with 16 projects contributing to standardisation documents, 10 making proposals for standards to an existing group, and three setting up a new group. Some projects were also undertaking other standardisation activities, such as producing a Workshop Agreement or offering guidance on best practice on standardisation in general (e.g. HARMONI). The number of standardisation activities per project (0.77), significantly exceeds the 2014 baseline value (0.25). In addition, a sample of 41 projects and 67 companies reported 43 contributions to standardisation documents, which meets the 2014 baseline value in this area.

3.2.5 Promoting sustainable process industries in Europe

Data from samples of SPIRE projects suggest that SPIRE is performing well against its contractual target of developing systems and technologies that can reduce European process industries' emissions by up to 40%, fossil-energy consumption by up to 30%, and non-renewable primary raw material consumption by up to 20%.[14] The sample data also suggest that SPIRE is exceeding the relevant 2014 baselines on environmental impact (based on FP7 projects).

On average, SPIRE projects that provided figures reported that their innovations had the potential to reduce emissions by 30%, fossil energy consumption by 36%, and non-renewable primary material consumption by 25% (compared to current practice).[15] They further reported that their innovations could reduce waste by 32%, and freshwater consumption by 20%. It should be noted that these are sample means, so may well differ from the true mean for all SPIRE projects.[16] Indeed, some of the samples were very small, and the dispersion wide. Nevertheless, we note that the SPIRE samples outperform the small sample of eight FP7 projects used to set 2014 baselines in this area, sometimes by over ten percentage points.

Metric	Sample size	Mean	Median	Mode	Low	High	STDEV
CO2 Reduction (%)	17	**30**	30	30	1	90	25
Energy Reduction (%)	10	**36**	33	50	1	78	23
Material Reduction (%)	7	**25**	15	30	1	90	31
Waste Reduction (%)	10	**32**	25	20	1	98	28
Water Reduction (%)	2	**20**	20	10 & 30	10	30	14

Table 4: *Average proportional environmental impacts reported by SPIRE projects. 'Energy Reduction' refers specifically to fossil-energy consumption; 'Material Reduction' refers specifically to non-renewable primary raw material consumption; 'Water Reduction' refers specifically to freshwater consumption; 'Waste Reduction' covers waste going to landfill, incineration, or being discharged.*

In relation to SPIRE's three contractual environmental indicators, 85-90% of the projects estimated that their innovations would perform as well as, or better than, expected at proposal stage. Projects that intensified processes reported the highest proportional energy and emissions savings. The ROMEO project, for instance, which combines chemical synthesis and downstream processing in one step with catalysis and membrane technology, has the potential to reduce total energy consumption in large industrial processes by up to 78% and emissions by 90%.[17] Meanwhile, circular economy projects that sourced materials through secondary routes, reported the highest proportional material and waste savings. The CABRISS project, for instance, is developing technology with the potential to collect up to 90% of photovoltaic waste in the EU, and retrieve up to 90% of the valuable metals for use in new solar panels.[18]

The smaller reported proportional values were from projects developing site-level process control, especially if they had used wide system boundaries in their assessment. These projects, nevertheless, often reported strong absolute reductions at the case study level, and cost savings worth millions of euros per annum. A few projects were able to provide information on estimated impact at EU-wide level under a deployment scenario for their technology (which they defined variously). Three estimated that their innovations could save a total of 2.5 million tonnes of CO2 a year when deployed in the future, two reported potential savings of 600 thousand tonnes of raw material a year, and one estimated energy savings exceeding 400 ktoe a year.

3.3 Evolution over the years

SPIRE's measured performance has improved considerably since last year, but it is difficult to draw robust conclusions due to significant changes in the measurement process itself, including improvements in data gathering and analysis. Where measuring methods have been consistent, results per project/company tend to show a slight improvement, but are broadly consistent.

Indicator		2017 PMR Measured Value	2018 PMR Measured Value
Leverage Factor		5.4	7–10 (Improved methodology)
Innovations per project		4.1	4.6
Job profiles per project		No equivalent measure	0.55
SMEs	Turnover Increase	11% (No robust data)	25% (Improved data)
	New jobs per company	No equivalent measure	9
Environment	CO_2 reduction	25%	30% (Simplified methodology)
	Energy reduction	20%	32% (Simplified methodology)
	Material reduction	20%	32% (Simplified methodology)
	Waste reduction	28%	32% (Simplified methodology)

Table 5: *SPIRE's measured performance in the 2018 PMR compared to the 2017 PMR on its main KPIs. Energy reduction does not refer specifically to fossil-based energy. Material reduction does not refer specifically to non-renewable primary material.*

Methodological changes in the 2018 PMR:

- In contrast to previous years, SPIRE's leverage factor for the 2018 PMR has been calculated including over-budget project expenditure and excluding potential future investments reported by companies. A new methodology was introduced for scaling-up sample values to estimate population parameters, and a complementary approach was adopted to calculate the weighted average leverage factor based on sample statistics and known population values.

- Surveys were redesigned for the 2018 PMR to distinguish more clearly between job profiles and positions, as well as gather data on SMEs' turnover and employment since 2014, enabling more robust reporting on these metrics.

- A simpler methodology for environmental KPIs has been used this year, based on calculating the average estimated proportional improvement reported by projects (compared to the relevant practices that would be displaced).

- The SPIRE population has been defined more accurately for the 2018 PMR by i) distinguishing between project participations and participants, ii) classifying companies of unknown size based on new data from Coordinators, and iii) sourcing information on the size of SMEs within the SPIRE SME community. This was used to weight samples, infer parameters, and determine margins of error.

Endnotes

4 https://www.spire2030.eu/sites/default/files/users/user221/STYLE/SAMT_STYLE_MEASURE%20Harmonized.pdf

5 https://www.spire2030.eu/inspirewater/New-Event/save-date-8-february-2018-joint-cross-cutting-issue-workshop

6 https://www.cen.eu/news/workshops/Pages/WS-2018-001.aspx

7 This is an estimate of the ratio of total private investment to total EU investment within SPIRE that is of relevance to the SPIRE2030 Roadmap. This is in line with the Commission's guidance on measuring the leverage factor.

8 The confidence interval for the number of over-budget projects in the population was computed with a 95% confidence level based on the proportion of over-budget projects in the sample (taking the SPIRE population to comprise 76 projects). This confidence interval was then multiplied by the sample mean additional expenditure for over-budget projects. This method was chosen because it was not possible to calculate a useful confidence interval using the sample mean (due to the dispersion of the data), and it seemed preferable to report a sensible range, rather than a single figure with high uncertainty.

9 The confidence intervals for the number of SMEs and large enterprises investing in the population were calculated with a 95% confidence level based on the proportions reported in the respective samples (taking the SPIRE population to comprise 270 large enterprises and 258 SMEs). Each interval was then multiplied by the relevant sample mean investment and summed to arrive at the final estimate. This method was chosen because it was not possible to calculate a useful confidence interval using the sample means (due to the dispersion of the data), and it seemed preferable to report a sensible range, rather than a single figure with high uncertainty.

10 This factor was calculated by summing: i) companies' average reported investment outside of projects from a sample of 71 companies (which was weighted to reflect the composition of the SPIRE population); ii) companies' average budgeted contribution to projects (based on the known population values for total private contribution to budgets and the total number of companies involved in SPIRE); and iii) companies' average over-budget project expenditure (calculated by dividing the reported additional expenditure from a sample of 43 projects by the estimated number of distinct companies involved in 43 projects, itself derived from the known population values for the number of projects and companies in the population). This was then compared with the EU's contribution to projects divided by the number of companies in the SPIRE population (i.e. an individual SPIRE company's share of the EU's contribution).

11 Margins of error in this paragraph are based on a 95% confidence level and an assumed population of 258 SPIRE SMEs.

12 'Major innovation' is defined as the main innovative outcome/s that the project seeks to achieve that corresponds to the Contractual Agreement taxonomy, e.g. developing a chemical recycling technology that 'closes the loop'. This is in contrast to all the smaller innovations that are involved in delivering the overarching objective of the project (e.g waste sorting methods, a new depolymerisation technology, and so on) which are classed as 'significant innovations' in the analysis that follows. If a major innovation was related to more than one category, it was classified in the one that best captured the project's overall objective.

13 These significant innovations are the components that make up the major innovations previously discussed, and as such the two categories of innovation should not be summed to arrive at a total number of innovations. This broader definition of innovation is in line with the European Commission's guidance on how to count 'significant innovations' for the purposes of reporting on Common KPI 4. In this instance, 'significant' does not indicate particular importance, or higher impact compared to other innovations, but rather that the innovation has some exploitable value: it is an inclusive rather than exclusive classification. Standardisation outputs and TRL increases have not been counted as innovations, however, despite this being presented as an option by the Commission. Data on standardisation and TRL increases are instead presented separately for the purposes of clarity.

14 We will not seek to estimate the potential impact of SPIRE innovations in aggregate on SPIRE industries' environmental footprints in a target year under a deployment scenario compared to a business as usual forecast for that year. Projects cannot contribute relevant EUwide data for such complex modelling on the whole, and building an EU-wide baseline for SPIRE industries' environmental footprints, and an economic uptake model are beyond the remit of the PMR process. Furthermore, the contractual agreement does not define SPIRE's environmental targets in this way, and the percentage targets in the contractual agreement would be infeasible if the targets were defined in this way. For this reason, we will interpret the targets to mean that SPIRE should support projects that on average are developing innovations that offer a certain proportional environmental improvement compared to the relevant counterfactual practices they would displace (when the metric is relevant and figures have been provided).

15 Projects were asked to define the comparison scenario they were using to provide figures (typically an LCA functional unit or case study), and provide information on system boundaries, assumptions, data sources, and methods. The scope of the projects' assessments varied, which should be borne in mind when making comparisons, but their data were consistently robust and typically based on current best practice (e.g. as defined in BREFs).

16 Due to the non-normal nature of the data and size of the samples and population, it is not possible to calculate confidence intervals (even under the Central Limit Theorem), so sample statistics have been provided, despite their limitations.

17 http://www.romeo-h2020.eu/wp-content/uploads/SPIRE-Projects-ROMEO.pdf

18 https://www.spire2030.eu/sites/default/files/users/user357/2016_CABRISS%20leaflet%20ver1%20Print%20CMYK.pdf

4. OUTLOOK AND LESSONS LEARNT

The Next Generation of EU Process Industries is the backbone of European competitiveness and sustainability. SPIRE is strengthening its support for IA projects under its 2018–2020 Work Programme to take innovations to higher TRLs nearer to commercialisation and deployment. Beyond this, SPIRE sectors are developing an ambitious mid-century strategy (SPIRE 2050 Vision) to deliver integrated digital European process industries that support a 'well-below 2C' and fully circular future for our planet and society.

Mobilising private investment

SPIRE should continue to perform well on leveraging private investment. Over 88% of companies we surveyed, reported that they were 'considering' future investments of relevance to the SPIRE2030 Roadmap. A sample of 105 companies reported €1.3 billion further investment under consideration, and we estimate that over €750 million is likely to go ahead, primarily in the next five years (based on additional information provided by the companies).[19] Given that this sample only represents a fifth of the companies involved in SPIRE, we might expect further investment worth a few billion euros over the next five years. Rising carbon prices, revised Energy Efficiency and Renewables Directives, and new industry commitments under the EU's Plastics Strategy, may also stimulate higher levels of investment.

More could be done, however, to unlock investment. Almost 70% of 38 surveyed projects reported policy barriers, such as insufficiently harmonised regulation across Member States, and legal obstacles to valorising waste streams in processes and products. Over 50% of 41 projects reported wider non-technological barriers, such as poor return of investment, general economic uncertainty, imperfect information, insufficient skills, organisational inertia, and spatial/infrastructural limitations. Policymakers should alleviate such obstacles and strengthen financial incentives to invest in efficient low-carbon practices. A particularly challenging stage is raising funding for a First of a Kind demonstration, which would benefit from a targeted policy response that helps coordinate multiple sources of funding.[20]

Promoting jobs and skills

Sixty-three percent of surveyed projects reported that their innovations had the potential to create or safeguard jobs in the future, if successfully developed and deployed. In the short term, data suggest that SPIRE projects could continue to create a modest number of jobs while they are running, and SPIRE companies could continue to create a good number of jobs in connection to their wider SPIRE2030 Roadmap investments (especially those that involve implementing higher-TRL technologies).

In the longer term, we anticipate that innovations under development within SPIRE may have a more significant impact. The extent of job creation will of course depend on economic trends and other factors, but innovations under development within SPIRE could have a significant impact in the future, creating new types of jobs, and safeguarding existing jobs, as process industries transition to a low-carbon circular economy.

Supporting SMEs

SPIRE is a young cPPP, so its impact on SMEs is only starting to show, and should become more apparent with time. Our analysis suggests that SMEs have so far benefited primarily through gaining contacts, visibility, and knowledge, but as projects increasingly deliver exploitable results, SMEs may also be able to improve competitiveness and access new markets. Indeed, 72% of surveyed SMEs anticipated SPIRE would open up markets for them, with some expecting increases in turnover of up to 50% in the next 3–5 years. Furthermore, 82% reported that they expected SPIRE to improve their competitiveness by enabling them to introduce new technologies, develop company knowledge, or enhance products and services.

Developing innovations that enhance environmental performance

SPIRE projects are developing almost double the contractually targeted number of 'major innovations' with three years of calls to go, so SPIRE should perform well against its 2020 targets. In addition to 'major innovations', SPIRE projects have again reported that they are developing 4–5 'significant innovations' each on average, which we expect to remain consistent from year to year. What will change is how many such innovations are 'developed' (rather than 'ongoing'). Indeed, projects this year classified 24 of their reported innovations as 'developed' roughly three times as many per project as last year. Similarly, projects reported awarded patents for the first time, and this number should increase steadily from now on.

Projects mostly reported environmental performance figures for their innovations that were consistent with initial project proposals. Assuming this trend continues, SPIRE should perform well on its environmental KPIs, insofar as calls select proposals in line with the cPPP's environmental targets. If larger samples of data can be gathered in future years (or completed projects' deliverables are accessible to the PMR), SPIRE will be better placed to assess the mean proportional environmental performance of projects.

Opportunities for improvement

The PMR is not currently able to model the potential environmental impact of innovations if deployed across the EU in the future. Projects typically do not have data on this, and there is no standard methodology that specifies the target year to use in such modelling, or how to construct business-as-usual baselines for the environmental footprints of the relevant value chains, and build economic uptake models. Further development of the methodology and tools for such modelling is needed with the leadership of the European Commission and the collaboration of the cPPPs. The proposed methodology could be tested and improved by stakeholders with the help of a CSA, and future projects could ultimately be required to conduct this type of modelling under the terms of calls. As well as enriching the analysis in the PMR, developing such practices seems critical to supporting a mission-driven approach to R&I under Horizon Europe.

Given that SPIRE projects concern innovations at TRL 7 or lower, it would be valuable to track progress after projects end, but it is unrealistic to expect former project coordinators to complete a long questionnaire indefinitely. Indeed, this year the response rate of the six completed SPIRE projects to the online survey was 25 percentage points lower than ongoing projects, and next year 14 more projects will be finished. SPIRE needs to consider how best to gather data from completed projects (and over what time period), including maintaining up-to-date contact details for former coordinators, and perhaps using a simplified (and largely optional) format. Support and action from the European Commission is essential in this case to achieve a higher response rate or even to set up measures to encourage participation. For example, special funding could be provided to cover the cost of former-coordinators' participation in the PMR survey. More generally, SPIRE will consider whether other complementary data sources can be used to gauge longer-term real-world impacts.

There is room to improve existing metrics and statistical methods used in PMRs, in conjunction with the Commission and other cPPPs. If sample statistics are to be used when reporting on metrics, it is important to use values per project or per company, and define best practice in terms of sample size, composition, and weighting. If population parameters are to be estimated, on the other hand, best practice in inferential statistics should be defined regarding appropriate methods with samples and populations of different sizes and distributions that may be non-normal. This would itself benefit from improved data collection on the size of companies participating in projects. More specifically for SPIRE, 2014 baselines have been co-opted from previous PMRs this year, but are patchy and not always coherent, so would benefit from a review before the 2019 PMR. In addition, we must ensure that the pursuit of harmonised common metrics still allows sufficient flexibility to respect the distinct characteristics of the industries in different cPPPs. Time-to-market after reaching TRL 7 can be one year for some digital companies, for instance, but 10 years for process industries under SPIRE cPPP.

The most challenging PMR metric to calculate is perhaps the leverage factor. While a basic harmonised approach has been agreed between the Commission and cPPPs this year, more could be done to develop best practice concerning data collection and the calculation methodology, perhaps with consideration of approaches that do not require population parameters to be inferred (such as SPIRE's weighted average leverage factor calculation set out in Annex III). Analysis of SME impact would also benefit from the development of official EU28/EU27 baselines for the purposes of benchmarking (that reflect the location, sector, and size of SMEs in the cPPP), as well as more nuanced qualitative assessment of how different types of SMEs benefit from and contribute to the cPPP (perhaps based on case studies).

Endnotes

19 Companies were asked to rate the accuracy of their reported value, and to state what percentage of the investment they considered 'likely to go ahead'. Each company's reported investment was adjusted down in line with their reported margin of error, and multiplied by the proportion they considered 'likely to go ahead', before being summed to estimate a lower limit for the amount that was likely to go ahead. Companies were asked about the timeframe of these investments, with over 75% reporting investments would mainly happen in five years.

20 See for instance: http://ec.europa.eu/research/energy/pdf/innovative_financial_instruments_for_FOAK_in_the_field_of_Energy.pdf

ANNEXES

ANNEX I – DATA AND METHODS

Data sources

Official European Commission data on projects were used for project participation numbers and budget figures. This was complemented with A.SPIRE data on member companies (for the purposes of defining the SPIRE population of companies), as well as two online surveys conducted for the purposes of the PMR to gather information from project coordinators and companies. Data from the EU's official SME annual assessment reports were also used to construct the EU28 references on employment and turnover growth for the purposes of tracking performance on common KPI 3.

Populations

The population of SPIRE projects for the PMR 2018 (based on data of 2017) was defined as all SPIRE projects with a start date before 2018 (76 projects). To define the size of the population of companies involved in SPIRE we cross-referenced official data from the European Commission on all companies participating in SPIRE projects, with data from A.SPIRE on its member companies, identifying 528 distinct companies (521 participating in projects). Companies were counted as they were defined in projects (or as an A.SPIRE member), e.g. as a particular branch of a multinational, rather than the multinational itself.

The population of SPIRE companies was then analysed to understand the proportion of large enterprises and SMEs. The Commission data had a size classification for 393 of the companies, and A.SPIRE data had a classification for a further seven. Survey data from 43 projects on their participants allowed us to classify 31 more, and estimate the size of the remaining 97 unknown companies based on the reclassification rate that had been observed. Using this method, we defined the population as comprising 258 SMEs and 270 large enterprises. The SME community was then further broken down into Micro, Small, and Medium enterprises based on survey data from 105 companies, with a 7.4% margin of error (assuming a population of 258 SMEs). Using these data, we defined the SPIRE SME community as 9% Micro, 60% Small, and 31% Medium.

Surveys

Data were gathered for the 2018 PMR through two online surveys: the Coordinators' Questionnaire, which was sent to all 76 SPIRE projects with a start date before 2018 (including six completed projects), and the Companies' Questionnaire, which was sent to companies involved in the cPPP, directly and via Coordinators. Companies were instructed to answer the questionnaire in relation to their company as defined in the relevant project (or as a member of A.SPIRE) to ensure consistency with how the population of companies had been defined, and avoid double counting.

We received 43 completed responses to the Coordinators' Questionnaire, and 100 completed responses to the Companies' Questionnaire, which covers 57% of SPIRE projects, and 19% of SPIRE companies, respectively. We also received 10 partial responses from projects, and 40 partial responses from companies, which provided larger samples on certain questions. Because many questions were optional, sample sizes were often smaller than the total number of responses to the questionnaire itself.

Statistical methods

Sample data was tidied up to exclude blank responses, inconsistent or clearly erroneous responses, and 'Don't Know' responses. When reporting sample statistics in the report, we have made an effort to note the size of the sample for the sake of transparency. When population parameters were inferred from sample data, margins of error and confidence intervals were calculated using a 95% confidence level in relation to the relevant sample size and populations (as defined above). Weightings of sample statistics were also based on the populations defined above. In the case of the leverage factor, a combination of sample statistics and inferred parameters was used, due to the difficulty of calculating a confidence interval using the sample mean. This is explained in the endnotes of Section 3.2, and the calculation is set out in Annex III in greater detail, along with the calculation used for the weighted average leverage factor.

ANNEX II – PROJECT CLASSIFICATION

Green projects started in 2017. Red projects are complete. **Bold** projects in large font completed the questionnaire (some others also partially responded). MAESTRI & FISSAC have been reclassified.

Action	PROCESS EFFICIENCY			SUSTAINABILITY AND CIRCULAR ECONOMY			ENABLING SUSTAINABLE INDUSTRY DEVELOPMENT
	Modelling and integrated process control	Process Optimisation	Valorisation of different energy sources	Adaptable processes using alternative feedstock	Recovery from Waste	Industrial Symbiosis & Water	
RIA	**MONSOON** **iCspec** **COCOP** **FUDIPO** **CoPro** **CONSENS** ProPAT RECOBA DISIRE	**DREAM** **PRINTCR3DIT** **ADREM** **TERRA** **ROMEO** **MEMERE** **IMPROOF** **MAESTRI** VULKANO SIDERWIN	**SUSPIRE** **TASIO** **SOLPART** **I-ThERM** Indus3Es CHPM2030	**FReSMe** **OCEAN** **RECODE** Carbon4PUR ICO2CHEM		**EPOS** **FISSAC** SHAREBOX SYMBIOPTIMA	
IA	Morse	**DEMETO** **NOVUM** **PORTABLECRAC** PRODIAS ibD ENSUREAL SUPREME	**ETEKINA** **ECCO** DRYficiency SMARTREC	**REHAP** **Bio4Products** **SteamBio** **MefCO2** MOBILE FLIP CIRC-PACK KARMA2020	**CABRISS** **BAMB** **REMAGHIC** **REE4EU** **ECOBULK** RESLAG ADIR RESYNTEX PolyCE FiberEUse Plasticircle	**SPOTVIEW** **ZERO BRINE** ReWaCEM INSPIREWater	
CSA				CarbonNext		**SCALER**	**HARMONI** **SPRING** **STYLE** INSPIRE MEASURE SAMT

ANNEX III – LEVERAGE FACTOR CALCULATION

For a description of the methodology, please see the 'Methodology' column in the Common Priority KPI table, or the endnotes of Section 3.2.1.

Estimated leverage factor for cPPP	Min	Max
Number of SMEs investing outside projects (95% confidence level)	77	153
Number of Large enterprises investing outside projects (95% confidence level)	132	180
Number of SMEs investing outside projects * SME sample mean investment (only including those investing)	221,634,961	438,790,682
Number of Large enterprises investing outside projects * Large enterprise sample mean investment (only including those investing)	2,758,012,823	3,776,733,024
Sum of SME and Large enterprise investments outside projects (sum of previous two rows)	2,979,647,785	4,215,523,706
Total company co-financing in projects (from EC data)	56,169,451	56,169,451
Number of projects with over-budget company costs (95% confidence level)	24	39
Number of projects with over-budget company costs * mean additional private expenditure for over-budget projects in sample	12,406,932	20,103,390
Estimated total company spend	3,048,224,192	4,291,796,587
Total EU project spend	438,705,355	438,705,355
Estimated leverage factor for cPPP	**6.9**	**9.8**

Average leverage factor for surveyed companies	
Average outside investment for surveyed Large enterprises (sample of 33 including non-investors but not including Don't Know or blank responses)	12,068,639
Average outside investment for surveyed SMEs (sample of 38 including non-investors but not including Don't Know or blank responses)	1,279,895
Weighted average outside investment for surveyed companies (258 SME:270 Large)	6,796,866
Average company co-financing (total co-financing recorded in EC data / number of companies in the SPIRE population)	106,382
Average additional project expenditure per company [total value reported by 43 projects / (43 * average number of companies per project)]	30,786
Average company total Roadmap investment (previous three rows summed)	6,934,034
EU spend per company (total EU contribution to projects / number of companies in SPIRE population)	830,881
Average leverage factor for surveyed company	**8.3**

ANNEX IV – SME COMMUNITY PROFILE

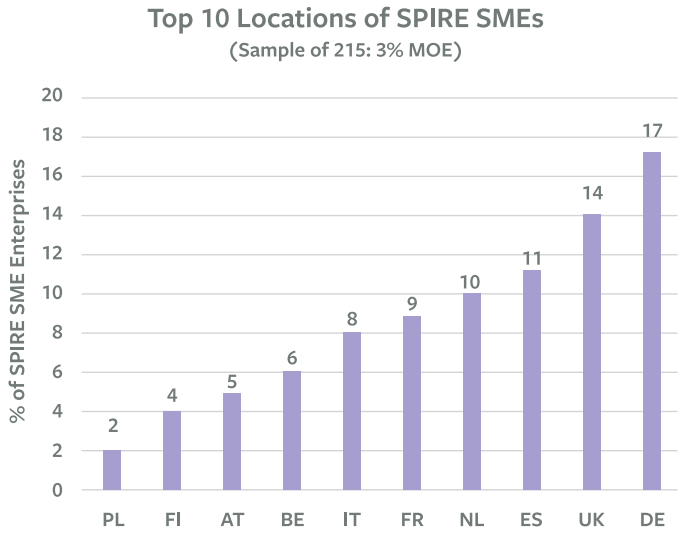


Figure 9: *SPIRE SMEs are distributed throughout the EU countries, with a bigger concentration in countries with higher number of Process Industries.*

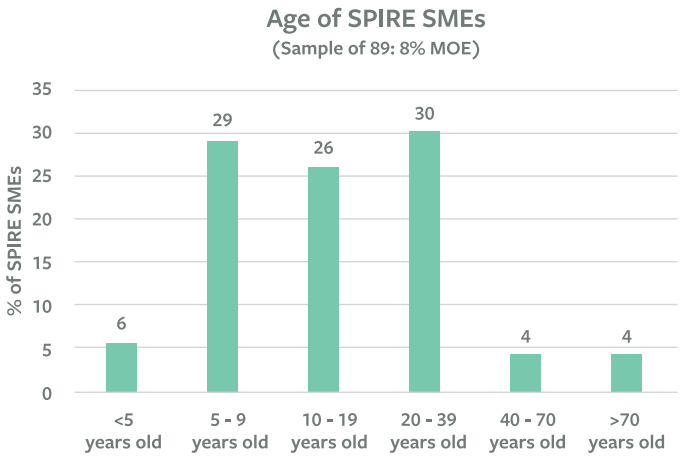


Figure 10: *While the SPIRE Community encompasses SMEs of all ages, most of SPIRE SMEs are established enterprises, with a significant level of experience.*

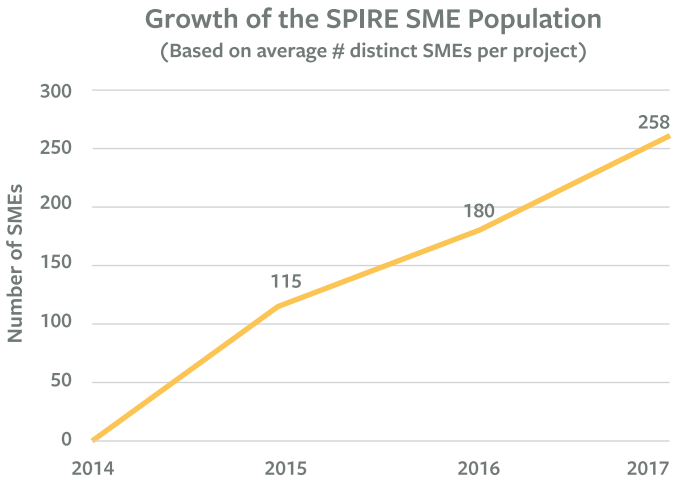


Figure 11: *The massive increase of the SPIRE SME community shows the attractiveness and success of this partnership.*

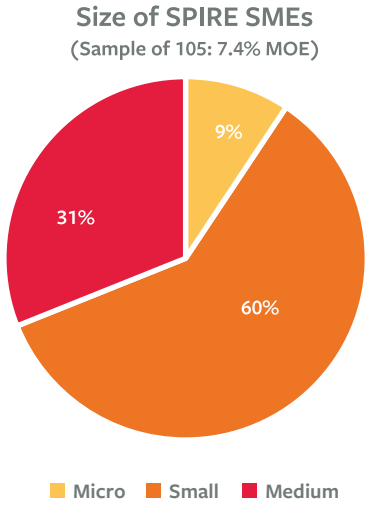


Figure 11: *Most SMEs from the SPIRE sectors employ significant numbers of people, adding socioeconomic value to their work and impact.*

ANNEX V – SPIRE SECTORS IN PROFILE

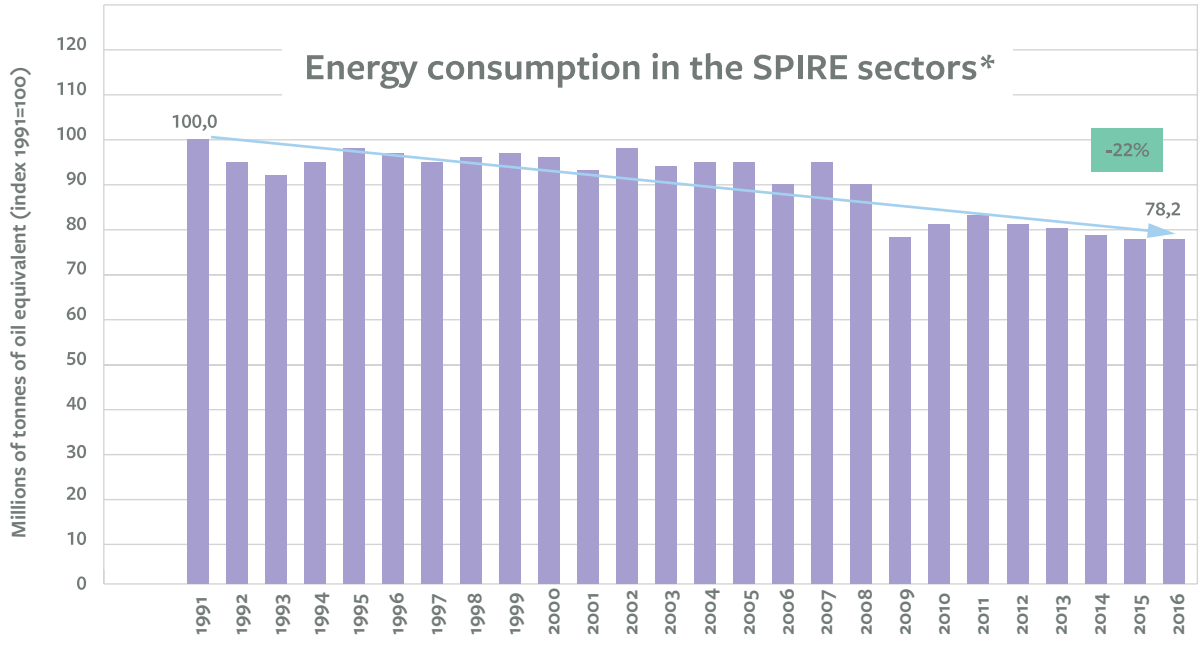
The SPIRE sectors are as follows: cement, ceramics, chemicals, engineering, minerals and ores, non-ferrous metals, steel, and water. Based on data from Eurostat and Associations, this section provides an overview of how these sectors contribute to the EU economy and environment[1].

Economic profile

The SPIRE sectors are the foundation for many EU value chains, and as such are critical to sustainable growth in Europe. They represent 20% of the EU manufacturing sector, turning over €1.8 trillion. They employ 6.3 million people directly, accounting for 46% of total industrial employment and 7% of all employment in Europe, and support a further 19 million jobs indirectly in value chains. They generate €565 billion added value, which is 56% of industrial value added in the EU, and approximately 10% of all economic activity. They are the largest manufacturing investors, investing €79 billion on average. Capital investment is essential to the future development of SPIRE sectors, and capital spending intensity is a key factor affecting their competitiveness.

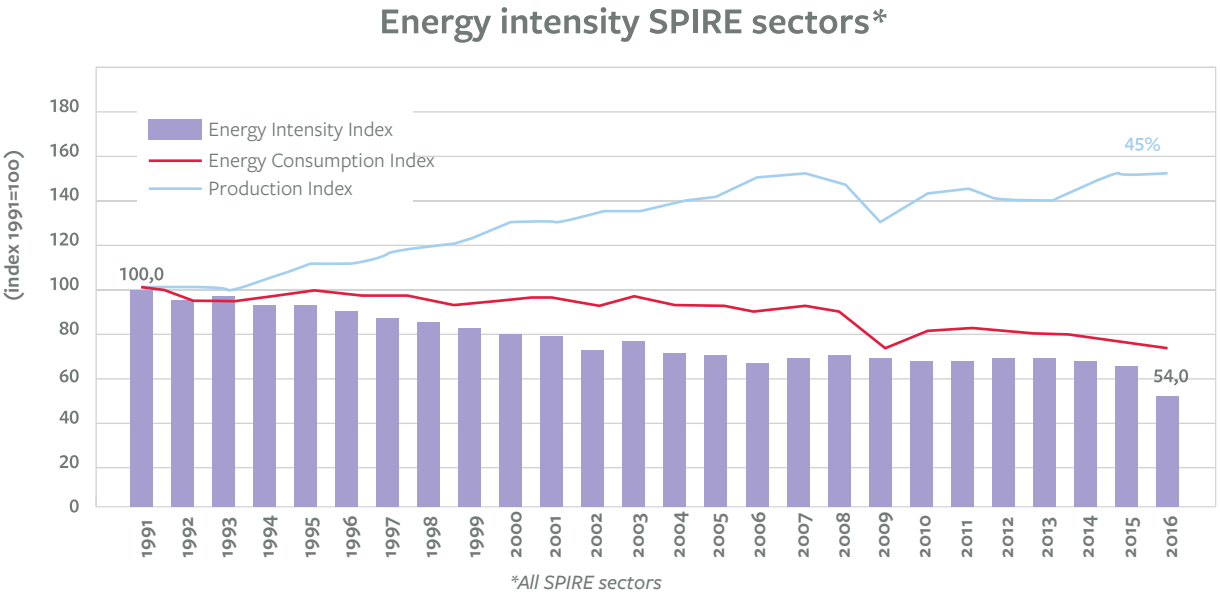
Sustainability profile

From 1991–2016, SPIRE sectors have reduced their energy consumption significantly while increasing production, dramatically reducing their energy intensity. Data from the steel, chemical, mineral, and non-ferrous metal sectors show a 22% reduction in energy consumption, for instance, over this period. And data for all SPIRE sectors show that energy-intensity has almost halved during this period.



**Steel, chemical, mineral, and non-ferrous metal sectors*

1 Data source: Eurostat and Cefic Analysis. VVT - SPIRE data group.



Data from 2008–2016 show that SPIRE sectors outperform the EU industrial average in terms of reducing energy use, greenhouse gas emissions (GHG) and improved energy intensity. Total EU industry GHG emissions were reduced by 16% during this time period, as opposed to SPIRE GHG intensity, which fell by 26%. Some sectors perform better than others, however, SPIRE provides a platform to exchange best practice and develop new disruptive technologies that are applicable across sectors, easing implementation, sharing cost and risk, boosting time to market and therefore competitiveness across a vast range of EU industrial and manufacturing sectors.

R&I activity of SPIRE sectors

SPIRE sectors are undertaking the following R&I activities to advance sustainability and competitiveness:

- Developing new breakthrough process technologies to radically increase energy intensity across the SPIRE sectors and beyond;
- Developing breakthrough process technologies to increase resource efficiency, promote industrial symbiosis and enable the establishment of a sustainable circular economy in Europe and globally;
- Accelerating the development and implementation of digital technologies within the EU process industries as key enabling technologies for resource and energy efficiency, thereby increasing digital intensity, reducing costs, and increasing competitiveness;
- Developing advanced process technologies that can provide materials to many industrial value chains (e.g. construction, transportation, energy) enabling higher energy efficiency and lower GHG emissions.

ANNEX VI – JOB PROFILES

Below are the number of job profiles reported by 31 projects and 44 companies in the 2018 PMR surveys. Please note that the job titles have been simplified.

Some titles are broadly similar, but the profiles involve different value chains and specific responsibilities, and therefore have been counted as distinct.

Reported Job Profiles	
1. Solar Heat Expert	20. Insulation Component Designer
2. 3D Design Specialist	21. 3D Printer Operator
3. Industrial Catalysis Expert	22. Membrane Development Specialist
4. AI Machine Learning Expert	23. Predictive Control Engineer
5. Process Modelling Expert	24. Energy Efficiency Engineer
6. Plasma Reaction Engineer	25. KET Expert
7. Digital Architect	26. IT Expert Plant Operator
8. LCA Engineer	27. Plant Optimisation Expert
9. Industrial Symbiosis Manager	28. Engineering Software Expert
10. Membrane Reactor Expert	29. New Equipment Manufacturer
11. Bioprocess Engineer	30. Waste Stream Digital Data Manager
12. Process Intensification Manager	31. Circular Economy Expert
13. Laser Operator	32. Biotechnologist
14. Feedstock Purification Expert	33. Environmental Optimisation Expert
15. Hydrogen Facility Attendant	34. Waste Treatment Manager
16. Simulation and Optimisation Expert	35. Sustainability Design Engineer
17. PAT Manager	36. Circular Economy Manager
18. Industrial Symbiosis Expert	37. Data Scientist
19. IT Energy Efficiency Expert	38. Cross-Sectoral IT Expert

ANNEX VII – COMMON PRIORITY KEY PERFORMANCE INDICATORS

	KPI domain	Key Performance Indicator (KPI)	Value in 2017	Baseline at the start of H2020 (where available)[2]	Target (for the cPPP) at the end of H2020	Methodology
1	**Mobilsed private investments**	**Total actual private investment mobilised in cPPP projects**	**€69–76 million** (€65 million reported /recorded)	**€242 million** (Based on the private contribution to similar FP7 projects of an equivalent number to SPIRE projects to date)		Total actual private investment mobilised in projects was calculated by summing i) official private co-financing in the 76 SPIRE projects (€56.2 million) and ii) estimated additional project-related expenditure for all 76 projects. Additional expenditure was estimated by calculating a confidence interval for the number of over-budget SPIRE projects, with a 95% confidence level, and multiplying this by the sample mean additional expenditure for over-budget projects.
		Estimation of the private investment mobilised in other R&I activities related to the cPPP	**€3–4.2 billion** (€461 million reported)	**€2.3 billion** (Based on the EU contribution to similar FP7 projects of an equivalent number to SPIRE projects to date multiplied by a 4.5 estimated leverage factor for FP7)		Based on data from 39 large enterprises and 38 SMEs, confidence intervals were calculated for the number of large enterprises and SMEs in the SPIRE population investing in the Roadmap, with a confidence level of 95% (taking the SPIRE population to comprise 270 large enterprises and 258 SMEs). Each confidence interval was then multiplied by the relevant sample mean investment for large enterprises / SMEs that were investing (and had provided figures), and summed together.
		Estimated leverage factor of SPIRE to date in Horizon 2020	**7–10** (**8.3** average for sample)	**4–5** (Based on analysis of 8 FP7 projects and information from their private company participants)	**5-10**	Calculated by summing the two previous ranges and dividing the resulting range by the total EU contribution to the 76 SPIRE projects (as defined in EC data). A weighted average leverage factor was also calculated based on sample statistics and known population values, based on data from 71 companies (8.3).

2. Baselines have been taken (and updated where necessary to reflect the growth in number of SPIRE projects) from the previous PMR (unless poorly defined).

	KPI domain	Key Performance Indicator (KPI)	Value in 2017	Baseline at the start of H2020 (where available)	Target (for the cPPP) at the end of H2020	Methodology
2	**New skills and/or job profiles**	**Number of new high skilled job profiles developed in cPPP projects**	**17** (17 reported by 31 projects: 0.55 per project)		**10 new high skilled job profiles**	Projects that said they didn't know about new job profiles were excluded from the sample when calculating the average per project.
		Number of new high skilled job profiles developed due to private investment mobilised in R&I activities related to the cPPP	**21** (21 reported by 44 companies: 0.47 per company)			Companies that didn't know about investments or job profiles were excluded from the sample when calculating the average per company.
		Number of new curricula developed in cPPP projects	**27** (14 university courses and 13 training resources reported by 43 projects: 0.6 per project)			

	KPI domain	Key Performance Indicator (KPI)	Value in 2017	Baseline at the start of H2020 (where available)	Target (for the cPPP) at the end of H2020	Methodology
3	Impact on SMEs	**Number of SMEs participating in cPPP projects**	**255** (245 known SMEs + 10 estimated additional SMEs)			EC data show that 241 SMEs, and 128 PRCs of unknown size are involved in projects. Cross-referencing this with information on SME participants from 43 projects, it was possible to identify 4 further SMEs, and estimate the proportion of remaining unknown PRCs that were SMEs, leading to another 10 PRCs being classified as SMEs. The final figure is for distinct SMEs, with no double counting. Project data were cross-referenced with A.SPIRE membership data to identify three further SMEs that were not involved in projects, but were involved in the cPPP. The total number of known SME participations (294) plus a representative number of unknown-size PRC participations (11) was divided by the total number of participations (1089). The estimated total number of distinct SMEs (258) was divided by [total number of distinct organisations involved in projects (781) + additional organisations involved in A.SPIRE but not participating in a project (65)]. A sample of 30 SMEs (5 Micro, 13 Small, and 12 Medium) showed an increase in turnover of 25% from 2014–2017. The sample was weighted to reflect the composition of the SPIRE SME population (Micro 9%, Small 60%, Medium 31%) which was estimated based on a sample of 105 SMEs that provided information on their size. The weightings have an 8% MOE, but the resulting average is not particularly sensitive to this. A sample of 39 SMEs (10 Micro, 16 Small, and 13 Medium) showed an average increase of 9 jobs from 2014–2017. The sample was weighted to reflect the composition of the SPIRE SME population (Micro 9%, Small 60%, Medium 31%) which was estimated based on a sample of 105 SMEs that provided information on their size. The weightings have an 8% MOE, but the resulting average is not particularly sensitive to this.
		Number of SMEs participating in the cPPP	**258** (248 known SMEs + 10 estimated additional SMEs)			
		Share of participation of SMEs in cPPP projects	**28%** (27% 'known' share)	**22.5%**		
		Share of SMEs in the cPPP	**30%** (29% 'known' share)			
		Estimation of the increase in turnover of SMEs participating in the cPPP	**25%** (Weighted sample increase)	**16%**		
		Estimation of the increase in number of employees for SMEs participating in the cPPP	**9 per SME** (Weighted sample average)	**2-25 per SME**		

	KPI domain	Key Performance Indicator (KPI)	Value in 2017	Baseline at the start of H2020 (where available)	Target (for the cPPP) at the end of H2020	Methodology
4	**Significant innovations**	**Number of major innovations developed in cPPP projects**	**74** (Based on analysis of all 76 SPIRE projects with a start date before 2018)		**At least 40 innovative systems and technologies**	All 76 SPIRE projects with a start date before 2018 were analysed to classify their major innovations with reference to the taxonomy in the Contractual Agreement.
		Number of significant innovations developed in cPPP projects	**221** (Reported by 48 projects: 4.6 per project)	**4-5 innovations per project** (Based on 35 innovations in 8 similar FP7 projects)		221 significant innovations were reported by a sample of 48 projects. These are the various processes, technologies, products, methods, and tools involved in delivering over-arching 'major innovations'. They make up major innovations rather than being additional to major innovations, and as such should not be added to major innovations to arrive at a total figure of innovations.

ANNEX VIII – SPECIFIC KEY PERFORMANCE INDICATORS FOR THE cPPP

	KPI domain	Key Performance Indicator (KPI)	Value in 2017	Baseline at the start of H2020 (where available)[3]	Target (for the cPPP) at the end of H2020	Methodology
1	**Contribution to the reduction of energy use and CO_2 emissions**	**Average % reduction in energy consumption reported by cPPP projects compared to the practices their innovations would displace**	**32%** (Sample mean: 13 projects)	**15-30%** (All baselines in this section are based on analysis of 8 similar FP7 projects)	No target	Projects were asked to define a comparison scenario (functional unit or case study) in order to provide figures on the environmental impact of their innovations compared to relevant current practices they would displace. The average proportional reduction reported by the projects (that provided figures) was calculated. If projects responded in relation to more than one scenario, their highest reported figure was used when calculating the sample mean. Reported values were almost entirely estimated (rather than measured) by the projects, which should be borne in mind. The sample statistic is reported in each case due to the samples being non-normal and not appropriate for calculating a confidence interval based on the Central Limit Theorem (n<30, and >10% population).
		Average % reduction in *fossil* energy consumption reported by cPPP projects compared to the practices their innovations would displace	**36%** (Sample mean: 10 projects)		Develop innovations that offer **up to 30% reduction** in fossil energy intensity	
		Average % reduction in CO_2e reported by cPPP projects compared to the practices their innovations would displace	**30%** (Sample mean: 17 projects)		Develop innovations that offer **up to 40% reduction** in CO_2e footprint	

3 Baselines have been taken (and updated where necessary to reflect the growth in number of SPIRE projects) from the previous PMR (unless poorly defined).

	KPI domain	Key Performance Indicator (KPI)	Value in 2017	Baseline at the start of H2020 (where available)	Target (for the cPPP) at the end of H2020	Methodology
2	**Contribution to the reduction of waste**	**Average % reduction in waste streams reported by cPPP projects compared to the practices their innovations would displace**	**32%** (Sample mean: 10 projects)	**Up to 20%**	No target	Calculated as described above, but the highest reported value from each project across three waste indicators was used to calculate the overall average for this metric. The three indicators were i) % reduction in landfilled waste, ii) % reduction in incinerated waste, and iii) % reduction in discharged wastewater.
3	**Contribution to the reduction in the use of raw materials**	**Average % reduction in raw material consumption reported by cPPP projects compared to the practices their innovations would displace**	**32%** (Sample mean: 8 projects)	**Up to 20%**	No target	Calculated as described above.
		Average % reduction in *non-renewable primary* raw material consumption reported by cPPP projects compared to the practices their innovations would displace	**25%** (Sample mean: 7 projects)		Develop innovations that offer **up to 20% reduction** in non-renewable primary raw material intensity	
4	**Project results taken-up for further investments (into higher TRLs)**	**Number of project results taken-up for higher TRLs using additional investments**	**77** (Reported by 48 projects: 1.6 per project))		No target	A sample of 48 projects reported that 77 innovations would be taken up to a higher TRL using additional investments after the project.
		Share of innovations (with a TRL) that will be taken up to higher TRLs after projects end	**49%** (Reported by 48 projects: 77 of 157 innovations)	**~30%**		Data from 48 projects showed that project participants plan to take up 49% of 157 innovations (with a TRL) to a higher TRL after their project ends.

	KPI domain	Key Performance Indicator (KPI)	Value in 2017	Baseline at the start of H2020 (where available)	Target (for the cPPP) at the end of H2020	Methodology
5	**Trainings for a high-quality workforce at project level**	**Number of dissemination events, seminars, conferences organised in PPP projects**	**106** (Reported by 36 projects: 3 per project)		No target	A sample of 36 projects reported 106 dissemination events: almost 3 per project.
		Average number of participants in dissemination events organised in PPP projects	**41** (Reported by 36 projects: 4391 participations in 106)			The same sample reported 4391 participations in the 106 aforementioned events, giving an average of 41 participants per event

ANNEX IX – CONTRIBUTION TO PROGRAMME LEVEL KEY PERFORMANCE INDICATORS

	KPI domain	Key Performance Indicator (KPI)	Value in 2017	Baseline at the start of H2020 (where available)[4]	Target (for the cPPP) at the end of H2020	Methodology
1	**Patents**	**Number of patent applications stemming from cPPP projects**	**78** (43 projects reported 78 applications: 1.8 per project, which is over 3 applications per €10million of funding.)		Horizon 2020 Target (not SPIRE-specific): **3 applications per €10 million funding**	78 patent applications (18 undertaken, 60 planned) were reported by a sample of 43 projects. This is 1.8 per project, which is over 3 per €10 million of EU funding, based on the average EU contribution to projects being €5.8 million.
		Number of patents awards stemming from cPPP projects	**2** (Reported by 43 projects: 0.05 per project. One trademark also reported)			
2	**Standardisation**	**Total number of activities relating to standardisation undertaken by cPPP projects**	**33** (43 projects reported 33 activities: 0.77 per project)	**0.25 per project** (based on 2 activities in 8 FP7 projects)	No target	33 activities were reported by a sample of 43 projects: 0.77 per project.
		Number of working items in European Standardisation Bodies at PPP level	**43** (19 reported by 67 PRCs + 24 reported by 41 projects, which is over 0.5 per project)	**0.5 per project** (based on 4 items in 8 FP7 projects)		41 projects reported 24 contributions to standardisation documents, and 67 companies reported 19 contributions. The average per project was over 0.5.
		Number of pre-normative research files – prEN - under consultation in ESBs	No data			

4 Baselines have been taken (and updated where necessary to reflect the growth in number of SPIRE projects) from the previous PMR (unless poorly defined).

	KPI domain	Key Performance Indicator (KPI)	Value in 2017	Baseline at the start of H2020 (where available)	Target (for the cPPP) at the end of H2020	Methodology
3	**Operational Performance**	**Time to grant**	**204 days**	**256 days**	No target	Average time to grant for all 76 projects with a start date before 2018 across all calls based on EC data.
4	**H2020 - LEIT - Number of joint public-private publications**	**Number and share of joint public-private publications out of all LEIT publications.**	**72 of 359 (20%)**		No target	Based on EC data for all 76 projects with a start date before 2018, which showed 72 joint public-private publications out of 359 LEIT publications.

SPIRE

Established at the end of 2013, the SPIRE contractual Public Private Partnership (cPPP) brings together eight important European process industry sectors to collaborate on research and innovation initiatives that will radically improve resource and energy efficiency across industry. Up to the end of 2017, SPIRE had launched 76 projects under the EU's Horizon 2020 programme with a combined budget of €500 million and involving participation from 781 different organisations including 521 private companies. The breakthrough innovations developed by SPIRE are setting the basis to move towards the 'next generation' of sustainable European process industries.

TOWARDS SPIRE 2050 VISION

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