European Commission

Impact of the SPIRE Public-Private Partnership

Report of the Workshop
held on 21-22 April 2015 in Brussels

EN

Research and Innovation

EUROPEAN COMMISSION

Directorate-General for Research and Innovation
Directorate D - Key Enabling Technologies
Unit D.2 – Advanced Manufacturing Systems and Biotechnologies

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Edited by Dr Keith Simons

Directorate-General for Research and Innovation
2015 Key Enabling Technologies EN

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Contents

Executive Summary

1 INTRODUCTION

The first SPIRE Impact Workshop was held in Brussels on 21st and 22nd April. A selection of relevant FP7 projects from the NMP calls (28 in total), either completed or ongoing were represented, together with the first batch of 12 SPIRE projects with presentations in three serial session covering:

- Efficient Processes
- Process Control and Associated Parameters
- Sustainable and Circular Economy

The purpose of the workshop was to allow the project to report on success and allow for an assessment of the impact achieved. Depending upon the stage of the project this would either be the potential for uptake, or the exploitation achieved thus far. It was also anticipated to identify cross-cutting issues for the benefit of all such as the potential benefits of clustering and good practises to maximise impact. It was also an opportunity for the new projects to be introduced to SPIRE and understand the context of the funding through the PPP.

This report details the outcome of the workshop together with the main recommendations regarding the execution of SPIRE projects to derive maximum value and synergy.

1.1 Objectives

The workshop was the first of a planned series of annual workshops to identify how the impact of SPIRE projects could be maximised but also what benefits could be gained from clustering projects with similar themes. The specific objectives were to:

- Report on cross-cutting issues with multiple project beneficiaries
- Identify project impacts: highlight targets and metrics
- Share best practice between projects
- Learn about success stories and outcomes
- Highlight the added value of undertaking the projects within the framework of the PPP

1.2 Background

SPIRE - Sustainable Process Industry through Resource and Energy Efficiency Public-Private Partnership (PPP) launched as part of the Horizon2020 framework programme. It is one of the four "new" contractual PPPs, and builds upon the success and experience of the four pre-existing PPPs (Factory of the Future (FoF), Energy-efficient Buildings (EeB), Green Vehicles (EGVI) and Future internet (5G)).

SPIRE consists of an association which represents more than 114 industrial and research process industry stakeholders from over a dozen countries spread throughout Europe. It is represented through the legal entity A.SPIRE which was established in Brussels on 18 July 2012, through the joint efforts of 8 industry sectors:

- chemical
- steel
- engineering
- minerals
- non-ferrous metals
- cement
- ceramics
- water

Through cooperation between the EC and SPIRE, a multi-year roadmap has been developed to address research, development and innovation activities and integrated into the Horizon2020 pillar of Leadership in Enabling and Industrial Technologies (LEIT) for the realisation of 2030 targets which ultimately aim for the deployment of innovative technologies and solutions required to reach long term sustainability for Europe and its process industries in terms of global competitiveness, ecology and employment.

The rationale for the contractual PPPs is the EC (and industry) desire for

- Long-term commitments and strategies
- Increased efficiency

- Covering whole value chain and interrelated sectors
- High level SME participation
- Expanding technological competencies and skills
- Shortening time to market

The specific objectives of SPIRE are

- Develop technologies and strengthen cross sectoral integration to improve efficiency (energy, resources)
- A reduction in fossil energy intensity of up to 30% by 2020
- A reduction in non-renewable, primary raw material intensity of up to 20%:
- Increase in renewables, reduction and re-use of waste (even cross- sectoral) with ambition to achieve a close loop
- Reduction of the water footprint of industrial processes
- Efficiency improvement of CO2-equivalent footprints of up to 40%
- Creating new high quality knowledge intensive jobs through knowledge transfer and training

1.3 Methodology

The European Commission hosted the Impact Workshop and staff from DG Research and Innovation (DG RTD) participated. Over 100 project representatives attended the event. In order to enhance cooperation links between projects, projects were pre-allocated into one of 7 domains, aligned to thee themes, with each domain presenting in a single session.

Pre-dating SPIRE, various NMP projects were launched under the FP7 programme, with a stronger focus on technology development and demonstration. With the advent of Horizon2020, the SPIRE PPP builds upon the FP7 programme, and as such they were included in the workshop.

The objective of the first day sessions was to assess the impact achieved to date by each project and to assess the potential impact of those that were just commencing. Furthermore, in order foster cooperation between the pre-identified clusters, the EC requested that projects within an allocated domain get in contact prior to the event to assess the potential and scope for synergy and to prepare joint domain presentations (see below). Three consecutive sessions were run, representing 7 domains in total. Within each domain, a single speaker (with support from an EC official) gave a presentation on the behalf of the representative projects. The schedule of the presentations was:

Session 1 : Efficient Processes
Domain 1: Process Optimisation (8 projects)
Domain 2 : Adaptable Processes using Renewables (8 projects)

Session 2 : Process Control and associated Paramaters
Domain 1 : Modelling and Elements of Process Control (5 projects)
Domain 2 : Integrated Process Control (4 projects)

Session 3 : Sustainability and Circular Economy
Domain 1 : Integrated Management of Resources (5 projects)
Domain 2 : Recovery from Waste (9 projects)
Domain 3 : Lifecycle Management (3 projects)

Each domain presentation was put together by the group of projects belonging to that domain that addressed the scientific and technical goals of the projects in the area; the expected or achieved impact of the supported area at both domain and project level; identified technical and non-technical cross-cutting themes; and the synergies and benefits of clustering.

The second day started with presentations from Clara de la Torre, from DG RTD, providing an EC view of the importance of "Key Enabling Technologies" in achieving the desired impact of the SPIRE PPP. This was followed by the PPP view from its Chairman, Klaus Sommer. He was followed by Piermario Di Pietro, Senior Advisor, EIB Advisory Services who described EIB financing for companies investing in KETs.

A presentation of four "success stories", projects with high impact and outcome, was given next and followed by a panel discussion on maximising impact and successful innovation strategies for the process industries. The panel, chaired by José-Lorenzo Vallés (EC) was asked to comment on three set questions, prior to invitation of questions and comments from the audience.

Following an initial feedback from the rapporteur, Keith Simons, closing statements from A. SPIRE ceo Loredana Ghinea and EC representatives were delivered.

2 IMPACT OF THE SPIRE PPP

This section provides an overview of the impact of the SPIRE PPP as an instrument followed by the summary conclusions of the cluster presentations.

2.1 Overview of the SPIRE PPP Impact

The indicative funding for SPIRE within Horizon2020 (2014-2020) is 900M€. The lies in second place, just below the (more) established Factories of the Future (FOF) PPP with funding of 1150M€. The PPP was created because of the importance the Process Industries are considered to have. As part of the contract, Key Performance Indicators were incorporated.

Key Performance Indicators (KPIs) at PPP implementation level are:

- New systems and technologies developed in the relevant sectors
- Participation and benefits for SMEs
- Contribution to the reduction of energy use
- Contribution to the reduction in the use of material resources
- New high-skilled profiles and new curricula developed
- Private investment mobilised in relation to the PPP activities
- Contributions to new standards

Key Performance Indicators (KPIs) at project impact level are:

- Scale of reduction in energy, material resources and waste
- Project results taken-up for further investments
- Trainings for a higher quality workforce
- Patents and activities leading to standardisation

By the time of the workshop, two calls (H2020–SPIRE 2014 and H2020-SPIRE-2015) had been launched. The former had attracted 68 proposals, seeking 365.2M€. 17 proposals were above threshold and the main list consisted of 11 proposals requesting 39.1M€. The "success" rate was 16%. Of the 59% overall industrial participation, a quarter were SMEs.

Spire-2015 had attracted 82 eligible proposals with 935 participants. 13 had been retained for funding, represented 72.6M€ of EC funding, though were not represented at the workshop as the applicants had yet to be informed of the call outcomes at the time of the workshop.

Session 1 : Efficient Processes

The two clusters of projects presented in this session covered a total of 16 projects. The range of technology and application areas covered:

Domain 1 : Process Optimisation

The 8 projects in the domain were COPIRIDE (COP), F3-Factory (F3), INCAS (INC), POLYCAT (POL), SYNFLOW (SYN), MAPSYN (MAP), INNOREX (INN), and ALTEREGO (ALT). The presentation was given by Professor Andrzej Górak of the University of Dortmund. All were "historical" FP7 projects which represented the Suschem inspired NMP projects.

The technical impact achieved by the projects were identified to be in the following topics

- Highly selective catalysts
    - High-end selectivities (>99 %) of advanced catalysts for hydrogenation of pharma molecules (MAP, SYN)
    - Development of novel polymer-based nanoparticulate catalysts (POL)
- New synthesis routes (F3, SYN, MAP)
    - Challenging hydrogenation
    - Synthesis of API
    - Use of abundantly available resources such as air (N2/O2) in nitrogen fixation to compete with very advanced technology (Haber-Bosch) by use of distributed manufacturing
- Modularisation of chemical production (MAP, COP, POL)

    - Technologies for modules in prefabricated containers for flexible, efficient continuous production. Demonstrated new modular, standardised, continuous production technology for low to medium scale production
    - Fast integration of novel (process intensification) technologies and concepts
    - Standardised processes and their interfaces
- Life cycle assessment(MAP, COP, POL)
    - Guidelines
    - Ex-ante cost analysis
- Process Intensification: integrated processes, new reactor concepts, batch to continuous, alternative energy sources
    - Integrated processes
        - New reactor concepts
    - Enzymatic reactive distillation (ALT)
    - Reactive extrusion (INN)
    - Reactive distillation (F3, COP, INC, SYN)
    - Membrane reactors (INC),plasma reactors (ALT)
    - Scalable (micro)reactors (POL, COP)
    - Automated reactors (SYN)
    - batch to continuous (F3, COP, ALT, POL)
    - Continuous polymerisation (INN)
    - Continuous-flow reactions (SYN)
- Advanced design of integrated technologies
    - Advanced design of catalyst/membrane integrated systems (INC)
    - Modelling of process with integrated alternative energy forms (ALT, INN)
    - Process modelling and optimisation of combined reaction/separation processes (F3, COP, SYN, MAP, INN)

Common to all the projects were claims for enhanced resource efficiency (raw material savings) and energy efficiency. Improvement arose in process efficiency through increased selectivity and (often) separation efficiency. Important economic aspects occurred through: increased competitiveness via cost-reduced and more resource & energy efficient processes (all); Flexible & adaptive production (COP, POL, F3, SYN); Novel concepts, alternative process design (competitive manufacturing) (all); Reduction of development time & faster market implementation (COP, POL, SYN). Importantly, avoiding the storage of toxic intermediates/reactants (INC) had significant safety benefits at a production level or reduced metal contamination in isolated pharmaceutical products (SYN) was safer for the end-user.

From an environmental aspect projects featured: use of alternative, green energy sources, reduction in emissions; fossil fuel use; and waste & water, leading to an overall reduction in environmental impact.

The magnitude of the impact was indicated in selected instances. A 15-50% reduction in waste and water usage was achieved by SYN. 70% reduction of fossil fuel use over traditional plastics was achieved via Poly Lactic Acid (PLA) being derived from a renewable resource (starch) (Inno). Moreover as PLA degrades completely within 3-4 weeks the environmental burden post-use is diminished.

Domain 2: Adaptable processes using renewables

The 8 projects in the domain were AFORE, BIOGO, CASCATBEL, EUROBIOREF, FASTCARD, MOBILE FLIP, PRODIAS and SteamBio. The presentation was given by Denilson da Silva Perez. FP7 projects and the new SPIRE projects were represented.

The technical impacts were identified to be in the following topics:

Renewable resources:

- Rationalize the use of raw materials
- Upgrade diverse and underexploited agro/forestry biomasses from different European regions for value added chemicals production, bioenergy and biofuels
- Increase the efficiency and economic viability of the transport of pre-treated biomass from decentralised rural locations to central production sites

Methodologies:

- Innovative, cost-effective and "renewable-tailored" separation, fractionation and processing technologies
- Flexible concepts able to process a variety of raw materials
- Address the scalability from lab to industrially relevant scale

Processes technologies development:

- Develop downsized, mobile and advanced technological solutions to valorize locally unexploited biomasses resources
- Validate technical suitability of processed biomass as source of value added chemicals, chemical building blocks, biofuels, bioenergy, etc.
- Develop innovative technologies for biomasses deconstruction, fractionation and separation
- Develop new efficient, robust nano-catalysts for biomass conversion

Demonstration:

- Isolation of components from the side-streams of current pulp mills and novel biorefinery concepts
- Production of densified (pre-treated) feedstocks
- Mobile unit for on-site treatment of biomasses
- Integrated process of bio-oil conversion to synthesis gas (already widely used in industry), then to methanol and to gasoline
- Biomass deconstruction and production of second-generation liquid biofuels using tailored nano-catalysts

EUROBIOREF, STEAMBIO, MOBILE FLIP:

- Zero-waste concept : maximum use of raw materials
- Upgrade underexploited and/or residual agro/forestry biomasses for bioenergy, biofuels and chemicals production ;
- Enable efficient transport pre-treated biomass from decentralized rural locations to central production sites

FASTCARD:

- QSAR models transferred from conventional to renewable feedstocks based processes.

PRODIAS, AFORE:

- Novel and cost effective tools and technologies for separation of targeted molecules from complex and diluted aqueous streams

MOBILE FLIP, STEAMBIO:

- Develop mobile advanced technological solutions (comminution, drying, fractioning, compaction, hydrothermal treatments, saccharification, hydrothermal carbonisation, torrefaction, slow pyrolysis, etc) to valorise locally unexploited biomasses resources

AFORE, EUROBIOREF, STEAMBIO, MOBILE FLIP:

- Validate technical suitability of processed biomass as source of chemical building blocks, biofuels, bioenergy, etc

BIOGO, CASCATBEL:

- Develop new efficient, robust nano-catalysts for biomass conversion and second generation biofuels (syngas, methanol, gasoline)

EUROBIOREF:

- Develop highly specific products from biomass (biojetfuel)

AFORE:

- 6 separation, fractionation and upgrading process for forest residues or process side-streams demonstrated at pilot scale.

STEAMBIO:

- Production of densified feedstocks (torrefaction/grinding) for chemical and energy applications (6 biomass, 5 locations, 500kg/h) to be demonstrated

MOBILE FLIP:

- A mobile unit for on-site treatment of biomasses will be built

BIOGO:

- Bio-oil conversion to syngas, then to methanol and then to gasoline (modular multichannel reactors, extended run lasting 500 hours).
- Prepare semi-industrial scale quantities of a selected, optimised nanocatalyst in 6 month continuous operation.

Social and economic impacts were identified such as strengthening the competitiveness of the European Industry (e.g. by transforming the pulp industry to diversify outputs, and retain and create employment). New business, (especially for SMEs), based on local usage of co-products of forest- and agriculture-based industries generating jobs in rural areas was one example. Supporting the establishment of a more sustainable economy and the achievement of a circular economy was considered an potential outcome, together with shorter time to demonstration at pilot/industrial scales (enabling innovation, transition from lab to industry). More efficient utilisation of resources (e.g. use of wood side streams for added-value products instead of only burning/energy source)

Sustainable synfuel production to reduce import dependency and vulnerability as oil importer was anticipated, together with improvement by establishing value chains for the supply valuable biomass components (e.g. transportation of pre-treated/ enrichment biomass). Nanocatalysis would help reducing the EU dependence on imported rare earths/precious metals.

In certain instances, tangible key performance indicators were mentioned. EUROBIOREF has achieved 33 patents, processes at TRL 1 to 9, start-up creation and 5 value chains designed. AFORE has 2 pending patents, has participated in the StarColibri cluster, deilivered, 4 workshops, 40 publications, 4 PhD thesis, 15 master thesis.

2.1.1 Cross-cutting issues

Technical and non-technical cross cutting issues identified by projects in the domains are displayed in Table 1.

Technical cross-cutting issues	Non-technical cross cutting issues
Standardisation and demonstration Modular Equipment: Methods and standards for advanced characterization of raw materials and pre-processed materials Methodologies and tools for technico-economic, costs, market, socio-environnmental assessments Establishing baseline for linking lab/pilot. Transfer of modelling approaches to biobased processes. **New** production/scale-up **concepts and process** intensification **New technologies** Efficient separation and up-grading of all valuable components of biomasses and processing side-stream (biorefineries) Inherent flexibility for different agro-forestry biomasses Scalable, compact/containerized, autonomous mobile treatment systems Energy collection, storage and reuse Process monitoring, control and optimization Modelling tools supporting transition from lab to pilot Development of toolbox applicable for other sectors of the process industry Modelling at atom scale	Clustering within the domain: Plasma and hydrogenation cluster (MAP) Cluster on catalysis (INC) Clustering with outside the domain: ISPT (NL) SusChemSys, CLIB^{2021} (DE) MEPI (FR) SusChem (EU) Dissemination Skills development Business deployment Strengthening of collaboration Applications for new SPIRE calls (All) Applications outside SPIRE calls New emerging technology projects from ERC Advanced Researcher Grant holders Confidentiality & trust in the context of IPR Decision makers and knowledge brokerage Regional/national research policy (North Rhine-Westphalia, DE, NL) (ALT, MAP, F3, COP) Knowlegde brokerage Workshop of Process Intensification in SPIRE community (first attempt failed) KET activities (ALT, INC) “Classical” dissemination activities (website, leaflets, newsletters, scientific publications, specialized press publications, national and international conferences, workshops, etc) Demonstration technical meetings Training, creation of specific master courses Cross sectorial technology transfer (forest/agriculture, thermal/biotechnologies) Business plans, creation of start-ups/spin-offs, commercialisation

Table 1: Session 1 Cross-cutting Issues

As might be expected there was greater commonality of identified non-technical cross-cutting issues than of technical ones with the desire for cross-project publications, events and promotions being common to almost all areas.

2.1.2 Synergies and benefits of clustering, and gap analysis

The technical achievements of the domain were mapped against the SPIRE roadmap, and a good coverage was identified. A gap analysis was performed and the following suggestions and observations were made.

- Follow-up projects for bringing specific synthetic approaches to higher TRLs (SYN) would be welcome.
- Scale-up is a major challenge (MAP)
- Energy efficiency is the key to cost competitiveness and needs optimisation of the technology itself (MAP)
- Future challenges include process control/ automatisation, downstream integration, spread to other sectors aside broader uptake in chemical sector, new business models (COP, POL, F3)
- More Start-up companies need to be created from projects
- Dissemination to other industry sectors should be facilitated
- New research directions will result from intensified equipment
- New bussines models will resulting from new processesing
- Automation, novel IT solutions for chemical production is an opportunity
- Common database for mailing purposes of SPIRE projects
- Common public workshops involving the SPIRE projects
- "Common" demonstration activities
- Calendar of public projects activities (workshops, demonstrations, etc) in the webpage and SPIRE newsletters
- Communication of SPIRE programme with highlights of the projects in conferences (EFIB, Plant Summit, ECB, etc) and specialized/wide-public journals
- More information about the projects on the SPIRE website (partners, duration, objectives, etc.) and links to projects' websites
- SPIRE asbl to support in dissemination activities

2.2 Session 2: Process Control and associated Parameters

The 2 clusters of projects presented in this session covered a total of 9 projects. The range of technology and application areas covered:

Domain 1: Process Control and Resource Efficiency Monitoring

The 5 projects in the domain were Coopol, Optico, Top-REF, More and Reffibre. The presentation was given by Sebastian Engell. All were FP7 projects, the latter three are still ongoing.

The technical impacts summarised by project:

COOPOL – Control and Real-Time Optimization of Intensive Polymerization Processes

- Provide a generic basis for widely applicable sustainable intensified chemical processes
- Development of continuous production by intensive 'smart-scale' technology for polymerization
- Development of novel methods and state-of-art tools for model based control and optimization of intensified polymerization processes
- Advanced predictive models of emulsion polymerisation processes that can be utilised in new types of soft-sensors and in model-based control
- Development of novel sensors for emulsion polymerization and of a framework for sensor-fusion in real time

Main achievements and impacts

- Framework for intensification of chemical processes within a limited time frame
- Robust and detailed models for polymerization processes, improvement of complete process chain

- Hard/soft sensors
- Implementation of on-line optimization in an industrial environment
- Demonstration at BASF pilot reactor showed 10% batch time reduction without negative effects on polymer quality

OPTICO-Model-based Optimization and Control for Process-Intensification in Chemical and Biopharmaceutical Systems

- Adaptive and integrated computational framework consisting of multi-scale, multi-phase phenomena-based modeling methodologies and advanced process analytics tools for intensified chemical/biochemical plant design and operation
- Methodological design approach for sustainable, intensified chemical/biopharmaceutical plant design and operation through a flexible, integrated multi-scale modeling framework coupled with advanced process analytics tools and modern optimization/control techniques

Main achievements and impacts

Continuous Separation of Proteins

- Development of a novel twin-column MCSGP protein separation process (Multicolumn Counter-current Solvent Gradient Purification) with a 2-3 times higher productivity (Chromacon).

Continuous Crystallization Process

- Model-based process optimization led to the improvement of the product quality, reduction of process costs (e.g. energy), etc. Design of a new continuous process, i.e., air-lift crystallizer (DSM).

Suspension and Inverse Suspension Polymerization

- Utilization of Raman and Vis-spectrometry for on-line monitoring of monomer conversion and particle size distribution (RWTH/USTR). Use of developed mechanistic models for process optimization and control of product quality (e.g. MWD and PSD) (BASF/CERTH).

Fatty Acid Oxidation

- Process improvements of 17%, compared to the base case operation, was achieved via process monitoring and process modeling (ARKEMA).

MORE - Real-time Monitoring and Optimization of Resource Efficiency in Integrated Processing Plants

- Definition and implementation of near real-time resource efficiency indicators (REI) to measure the resource efficiency of large chemical production plants during operation
- Novel analytics and data reconciliation for REI computation
- Visualization and REI-based online decision support tools with what-if analysis to support operators and managers
- Multi-criterial real-time optimization of resource efficiency by adjusting operational parameters
- Implementation and demonstration of the methodologies in 4 industrial case studies

Main achievements and impacts

Process Dashboard - Definition of real-time resource efficiency indicators for continuous and batch plants

- Visualization of multi-dimensional resource efficiency indicators
- Identification of trends
- Evaluation against theoretical or historical optimum

Novel analytics

Neutral implementation platform

Optimal operation of evaporators

- Significant savings achieved

REFFIBRE - Modeling the Impact of Innovations on the Circular Economy

- Methodologies and models for environmental and economic assessments (Life Cycle assessment and technoeconomic analysis of the value chains)
- Methodologies and tools for eco-designed paper production (paper production/quality design models)
- Process modelling tools and innovative analytical tools to control production in a multi-product mill concept

Main achievements and impacts

- Improved resource efficiency in the paper/board production due to larger reject amounts in sorting, fractionation and screening
- Novel measurement for recycled pulp quality will be used to control the operation in the paper mill
- Adaption of novel technologies to produce side products or raw materials from waste fractions

TOP REF Innovative Tools, Methods and Indicators for Optimising the Resource Efficiency in the Process Industry

- Development of a set of Key Resource Indicators
- Cross-sectorial methodology for process diagnosis and monitorization.
- Identification of KPAs Key Process Attributes (Industry constrains) CPP Critical Process Parameters and the related Variables to measure and control
- Non-invasive, real-time and on-line monitoring and control tools adapted to three specific energy and resource intensive processes.
- New model software tools for resource efficiency management to the process industry
- Multisectorial board to spread the results to other intensive industries.
- Demonstration on real conditions in three demo-sites.

Main achievements and impacts

- Homogeneous audit and diagnosis based on thermo-economics of the resource efficiency of the processes (lack of European regulation taking into account water, raw material and wastes)
- Improved software library, models and platforms for modelling and simulation focused on resource efficiency. (Feasible to be integrated into to commercial tools already used by industries)
- Support to the decision making by KRIs especially by energy and exergy indicators (for industry, public authorities, policy makers)
- Decoupling of economy and environment by providing information that is easy to transform and compare between industries
- Standardization of KRIs

All of the projects in the domain were targeting economic and social impacts which would lead to higher competitiveness with higher resource efficiency; sustainable society and a more resilient economy; Less dependency on imported resources (energy and raw materials); higher human productivity due to self-optimizing plants; and lower transport costs due to smart-scale processes and lower collection efforts.

Target figures were quantified (which were broadly compatible with the SPIRE high-level goals)

- up to 20% improvement and energy and resource efficiency

- up to 10-20% enhanced production capacity
- 30% increase of reusability and recycling of materials
- up to 15% reduction of production costs

Environmental goals were a reduction of the CO_2 footprint; reduction of non-renewables consumption; reduction of fossil energy intensity; minimization of waste and off-spec product; and cleaner working environments

Domain 2: Integrated Process Control

The 4 projects in the domain were Consens, Desire, Propat and Recoba,. The presentation was given by Peter Singstad. All are from new SPIRE projects from the 2014 call and have only recently commenced. As such, all the impacts are aspirational.

The technical impacts summarised by project:

Consens: Integrated Control and Sensing for Sustainable Operation of Flexible Intensified Processes

Removal of obstacles for intensified continuous processes by:

- online sensors with new capabilities (NMR, fouling, rheology)
- closed-loop adaptive control concepts
- monitoring and engineering tools
- validation using 3 intensified continuous processes that cover the complete value chain of chemical production (organic compounds, polymers, consumer products)

Expected Impacts

Technological:

- making processes resilient to variances in feed-stocks and to external disturbances
- enabling the migration of batch processes to flexible continuous intensified processes
- enhancing fast development of new products.

Economic:

> 130 M€/year in pharmaceutical & specialty industry

> 100 M€/year in consumer chemicals

> 35 M€/year in polymer

Environmental:

- Reduction of CO2 emission
  - 230,000 t/year in polymer
  - 170,000 t/year in pharmaceutical & specialty industry
- Less consumption of non-renewable raw materials
  - 176,000 t/year less use of solvents in pharmaceutical & specialty industry

DESIRE - **Integrated Process Control based on Distributed In-Situ Sensors in Raw Materials and Energy Feedstock**

Develop an optimisation scheme for belt conveyor transportation systems, which

- eliminates idle running of conveyors
- improves the reliability and availability of belt conveyors through novel condition based maintenance schemes
- increases the efficiency by modernisation (belt, drive units, idlers)

Expected Impacts

- **STEEL**
  - Reduction of 3 kg of C from fossil fuels per ton hot metal
- **MINING**
  - 2% energy savings of electricity and fossil fuel.
- **COMBUSTION**
  - Increased efficiency and continued optimization through detection and correction of operation drifts
  - Greater operation flexibility, with different loads and combustibles
  - Reduced pollutant emissions (including Nox)
  - Introduce new combustibles to the energy market, enabling reliable and efficient combustion.

PROPAT - Robust and affordable process control tecnologies for improving standards and optimising industrial operations

GOALS:

- To develop an INTEGRATED PROCESS CONTROL PLATFORM based on novel low cost real time on-line sensors and a versatile Global Control System Platform that acquires and processes the data
- To develop models for individual sensors and methods for analysing multisensory inputs
- To perform PAT and QbD implementation case studies in order to evaluate their impacts and demonstrate their advantages.

Expected Impacts

- Technologica**l**
  - To ensure a more efficient control of processes through on-line measurement and modelling critical quality attributes
  - Implementation of PAT in the European process industry
  - Improved and affordable measurement tools
- Economic/Social
  - Strengthening of the competitiveness of the European industry
  - Retention and growth of jobs in process automation sectors
  - Operator safety
- Environmental
  - More sustainable plant operations
  - Significant decrease in greenhouse gas emissions
  - Increased resource and energy efficiency in plant operations in the short to medium term

RECOBA - Cross-sectorial real-time sensing, advanced control and optimisation of batch processes saving energy and raw materials

- Innovative sensor technique (Raman Spectroscopy, Acoustic sensors, TEM, Fibre-optic sensors)
- Innovative process models with less parameters and equations to solve
- More reliable and faster control and optimization methods
- Case-studies on batch production in polymer, steel and silicon industries

Expected Impacts

- Technological
  - Products have higher and more consistent quality
  - Robust real-time control
- Economic/Social
  - Resource efficiency: depending on industrial sector raw material savings 1-5 %, up to 25 % for new products
  - Energy efficiency
  - Reduction of waste water

- employment opportunities along value chain
- Environmental
    - Reduced carbon footprint: 1.554 GWh/a = 932,500 t/a CO_2

2.2.1 Cross-cutting issues

Technical and non-technical cross cutting issues identified by projects in this track are shown below in Table 2.

Technical cross-cutting issues	Non-technical cross cutting issues
Process modelling methods and tools, multi-scale and multi-phase Novel analytical on-line measurements Realization of advanced control Data reconciliation Process monitoring DCS-vendor neutral implementation platform for advanced monitoring and control solutions Model-based off-line and real-time optimisation Robust smart-scale continuous processes **Standardisation** ProPAT will contribute to the creation of a CEN Workshop Agreement as a best practise document. **New technologies** Several of the projects will contribute to improved technology for process control and optimization New sensors for traceability of raw materials in the steel industry New sensors for high temperature applications New tools for sensor failure detection Practical implementation of PAT and Quality by Design in the process industry (high transferability across sectors) "Data cubes" which integrate control, process and design data facilitate efficient data analysis to improve the running processes.	Standardisation Common references and tools to analyse and compare industrial processes Novel audit methodology focused on resource efficiency Cross-sectorial life-cycle, cost and sustainability assessment Business models for technology transfer Motivation and education of the operators Education and skills development Promoting the importance and opportunities in the European process industry Creating awareness among the European energy-intensive (batch) process industry and related stakeholders Stimulating the market uptake in the European manufacturing industry CONSENS proposes a Cross-sectorial Advisory Board (CAB) to facilitate technology transfer. The industrial members should feed in the needs of their industrial sectors.

Table 2: Session 2 Cross-cutting Issues

2.2.2 Synergies and benefits of clustering, and gap analysis

The identified synergies and benefits of clustering were identified as:

- Joint events of projects and support actions on resource efficiency monitoring and improvement
- Joint publication
- Cross-industry exchange (e.g. joint Advisory Board meeting)
- Standardization activities
- Closer collaboration of the projects and support actions on resource efficiency monitoring and lifecycle management
- Public event – SPIRE Conference on Ressource and Energy Efficiency by Monitoring and Control
- Liasing between the industrial advisory boards
- Promoting the importance and opportunities in the European process industry
- Creating awareness among the European energy-intensive (batch) process industry and related stakeholders
- Stimulating the market uptake in the European manufacturing industry
- CONSENS proposes a Cross-sectorial Advisory Board (CAB) to facilitate technology transfer. The industrial members should feed in the needs of their industrial sectors.

2.3 Session 3: Sustainability and Circular Economy

The 3 clusters of projects presented in this session covered 17 projects. The range of technology and application areas covered:

Domain 1: Integrated management of resources

The 4 projects in the domain were E4Water,R4R, MefCO_2 and Tasio. The presentation was given by Anna Sager. Both existing FP7 projects together with new SPIRE projects were represented.

E4Water

- Develop, implement and validate new integrated approaches for a more efficient and sustainable management of water in Chemical Industry achieving solutions that are: eco-efficient (-20% water use, -30% wastewater production, -15% energy consumption), cost-effective (up to > 20% cost reduction) and industrially relevant
- Significant reduction of water uptake and waste water production due to the use of alternative water resources, reuse of water, water loop closure, industrial symbiosis, on site integrated water management:
    - up to ~ 45% in water use
    - up to ~ 65% in wastewater production

R4R

- Overcoming the European fragmentation of ambitious and innovative regions, improving research and cooperation between chemical regions in the areas of resource and energy efficiency.
- R4R will be the major community to share best innovation practices and address the following needs and challenges
- Identification and promotion of valuable and pragmatic resource efficiency opportunities for industry
- Cross regional cooperation
- Joint Action Plan for Resource Efficient Process Industry and chemical industries especially (33 initiated new actions)

MEFCO_2

- Mitigation of exhaust carbon dioxide and reduction of greenhouse gas emissions through the conversion of CO_2 into methanol (an extremely versatile chemical) through an efficient process supported by a non-noble metal catalyst.
- Utilisation of ordinarily emitted greenhouse gas carbon dioxide and hydrogen, produced from redundant electrical energy into a widely-useable platform chemical, methanol. The

technology is being designed in a modular intermediate-scale, with the aim of being able to adapt it to varying plant sizes and gas composition.

- Construction of a pilot plant with a production capacity of 1,000 Kg of methanol per day through the conversion of 2.7 tonnes of CO_2 and with an energy consumption (for electrolysis) of 23,000 kWh.
- This process is envisaged to reach high efficiency
- Some of the chemicals that can be obtained from methanol are the following: formaldehyde (used in construction and wooden boarding), acetic acid, MTBE (fuel component), and the formation of methyl esters in the production of bio-diesel. In addition, methanol can be blended with other substances to produce fuels.

TASIO

- Demonstration of the potential for easy, compact and completely modular recovery of the process waste heat in the cement industry through a real installation
- Proven capacity of the ORC plant to be operated in a flexible and modulated way following the overall plant work fluctuations and energy-heat demand dynamics
- Proven complete integration with the industrial facilities selected and positive feedbacks from workforce on operation friendliness and performances control
- Recovery of waste heat produced in energy intensive processes of industrial sectors such as cement, glass, steelmaking and petrochimical and consequent transformation into useful energy
- Development of advanced Waste Heat Recovery Systems (WHRS) based on the Organic Rankine Cycle (ORC) technology, able to transform the thermal energy of the flue gases of E.I.I. into electric power for internal and external use
- Cross sectoral applications in different E.I.I., increasing the overall efficiency and reducing investment costs
- Application of new materials and coatings to improve heat transfer and avoid heat exchanger corrosion

Domain 2: Recovery from Waste

The 4 projects in the domain were *RECLAIM, REMANENCE, HydroWEEE, RECYVAL-NANO, REEcover, RecycAl, ReFraSort, C2CA, BIOMETALdemo.* The presentation was given by Jan Meneve. The projects were from the FP7 programme.

Technical Impacts were claimed in the following topics.

E-waste recycling:

- Assessment of value chains, product life-cycles and market trends
- New (automated) sorting, disassembly and separation concepts
- Re-assessment and optimization of conventional recycling processes (KAIZEN)
- Elaboration of new (hydrometallurgical) processes for highly efficient extraction and refinery of materials
- Recovery of REE and other technology metals, for substituting mining of virgin raw materials
- Innovative solutions for integrated treatments of liquid and solid wastes
- Validation of re-mined elements from tailings
- Industrial validation and scaling of stationary and mobile facilities

C&D-waste recycling:

- Development of a 100% end-of-life (EoL) concrete separation process that produces:
- aggregates for use in new concrete production
- calcium rich feedstock for low-carbon cement production
- Elaboration of new concrete type that uses recycled aggregates which is 30% stronger
- Development of HSI and laser based sensors for quality assessments
- Save costs by largely using conventional facilities for primary concrete
- Deployment of the in-situ, multi-purpose new concrete recycling process

Refractory waste recycling:

- Innovative identification techniques for industrial residues with dust and slag contaminated layers
- New mechanical separation systems able to separate up to 8 classes of large, heavy bricks (up to 30 cm diameter, 20 kg weight)
- Industrially viable technology: high throughput, dust issues, ..
- Aiming at 20% (instead of current 5%) replacement of virgin critical raw materials incl. graphite, magnesite, bauxite

Metal Recycling:

- Production of high quality raw material from Al scrap
- Development and optimization of new casting process that produces high quality non-ferrous metal
- Quantification of energy savings achieved during the development process
- Produce and test components from the recycled material that are currently manufactured from virgin feedstock
- Economic and logistics aspects for upscaling the High Shear Process for Al recycling, in view of the large quantities needed
- More efficient heavy metal pollutant elimination in waste water treatment – 3200 tonnes discharged in EU-27

Social and economic impacts would derive from a shift from primary production and waste storage to secondary resource production and reduced waste. Enhanced security of supply of (critical) resources; Reduced energy consumption, (and hence production costs) would increase competitiveness of Europe`s industry, thereby securing jobs. SME involvement in urban-mining business solutions was considered particularly important.

Tangible measures of success were provided with examples of patents and licences being granted. In one instance a spin-off company is being founded. Contributions were also made to standards.

Domain 3: Lifecycle Management

The 3 projects in the domain were Measure, SAMT and Style. The presentation was given by Amy Peace. The projects were from the SPIRE 4 programme.

Key Goals and Deliverables

- Recommendations for the current use of sustainability indicators, tools and methodologies for the SPIRE sectors.
  - Supporting future SPIRE and other H2020 funded projects
  - For practical use in European process industries
- Identification of gaps in the available tools
- Recommendations for future research needs and standardisation
- A harmonised roadmap summarising the recommendations across the three projects (available at the end of December 2016)

The SPIRE4 projects aim to ensure that the sustainability impact of these technologies can be evaluated in a consistent manner, across sector boundaries and through value chains.

The recommendations from the projects aim to ensure that broad sustainability factors are not overlooked when evaluating new technologies.

Interestingly, the three projects had developed a common project roadmap (post project-commencement). The synergy and the impact from this horizontal activity –although easier for a Coordinated Support Action is an interesting model.

2.3.1 Cross-cutting issues

Technical and non-technical cross cutting issues identified by projects in this track are shown below in Table .

Technical cross-cutting issues	Non-technical cross cutting issues
E4WATER: Technical approaches for cost reduction in water treatment, Towards water loop closure, Integrated water management (process – plant – site), (Trans)industrial symbiosis **MefCO$_2$:** cross-sectorial impact of the proposed technology is aligned with SPIRE's Key Component FEED and, more precisely, with the Key Activity 1.2 "Optimal valorisation of waste, residue streams and recycled end-of-life materials as feed. Carbon dioxide sequestration and usage as a feedstock for methanol production has the potential to provide a significant reduction of CO_2 emissions **TASIO:** Energy efficiency by filling the gap between unused surplus heat and its internal and external use; Energy sustainability of industrial processes through the design, implementation and testing of an innovative new energy recovery system **R4R:** Identification of new technologies through cross-sectional/ stakeholder and over regional cooperation Exchange and integration of knowledge and technologies from primary mining, metal & mineral processing, refractory production, waste recycling industry Waste recycling companies as key players in the process industry, working together with technology provider research institutes to implement effective technology transfer Waste valorisation in associated industries – industrial symbiosis **Standardisation** – involvement of standardisation bodies to aid uptake of recommendations and practical implementation **Dissemination activities** – coordinated across the three projects to ensure clarity of message to stakeholders and broad sector awareness and input **Cross-sectorial best practice sharing and technology transfer** – all SPIRE sectors included in projects with experiences and tools shared **Opportunities for business development** – through utilisation of the Roadmap recommendations	Cross sectional/stakeholder workshops Exchange of Best Practices and Knowledge transfer/dissemination Skills development Business deployment Different dissemination channels (website, twitter etc.) Link with EU and national technology Platforms and Associations Presentation of project results in scientific literature, international and national conferences and trade fairs Specific dissemination activities at international fairs and congresses Cross-sector and industry-academia IPR activities for: integrated systems patents; scaling-up activities; spin-offs, start-ups Exploitation of the recycling pilot lines and new products from recycled raw materials as well Tailor made communication and training activities at regional level Involvement of all relevant stakeholders incl SMEs for data mining, technology validation, supporting regulation and public awareness

Table 3: Session 3 Cross-cutting Issues

2.3.2 Synergies and benefits of clustering

The identified synergies and benefits of clustering were identified as:

- Get easier access to neighbourhood industrial sectors/application fields
- Through synergies and common ground among the cluster projects, common market segments and needs
- Standardisation issues
- Replication activities and support in the exploitation and operation of new technologies/processes in specific locations throughout Europe
- Cross sectional and value chain cooperation, system approach
- Input of ideas from SME's would help to guide the goals of the project to suit the needs of more end-users
- It would help us to understand the best commercialisation route for the (HSP) technology and generate awareness of the quality of potential material which can be produced
- Dissemination and clustering activities are a key part in helping to disseminate the project results towards industry, policy makers and the public, and aid uptake of the developed technologies by the European industry
- Bringing waste owners and resource processing end-users together
- Join forces with H2020 clusters, EIP and EIT Raw Materials
- Understanding the real problems and opportunities
- Communication documents, questionnaires and workshops are being coordinated across the three projects
- Common webpage through www.spire2030.eu
- Dissemination of results to be clustered and combined through generation of harmonised Roadmap
- Expect higher acceptance, outreach and impact through cooperation
- Would like further involvement from other SPIRE projects

3 Success Stories

Four success stories from different topic areas were selected to present their achievements and impact to date. The end applications ranged continuous catalytic synthesis, process control systems, water-use reduction and regional resource efficiency. The projects were at different stages of realisation, although all had achieved significant impact to date.

SYNFLOW

http://www.synflow.eu/

SYNFLOW was a 48 month large-scale collaborative research project within the 7th European Framework Programme for Research and Technological Development. The project started September 1, 2010. 19 industrial and academic partners from 8 European countries with a consortium combining leading expertise in catalysis, organic synthesis and reaction and process engineering.

The vision of SYNFLOW was to shift paradigm from batch-wise large volume processes comprising many separate unit operations to highly integrated and yet flexible catalytic continuous-flow processing. This was achieved by a unique integrative approach combining molecular understanding of synthesis and catalysis with engineering science in process design and plant concepts.

Demonstration at industrial pilot plant scale were performed for Buchwald-Hartwig Chemistry, Hydrogenations and Olefin Telelerization.

Key Deliverables included

- Commercialisation of new catalyst for Buchwald Hartwig amination
- Improved pharmaceutical product quality through reduced metal contamination
- Patents on new reactor technologies
- Energy reduction 15- 50%;
- E-factor: reduced up to 10x
- Timelines for scale-up reduced by 25%
- Increased flexibility for drug development projects up to 100 Mios €

COOPOL

http://www.coopol.eu/

COOPOL addressed the complex issues of real-time process control based on advanced models and on-line sensors, to develop a generic basis for widely applicable sustainable intensified processes. COOPOL developed a new process control approach, linking molecular level information and understanding of the reaction chemistry with real-time sensing, rigorous modeling based on first principles, subsequent model reduction and non-linear model-predictive control (NMPC) with economic objectives, called dynamic real-time optimisation (DRTO).

The approach of COOPOL was to develop robust real-time optimisation-based control and sensing methodologies and through their application to achieve, in parallel, the intensification of (i) the existing processes, and (ii) the development of novel intensive 'smart-scale' processes.

This was applied to semi-batch seeded emulsion copolymerization with 4 monomers. The devel;oped model and process control was applied to a pilot plant at BASF Ludwigshafen. The batch time (for an already "optimised" industrial system) was reduced by 10%. The technology will be commercially available this year. The project has demonstrated how process intensification can increase productivity by 10-20% whilst also maintaining in-spec product quality. Analytical costs are also decreased as less sampling is required.

E4WATER

Economically and Ecologically Efficient Water Management in the European Chemical Industry

http://www.e4water.eu/

The chemical industry provides the highest potential for increasing eco-efficiency in industrial water management. E4Water addressed crucial process industry needs, to overcome bottlenecks and barriers for an integrated and energy efficient water management. The main objective was to develop, test and validate new integrated approaches, methodologies and process technologies for a more efficient and sustainable management of water in chemical industry with cross-fertilization possibilities to other industrial sectors.

Original targets were

- reduction of > 20% in water use
- reduction of > 30% in wastewater production

Double the original targets were achieved

- up to ~ 45% in water use
- up to ~ 65% in wastewater production

This was achieved via

- use of alternative water resources,
- reuse of water,
- water loop closure,
- industrial symbiosis,
- on site integrated water management

Economic benefit of ca. 30% has been achieved, with 15% reduction in energy use.

Chemical Regions for Resource Efficiency

www.regions4resource.eu

Launched in November 2012 under the funded Research and Innovation Programme from the European Commission for a three years period, Chemical Regions for Resource Efficiency (R4R) aimed to overcome the European fragmentation of ambitious and innovative regions. Through its methodology, R4R explored positive impacts on resource efficiency.

R4R achieved a major step improvement in regional and transnational cooperation among the participating regions developing practices, tools and examples which were adopted by multiple

European regions to improve regional and cross-regional collaboration in general, and on resource efficiency in the process industry in particular.

R4R will created the platform for international collaboration on resource efficiency with clusters in third countries to improve and accelerate innovation and promote European eco-innovative technologies globally.

4 Maximising Impact and Successful Innovation Strategy

The panel discussion centred on the experience of the panellists in achieving real-world impact and on their thoughts on the elements of a successful innovation strategy for the process industries. To help focus the discussion each panellist was asked to make an introductory statement based on three questions before the debate was opened up to the general audience. The three questions were:

1. How do you understand project success and impact in exploitation for the SPIRE PPP? What is the role of patents, standardisation and start-up creation?

2. What is the added-value of cooperation beyond the consortium to maximise project success (e.g. clustering and international cooperation)?

3. What could help to further ensure that the SPIRE projects and the PPP generate breakthrough exploitable results and maximise impact?

The participating panellists and their respective organisations were:

Ignacio Martin – CIRCE

Ignacio Calleja – Technalia

Pietro Gimondo – CSM

Ralf Sievering – BFI

Peter Singstad - Cybernetica

The moderator was José-Lorenzo Vallés.

Among the points made by the panellists during their opening statements were how to measure the outcomes from projects in Production. This should of course be under real conditions. The opportunity to lever participation from other sectors should be sought, overcoming the barriers created through a lack of mutual understanding.

It was also felt that there was a need for specific events to get the different sectors together to share successes. Concern was expressed however, that little in the way of "real" success was presented at the meeting. To maximise the impact you clearly need deployment of the technologies! Presenting Techno-economic data such as CAPEX and OPEX are is much more of an indicator of success than claiming a % reduction in energy! The rate of uptake much also be measured and accelerated.

A clear advantage was expressed in having the SPIRE cross-sectoral approach, though common themes/needs (such as process control or sensors) should be identified.

Clearly, a strong(er) involvement of industry is required for SPIRE to be successful. As a community we need to ensure we are solving the right problems. The roadmap is clearly an impressive document, but once the problems have been translated into a real project, the real work actually starts to achieve impact upon project completion. Technical results need to translate into purchase orders!

Technology development is a difficult market – especially when we are creating technology no one is asking for!

The discussion was then opened to the floor, and a lively debate ensued, and many suggestions and observations offered.

To strengthen the bonds between SPIRE and projects, it would be a good idea for workshops with the SPIRE working groups during execution as opposed to at the end.

We really need to Showcase was has been implemented, and how we are achieving success (or not) in bridging the valley of death. More effort is probably required to monitor (and communicate) success at a SPIRE level.

Although Standardisation is seen as being important, and the EC does offer support seminars in the field, specific workshops, with project participants who have successfully pursued standardisation of project outcomes would help. A new Project Coordinator (with an academic background) can often be lost as to how to tackle these opportunities for impact.

On the topic of cooperation, questions were raised as to how SPIRE can increase global cooperation with international initiatives, organise cross-sector workshops around common interests (processing at 700C for example). It was stressed that these should be true workshops as opposed to the seminar-type event held today.

Thinking to the future, fears were expressed whether or not the current Horizon2020 approach to collaborative funding will "fill the pipeline" of new emerging technologies. It was also suggested that with a focus on higher TRLs, open discussion (especially with academics) becomes difficult.

Further challenges, such as how to tackle the barriers to implementation, the lack of coordination within member states for regulation were raised. It was pointed out that the EC is working with the PPPs to renew regulation and make it more innovation friendly. However, regulation to promote bioenergy usage creates a disincentive to use the feedstock as (non-subsidy bearing) renewable chemical feed.

5 CONCLUSIONS AND RECOMMENDATIONS

The stated aims of the workshop were to identify how the impact of SPIRE projects could be maximised but also what benefits could be gained from clustering projects with similar themes. The specific objectives were to:

- Report on cross-cutting issues with multiple project beneficiaries
- Identify project impacts: highlight targets and metrics
- Share best practice between projects
- Learn about success stories and outcomes
- Highlight the added value of undertaking the projects within the framework of the PPP

Considering that this was the first workshop, which was the first opportunity for many project participants to meet their peers, this workshop clearly contributed to these aims**.** All but two of the invited projects were represented (as they had prior commitments). **However, an opportunity was missed to hand out a questionnaire at the end of the meeting to attain quantifiable feedback**. Given the large number of projects which were represented, the format, where projects were grouped by domain and presented by a single speaker worked well.

The bringing together of projects inspired by the efforts of the PPP, but not necessarily part of SPIRE clearly provided context (together with expectations) of the high-level strategic goals.

However, to formally assess the impact (or potential for impact) it is worth revisiting the KPIs which have been developed, and against which the success of SPIRE will be measured.

Key Performance Indicators (KPIs) at PPP implementation level are:

- New systems and technologies developed in the relevant sectors
- Participation and benefits for SMEs
- Contribution to the reduction of energy use
- Contribution to the reduction in the use of material resources
- New high-skilled profiles and new curricula developed
- Private investment mobilised in relation to the PPP activities
- Contributions to new standards

Key Performance Indicators (KPIs) at project impact level are:

- Scale of reduction in energy, material resources and waste
- Project results taken-up for further investments
- Trainings for a higher quality workforce
- Patents and activities leading to standardisation

New systems and technologies developed in the relevant sectors

There is clearly wide technology coverage. The FP7 programme in particular has contributed to this. However, progress, as presented is somewhat opaque. That said, the FP7 programme for NMP put a major focus upon technology development and demonstration by industrial partners. The usage of Technology Readiness Levels has only been adopted since the Horizon2020 programme. As such, quantifying progress is difficult – though examples at TRL 6-7 have clearly occurred. Less apparent was deployment which has taken place at TRL 9, though it is certainly a question to ask***!*** ***The impact of the programme would have been much more transparent if the projects had presented the starting and finishing TRL as a result of the effort expended***.

With the advent of Horizon2020, TRL levels, together with business cases and business plans are explicitly requested for all SPIRE proposals. Although clearly commercially sensitive date, the intention and the potential is much can be much more explicitly be determined (a poor business case by reason of unfavourable OPEX, CAPEX or market figures would allow for a different interpretation of a "successful project" that had taken a technology from TRL 2 to 7). ***As such, reviewing the business case/plans will be a much more effective manner to assess the (potential) impact for Horizon2020 programmes.***

Participation and benefits for SMEs

SME participation in the workshop was low. However, data from the EC indicates that 24% of the industrial participants of the SPIRE calls are now SMEs. Although hardly representative, the Coopol participant, Cybernetica indicated that they are bringing the process control software, developed during the project this year (for a project that completed in February!). The session on Sustainability and Circular Economy in particular suggested that SMEs are benefiting from the new value chains which are being created. ***This would suggest that a systematic study of opportunities for SMEs (together with barriers for large corporations) would be a useful way to maximise the opportunity for impact from SPIRE.***

Contribution to the reduction of energy use

The SPIRE goal of a reduction in fossil energy intensity of up to 30% by 2020 was clearly supported by many of the projects and energy efficiency improvements of this magnitude (or more) frequently being reported. The developments in improved process control create cross-sectoral opportunity. Also very promising, are projects aiming to address major energy intensive systems such as Ammonia and Methanol synthesis, improved catalytic processes, overall water usage and metals manufacture (through recycling). However, this target is very ambitious, and to assess impact (in 2020) SPIRE would have to be able to show that in absolute terms (per unit of production) that this has taken place. ***Given that incremental improvement in energy consumption is underway, a brokerage event entitled, for example "Ideas to remove 20M Tonnes of Oil Equivalent from the European Chemical Sector", with similarly provocative titles for the other SPIRE sectors would certainly be an marvellous opportunity to bring the industrial base together with the academic base!***

Contribution to the reduction in the use of material resources

Similarly many projects had resource efficiency, whether through improved catalyst selectivity, use of renewables, implementation of circular economies etc. The target impacts were all at a percentage improvement to be compatible with the SPIRE objective for a reduction in non-renewable, primary raw material intensity of up to 20%. ***However, once again, the lack of absolute numbers would make it hard to determine the impact, even if all the processes came to fruition***.

New high-skilled profiles and new curricula developed

This data was presented in some instances (especially with regard to the number of PhDs and MScs). More systematic data collection would be required to ascertain this impact.

Private investment mobilised in relation to the PPP activities/ Project results taken-up for further investments

Although the industrial contribution to FP7 and SPIRE projects can be easily calculated, information on project results taken-up for further investments was less clear. There was a clear desire for "showcase" events where SPIRE technologies taken to TRL 9 could be exhibited. At lower TRLs, information on OPEX and CAPEX, payback-time etc (perhaps aggregated to address commercial sensitivity) would be necessary to provide an indicator.

Patents and activities leading to standardisation/ Contributions to new standards

This was not systematically presented, though it is occurring. Patents as a result of activities are a useful indicator of impact, especially for FP7 projects. By definition, Horizon2020 projects are more likely to be based upon pre-existing fundamental patents, or (perhaps) producing process improvement patents. Contribution to standards was discussed several times, though usually in the context of requests for support in understanding how to implement in practice.

Clustering

The benefit of clustering was frequently declared. Ideas such as common industrial advisory boards, joint dissemination workshops were raised. Synergies were seen in cross-sectoral working and projects, though the challenge is to identify the common "hooks". Process control and sensor development were seen as high impact "quick wins" from this standpoint.

5.1 Recommendations

Based on the presentations from the cluster groups and the subsequent discussion, the following recommendations have been formulated:

1. Greater transparency should be provided as to the progress/impact that projects are making in achieving SPIRE objectives. Technology Readiness Levels should be presented. Percentage improvements to a process are only partially useful. Absolute (Euros, kgs, tonnes of oil equiavelents etc) numbers, indicating OPEX, CAPEX and market volumes are stronger indicators of success and impact. If necessary these could be aggregated due to commercial sensitivity and presented at a SPIRE/sector level. Other indicators such as PhDs, patents and publications produced could be collated. Such guidance should be provided prior to the next impact workshop. A post-meeting questionnaire would also be useful to capture information.
2. There was a clear anticipation that A.SPIRE will play a crucial facilitation role for the projects.
    a. Organisation of cross-sectoral workshops around common thematic “hooks”
    b. In addition to the present (generic) Standardisation seminars, workshops delivered by SPIRE participants who have successfully incorporated Standardisation into project outcomes would be valuable for (new) project coordinators.
    c. “Showcase” events for SPIRE technologies that had been taken to TRL 9 should be organised. A greater analysis of previous FP7 projects using the terms of reference of the SPIRE objectives to identify “success” would also be valuable.
    d. Meetings between newly funded SPIRE projects and the relevant working groups should be organised

Appendix 1: Agenda

Agenda

Workshop

Impact of the SPIRE cPPP

21-22 April 2015, Brussels, Belgium

21 April 2015, Tuesday

Venue: Committee of Regions, Room VMA 1, 2nd floor, Rue Van Maerlant 2, Brussels

13:30-14:00 **Registration and welcome coffee**

Chair: José-Lorenzo Vallés, Head of Unit, DG RTD

14:00-14:30 **Welcome to the participants and objectives of the workshop**

The SPIRE projects in Horizon 2020 – Søren Bøwadt

Plenary sessions Room VMA 1:

14:30-18:00 **Presentations on the Impact of Collaborative Research projects relevant to the SPIRE cPPP**
Aim: To assess the impact achieved, the potential uptake and exploitation, the potential benefits of clustering and good practises to maximise impact

(Coffee break between the sessions at 16:00-16:30)

Session 1: Efficient Processes

Facilitators: Ignacio Martin, CIRCE

Søren Bøwadt and Carmine Marzano, EC

Session 2: Process Control and associated parameters

Facilitators: Sebastian Engell, TU Dortmund

Peter Singstad, Cybernetica AS

Sébastien Mortier, EC

Session 3: Sustainability and Circular Economy

Facilitators: Ignacio Calleja, Technalia

Istvan Ritz, EC

18:30 **Networking Cocktail with Welcome Address by the Directors**

22 April 2015, Wednesday

Venue: Committee of Regions, Room VMA 1, 2nd floor, Rue Van Maerlant 2, Brussels

Plenary session

Chair: José-Lorenzo Vallés, Head of Unit, DG RTD

9:00-9:10 **Welcome and Objectives of the Plenary Session**

9:10-9:30 **SPIRE and Horizon 2020**

Clara de la Torre, Director "Key Enabling Technologies", DG RTD

9:30-9:50 **Expected Impact from the SPIRE PPP based on the Roadmap**

Klaus Sommer, A. SPIRE

9:50-10:00 **EIB financing for companies investing in KETs. An InnovFin Advisory perspective.**

Piermario Di Pietro, Senior Advisor, EIB Advisory Services

10:00-10:50 **SPIRE relevant FP7 Success Stories – Projects with high impact and outcome: SYNFLOW, COOPOL, E4WATER, R4R**

10:50-11:20 **Coffee break**

11:20-12:20 **Panel discussion: Maximising Impact & Successful Innovation Strategy for the process industry**

12:20-12:30 **Concluding statement from the Rapporteur**

12:30-12:45 **Statement from the Private Side of the SPIRE cPPP**

Loredana Ghinea, A. SPIRE

12:45-13:00 **Statement from the Public Side of the SPIRE cPPP**

EC representatives

13:00 **End**

Rapporteur for the event: Keith Simons

Session 1: Efficient Processes

Domain 1: Process Optimisation

Facilitators: Ignacio Martin & Søren Bøwadt

Speaker: Andrzej Gorak

COPIRIDE

F3-Factory

INCAS

POLYCAT

SYNFLOW

MAPSYN

INNOREX

ALTEREGO

Domain 2: Adaptable processes using renewables

Facilitators: Ignacio Martin & Carmine Marzano

Speaker: Denilson da Silva Perez

AFORE

EUROBIOREF

FASTCARD

BIOGO for Production

CASCATBEL

STEAMBIO

Mobile Flip

Prodias

Session 2: Process Control and associated parameters

Domain 1: Modelling and elements of process control

Facilitators: Peter Singstad & Sébastien Mortier

Speaker: Sebastian Engell

OPTICO

COOPOL

MORE

TOP-REF

REFFIBRE

Domain 2: Integrated process control

Facilitators: Sebastian Engell & Sébastien Mortier

Speaker: Peter Singstad

RECOBA

DISIRE

CONSENS

ProPAT

Session 3: Sustainability and Circular Economy

Domain 1: Integrated management of resources

Facilitators: Ignacio Calleja & Istvan Ritz

Speaker: Anna Sager

E4WATER

R4R

MethCO2

CyclicCO2

TASIO

Domain 2: Recovery from Waste

Facilitators: Ignacio Calleja & Istvan Ritz

Speaker: Jan Meneve

RECLAIM

REMANENCE

RECYVAL NANO

BIOMETAL DEMO

C2CA

HYDROWEE DEMO

Recycal

Reecover

ReFraSort

Domain 3: Lifecycle Management

Facilitators: Ignacio Calleja & Søren Bøwadt

Speaker: Amy Peace

SAMT

STYLE

MEASURE

Appendix 2: List of registered participants

First Name	Last Name	Project / Affiliation
ADLER	Liv	BAYER
AKPORIAYE	Duncan	FASTCARD
AMZULESCO	François	Terreal
ANSEMS	Toon	RECLAIM
ASIK	Anna Natasa	EC
BACKBLOM	Göran	LKAB
BALBIER	Justyna	Hydro
BARESI	Marco	TASIO
BIRAT	Jean-Pierre	ESTEP
BOLDRINI	Claudia	EC
BOWADT	Søren	EC
BUCHARDT	Sabina	PRODIAS
CABEZA	Jose	BIOMETAL
CACHOLA MACHADO	Maria	CASCATBEL
CALLEJA	Ignacio	Tecnalia
CARPENTIER	Annick	Eurometaux
CENTI	Gabriele	eCAMM
CHEFNEUX	Luc	Arcelor
CIGANDA	Leticia	RECYVAL-NANO
DA SILVA PEREZ	Denilson	MOBILE FLIP
DAGOSTINO	Girolamo	InnoREX
DE BONIS	Piero	EC
DE LA TORRE	Clara	EC
DE MEESTER	Steven	MEASURE
DE SOETE	Wouter	MEASURE
DEVIC	Anne-Chloé	Repsol
D'HOOGE	Dagmar	OPTICO
DI MAIO	Francesco	C2CA
DI PIETRO	Piermario	EIB
DIELS	Ludo	VITO
EGNER	Siegfried	SteamBio
ENGELL	Sebastian	MORE
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The first SPIRE Impact Workshop was held in Brussels on 21st and 22nd April. A selection of relevant FP7 projects from the NMP calls (28 in total), either completed or ongoing were represented, together with the first batch of 12 SPIRE projects with presentations in three serial session covering:

- Efficient Processes
- Process Control and Associated Parameters
- Sustainable and Circular Economy

The purpose of the workshop was to allow the project to report on success and allow for an assessment of the impact achieved. Depending upon the stage of the project this would either be the potential for uptake, or the exploitation achieved thus far. It was also anticipated to identify cross-cutting issues for the benefit of all such as the potential benefits of clustering and good practises to maximise impact. It was also an opportunity for the new projects to be introduced to SPIRE and understand the context of the funding through the PPP.

This report details the outcome of the workshop together with the main recommendations regarding the execution of SPIRE projects to derive maximum value and synergy.

Studies and reports

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