FIT-4-NMP

Report

on Europe's leading research and innovation organisations in nanotechnologies, advanced materials and new manufacturing processes (NMP)

2021

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EXECUTIVE SUMMARY

This report has been prepared in the frame of the H2020 FIT-4-NMP project funded by the European Commission, which aims to increase the participation of talented newcomers from underrepresented regions in nanotechnologies, advanced materials and new manufacturing processes (NMP) research in Horizon Europe compared to Horizon 2020. In this context, the following definitions are used:

- Talented newcomers are organisations – companies and especially SMEs, universities, research institutes or other organisations – that have not participated in the H2020 NMP projects but are considered promising innovators based on their R&D activities, projects, patents and/or innovations.
- Underrepresented regions are regions with relatively low participation in H2020 NMP projects but with untapped NMP potential.

The underlying rationale of the work described in this report is to increase the participation of the talented newcomers in NMP research in Horizon Europe, by helping them to connect with Europe's leading NMP research and innovation organisations, or so-called NMP top innovators.

However, NMP covers a wide range of scientific domains. To link talented newcomers to top innovators, it is first necessary to define categories of NMP domains and NMP subdomains. Furthermore, with the transition from Horizon 2020 to Horizon Europe, there has been a reorganisation of NMP research. Therefore, to reflect NMP research's new position in Horizon Europe and to simplify matters, FIT-4-NMP uses the following categories of NMP domains: Advanced Materials; Manufacturing Technologies; Circular Industries and Clean Industries. To define NMP subdomains, FIT-4-NMP has then aligned with the strategic research and innovation priorities of European level initiatives that strongly influence the NMP related call topics in Cluster 4 of Horizon Europe.

For each of the NMP subdomains, FIT-4-NMP defined lists of 50-100 related scientific and technological keywords. These keyword lists were used to make searches of the Web of Science database for research publications and the PATSTAT database for EPO and PCT patent applications. Research publications tend mainly to be produced by public research organisations and universities while patents tend mainly to be filed by private companies. Thus, the database searches helped to provide a good balance of research and innovation organisations in the NMP subdomains.

Next, lists were created containing the most prolific publishing and patenting organisations – i.e. top innovators - for each NMP subdomain. Depending on how broad or narrow the NMP subdomain, each list contained between 20-40 organisations with slightly more than half of them being either public research organisations or universities.

Using Microsoft Power BI, the geographic locations of the top innovators have been plotted on an interactive map, which is accessible to public users – including talented newcomers - via the FIT-4-NMP website. The interactive map allows a user to choose to view the top innovators from one NMP subdomain or several concurrently. The name and address of each top innovator can be shown along with a weblink to the organisation's website and Horizon Europe contact person. Thereby, the interactive map supports talented newcomers to learn about and contact more easily top innovators who they would lie to collaborate with in NMP research for Horizon Europe.

1. INTRODUCTION

Linking talented newcomers to top innovators

FIT-4-NMP is a support action project funded by Horizon 2020 to increase the participation of talented newcomers from underrepresented regions in Horizon Europe research in the fields of nanotechnologies, advanced materials and new manufacturing processes (NMP) as compared to Horizon 2020.

Talented newcomers are promising innovation organisations – especially SMEs – that did not participate in research and innovation actions (RIA) or innovation actions (IA) funded by the Horizon 2020 programme Nanotechnologies, Advanced Materials, Biotechnology, and Advanced Manufacturing and Processing (NMBP). Meanwhile, underrepresented regions are regions in EU-13 Member States, EU-15 Member States and Associated Countries that had a relatively low participation in Horizon 2020 NMBP.

Conversely, there are research and innovation organisations from the public and private sectors – principally located in EU-15 Member States – that were prolific in participating in Horizon 2020 NMBP. Thanks to their outstanding research and innovation capacities in various fields of NMP, these top innovators were well-positioned to prepare competitive grant applications and win H2020 NMBP funding.

Thus, FIT-4-NMP's main efforts to increase the participation of talented newcomers from underrepresented regions in NMP research in Horizon Europe are focused on linking the newcomers with top innovators.

Categorising NMP domains and NMP subdomains

NMP covers a wide range of scientific domains. To link talented newcomers to top innovators, it is first necessary to define categories of NMP domains and NMP subdomains. However, with the transition from Horizon 2020 to Horizon Europe, there has been a reorganisation of NMP research. NMP research has been absorbed into Cluster 4 "Digital, Industry and Space" of the Horizon Europe Pillar 2. Among the eleven research and innovation priorities of Cluster 4, four priorities arguably relate closest to Horizon 2020 NMBP: Advanced Materials; Manufacturing Technologies; Circular Industries; and Low-Carbon and Clean Industries.

Therefore, to reflect NMP research's new position in Horizon Europe and to further simplify matters, FIT-4-NMP uses the following categories of NMP domains: Advanced Materials; Manufacturing Technologies; Circular Industries and Clean Industries. Next, to define NMP subdomains, FIT-4-NMP has examined and aligned with the strategic research and innovation priorities of European level initiatives – e.g. European Partnerships such as Processes4Planet and Made in Europe – that will strongly influence the NMP related call topics in Cluster 4 over the course of Horizon Europe.

Locating Europe's top innovators

For each of the NMP subdomains, FIT-4-NMP defined lists of related scientific and technological keywords. These keyword lists were used to make database searches to identify research publications and patents - in each of the NMP subdomains - and the organisations responsible for them. Research publications are mainly produced by public research organisations and universities while patents are mainly filed by private

companies. Thus, FIT-4-NMP's database searches of both publications and patents have helped to identify a balanced picture of public and private organisations active in the NMP subdomains.

Next, the location and contact details of the most prolific publishing and patenting organisations – i.e. top innovators - have been plotted on an interactive map made available through the FIT-4-NMP website. Interestingly, this map also helps to reveal the location of clusters of top innovators around Europe. Being online and comparatively easy to modify, it is anticipated the interactive map will be updated, over the course of the FIT-4-NMP project, with the details of additional leading European research and innovation organisations active in NMP research in Horizon Europe.

2. EUROPEAN LEVEL INITIATIVES SUPPORTING NMP

European level initiatives supporting NMP play a highly influential role in deciding the NMP research priorities in Cluster 4 of Horizon Europe. For this reason, it is instructive to know the European level initiatives that exist and their strategic areas of interest in NMP research and innovation. In this respect, the European Commission supports two main types of European level initiative: Public-Private Partnerships and Public-Public Partnerships.

The European Commission invests substantial amounts in Public-Private Partnerships - which bring together public research organisations and private industry - to enable long-term, strategic approaches to NMP research and innovation. In particular, Public-Private Partnerships:

- Provide a legal structure to pool resources and to gather critical mass from public organisations and private companies;
- Make research and innovation funding across the EU more efficient by sharing financial, human and infrastructure resources;
- Facilitate the creation of an internal market for innovative products and services;
- Enable innovative technologies to get faster to market;
- Can provide the right framework for international companies to anchor their research and innovation investments in Europe;
- Enable the scale of research and innovation effort needed to address critical societal challenges and major EU policy objectives.

Examples of Public-Private Partnerships include European Partnerships, European Technology Platforms and European Flagships. The membership of such partnerships includes many of Europe's leading research and innovation organisations active in Horizon Europe, who meet regularly with each other during membership-organised networking and brokerage events. Usually, the partnerships are open to receive new members and so talented newcomers from underrepresented regions should consider applying to join them.

Also, the European Commission supports Public-Public Partnerships targeting NMP research and innovation. Via ERA-NETs, the European Commission provides "topping-up" funding to EU Member States so that they can run joint transnational calls for proposals. This is done in selected areas of NMP with high added-value for Europe.

In the following sections, the main European level initiatives are described that support Advanced Materials; Manufacturing Technologies; and Clean Industries and Circular Industries.

2.1 ADVANCED MATERIALS

The main European level initiatives supporting Advanced Materials include Advanced Engineering Materials and Technologies (EuMaT), ERA-NET on materials and battery technologies (M.ERA-NET), and Graphene Flagship.

2.1.1 Advanced Engineering Materials and Technologies (EuMaT)

EuMaT is the European Technology Platform for Advanced Engineering Materials and Technologies, which has been established to facilitate the involvement of industry and other important stakeholders in the process of establishing of R&D priorities in advanced engineering materials and technologies. EuMaT covers all elements of the life cycle of industrial products: from components to systems to final goods:

- Design, development & qualification of advanced material.
- Advanced production, processing and manufacturing.
- Material and component testing.
- Material selection and optimization.
- Advanced modelling on all scales.
- Databases and supporting analytical tools.
- Life cycle considerations, including impacts, decommissioning, reliability, hazards, risks and recyclability.

2.1.2 ERA-NET on materials and battery technologies (M.ERA-NET)

M-ERA.NET is an extensive European network of public funding organisations supporting and increasing coordination and convergence of national and regional funding programmes on research and innovation related to materials and battery technologies to support the European Green Deal.

Transnational R&D projects funded by M-ERA.NET combine materials research with industrial needs by stimulating new products and production processes, and by developing synergies that can be very effective in achieving industrial symbiosis, in particular with the aim of preventing by-products from becoming waste.

M-ERA.NET started in 2012 under the seventh framework programme with 37 partners from 25 European countries. It continued as M-ERA.NET 2 from 2016 to 2022 with 43 partners from 29 countries and is now running in its third phase as M-ERA.NET 3 until 2026 under the Horizon 2020 ERA-NET COFUND scheme with currently 50 public funding organisations from 36 countries.

2.1.3 Graphene Flagship

Funded with a budget of €1 billion by the European Commission, the Graphene Flagship aims to secure a major role for Europe in the ongoing technological revolution, helping to bring graphene innovation out of the lab and into commercial applications. Implemented through a combined academic-industrial consortium, the research effort covers the entire value chain, from materials production to components and system integration, and targets a number of specific goals that exploit the unique properties of graphene.

2.2 MANUFACTURING TECHNOLOGIES

The main European level initiatives supporting Manufacturing Technologies include Made in Europe, ERA-NET on manufacturing (MANUNET), EIT Manufacturing and Manufuture.

2.2.1 Made in Europe

The Made in Europe partnership aims be the voice and driver for sustainable manufacturing in Europe. It plans to boost European manufacturing ecosystems towards global leadership in technology, towards circular industries and flexibility. The Partnership aims to contribute to a competitive, green, digital, resilient and human-centric manufacturing industry in Europe. It will be at the centre of a twin ecological and digital transition, being both a driver and subject to these changes.

The European Factories of the Future Research Association (EFFRA) is a not-for-profit, industry-driven association promoting the development of new and innovative production technologies. It is the official representative of the private side in the Made in Europe partnership under Horizon Europe.

2.2.2 ERA-NET on manufacturing (MANUNET)

MANUNET is an ERA-NET that supports innovation-driven, close-to-market research and development projects in manufacturing. It aims to encourage cross-border value chains that emerge from advancing technologies. Every year for over a decade, MANUNET has run a call for proposals to co-fund manufacturing research projects by preferably SMEs and their strategic partners. Funding is dependent on national and regional programmes.

2.2.3 EIT Manufacturing

EIT Manufacturing is an innovation community within the European Institute of Innovation & Technology (EIT) that connects the leading manufacturing actors in Europe. Supported by a strong interdisciplinary and trusted community of 60 European leading partners from business, education and research from 17 countries, it aims to build a network of ecosystems where people can acquire skills and find opportunities; and where innovators are able to attract investors and access venture capital.

2.2.4 Manufuture

The mission of the European Technology Platform Manufuture is to propose, develop and implement a strategy based on research and innovation, capable of speeding up the rate of industrial transformation to high-added-value products, processes and services, securing high-skills employment and winning a major share of world Manufacturing output in the knowledge-driven economy. ManuFuture National/Regional Technological Platforms have been established in EU member states to implement the main strategic and development goals defined by the European Technology Platform.

2.3 CLEAN INDUSTRIES AND CIRCULAR INDUSTRIES

The main European level initiatives supporting Clean Industries and Circular Industries include Processes4Planet (P4Planet), European Raw Materials Alliance (ERMA), BATT4EU, Circular Plastics Alliance (CPA), Clean Hydrogen Alliance (ECH2A), Clean Energy Transition Partnership (CETP), Clean Steel Partnership (CSP), Sustainable Chemistry (SusChem), European Innovation Partnership on Raw Materials (EIP RM), and ERA-NET on Raw Materials for Sustainable Development and Circular Economy (ERA-MIN).

2.3.1 Processes4Planet (P4Planet)

The Processes4Planet (P4Planet) partnership is about transforming European process industries to make them circular and reach overall climate neutrality at EU level by 2050, while enhancing their global competitiveness. The P4Planet partnership aims to achieve three general objectives:

- Develop and deploy climate neutral solutions.
- Close the energy and feedstock loops.
- Achieve a global leadership in climate neutral and circular solutions, accelerate innovation and unlock public and private investment.

The P4Planet partnership builds on the results of the previous European partnership, A.SPIRE.

2.3.2 European Raw Materials Alliance (ERMA)

The European Raw Materials Alliance (ERMA) was announced in September 2020, as part of an Action Plan on Critical Raw Materials, and the publication of the 2020 List of Critical Raw Materials. The Action Plan looks at the current and future challenges and proposes actions to reduce Europe's raw materials' dependency on third countries, diversifying supply from both primary and secondary sources and improving resource efficiency and circularity while promoting responsible sourcing worldwide.

ERMA's vision is to secure access to critical and strategic raw materials, advanced materials, and processing know-how for EU Industrial Ecosystems. The alliance will involve all relevant stakeholders, including industrial actors along the value chain, Member States and regions, trade unions, civil society, research and technology organisations, investors and NGOs.

2.3.3 BATT4EU

BATT4EU is a European Partnership established under Horizon Europe that aims to achieve a competitive and sustainable European industrial value-chain for e-mobility and stationary applications. It is a contractual public-private Partnership gathering – on the public side – the European Commission; and – on the private side – Batteries European Partnership Association (BEPA), which regroups all the battery stakeholders from the European Research community.

BATT4EU's vision is to establish by 2030 in Europe the best in the world innovation ecosystem to boost a competitive, sustainable and circular European battery value chain and to drive the transformation towards a carbon-neutral society.

2.3.4 Circular Plastics Alliance (CPA)

The Circular Plastics Alliance aims to boost the EU market for recycled plastics to 10 million tonnes by 2025. The alliance covers the full plastics value chains and includes 282 organisations representing industry, academia and public authorities. New stakeholders can join the alliance by signing its declaration. The Circular Plastics Alliance is an initiative under the European Strategy for Plastics (2018).

2.3.5 Clean Hydrogen Alliance (ECH2A)

The European Clean Hydrogen Alliance aims at an ambitious deployment of hydrogen technologies by 2030, bringing together renewable and low-carbon hydrogen production, demand in industry, mobility and other sectors, and hydrogen transmission and distribution. With the alliance, the EU wants to build its global leadership in this domain, to support the EU's commitment to reach carbon neutrality by 2050.

2.3.6 Clean Energy Transition Partnership (CETP)

The Clean Energy Transition Partnership (CETP) is a multilateral and strategic partnership of national and regional research and innovation programmes in European Member States and Associated Countries with the aim to contribute substantially to the implementation of the European Strategic Energy Technology Plan (SET Plan). It aims to deliver to higher level European policy goals towards Stepping up EU 2030 Climate Ambitions with the ultimate objective to achieve a climate-neutral society by 2050.

2.3.7 Clean Steel Partnership (CSP)

The Clean Steel Partnership (CSP) brings together all the major stakeholders in the European steel industry. Their membership includes major steel manufacturers; universities and research institutions active in steel research; major users of steel such as car manufacturers; and public bodies like the European Commission and national governments. CSP's mission is to engage in collaborative EU actions and projects on technology to tackle EU challenges - notably on renewable energy, climate change (low-carbon emission), circular economy - in order to create a sustainable EU steel industry.

2.3.8 Sustainable Chemistry (SusChem)

SusChem is the European Technology Platform for Sustainable Chemistry. It is a forum that brings together industry, academia, policy makers and the wider society. SusChem's vision is for a competitive and innovative Europe where sustainable chemistry and biotechnology together provide solutions for future generations. SusChem's mission is to initiate and inspire European chemical and biochemical innovation to respond effectively to societal's challenges by providing sustainable solutions.

2.3.9 European Innovation Partnership on Raw Materials (EIP RM)

The European innovation partnership on raw materials (EIP RM) is a stakeholder platform that brings together representatives from industry, public services, academia and NGOs. Its mission is to provide high-level guidance to the European Commission, EU countries and private actors on innovative approaches to the challenges related to raw materials.

EIP RM's aim is to help raise industry's contribution to the EU GDP to around 20% by 2020. It targets non-energy, non-agricultural raw materials. Many of these are vital inputs for innovative technologies and offer

environmentally-friendly, clean-technology applications, such as batteries for electric cars, photovoltaic systems and devices for wind turbines.

2.3.10 ERA-NET on Raw Materials for Sustainable Development and Circular Economy (ERA-MIN)

ERA-MIN is a global, innovative and flexible pan-European network of research funding organisations, supported by the EU's Horizon 2020, that counts now with its third edition, ERA-MIN3 (2020-2025). ERA-MIN3 aims to improve synergy, coordination and coherence between regional, national and EU funding in the raw materials sector by reducing fragmentation of raw materials funding across Europe and globally, as well as, improving the use of human and financial resources, the competitiveness and the environmental, social, health and safety issues of raw materials operations through supporting of transnational, excellent and translational R&I activities.

3. NMP DOMAINS

NMP covers a wide range of scientific domains. To help talented newcomers from underrepresented regions, it is necessary to define NMP domains and subdomains where Europe's leading research and innovation organisations can be categorised and more easily found.

As mentioned in the report introduction, there has been a reorganisation of NMP research with the transition from Horizon 2020 to Horizon Europe. NMP research has been absorbed into Cluster 4 "Digital, Industry and Space" of Horizon Europe Pillar 2. Among the eleven research and innovation priorities of Cluster 4, four priorities arguably relate closest to Horizon 2020 NMBP: Advanced Materials; Manufacturing Technologies; Circular Industries; and Low-Carbon and Clean Industries.

To reflect NMP research's new position in Horizon Europe and to further simplify matters, FIT-4-NMP uses the following categories of NMP domains: Advanced Materials; Manufacturing Technologies; Circular Industries and Clean Industries. Next, to define NMP subdomains, FIT-4-NMP has examined and aligned with the strategic research and innovation priorities of European level initiatives that play such an influential role in defining the NMP related call topics in Cluster 4 of Horizon Europe.

The links between NMP domains, NMP subdomains and related European level initiatives are captured in the table below.

NMP Domains	Advanced Materials	Manufacturing Technologies	Clean Industries and Circular Industries
NMP Subdomains	• Material Modelling and Simulation • Material Surfaces, Coatings and Interfaces • High Performance Composites • Functional Materials • Graphene • Materials for Additive Manufacturing • Materials for Healthcare • Materials for Energy • Materials for Transport	• Smart factories & supply chains • New integrated business, product-service and production approaches • Human-centered and human-driven manufacturing innovation	• Sustainable process industry • Sustainable raw materials • Electric batteries • Clean hydrogen • Clean energy transition • Clean/low carbon steel
Related European Level Initiatives	• Advanced Engineering Materials and Technologies (EuMaT) • ERA-NET on materials and battery technologies (M.ERA-NET) • Graphene Flagship	• Made in Europe (formerly EFFRA) • ERA-NET on manufacturing (MANUNET) • EIT Manufacturing • MANUFUTURE	• Processes4Planet (P4Planet) • European Raw Materials Alliance (ERMA) • Batteries European Partnership Association (BEPA) • Circular Plastics Alliance (CPA) • Clean Hydrogen Alliance (ECH2A) • Clean Energy Transition Partnership (CETP) • Clean Steel Partnership (CSP) • Sustainable Chemistry (SUSCHEM) • ERA-NET on Raw Materials (ERA-MIN)

In the following sections, the NMP subdomains are described for Advanced Materials; Manufacturing Technologies; and Clean Industries and Circular Industries.

3.1 ADVANCED MATERIALS

New material development has been historically closely-linked to significant industrial and societal advances and remains a key technology for responding to virtually every global challenge. Notably, material science and technology are considered by the European Commission as essential aspects of the "European Green Deal", because they can help to address the challenges of climate neutrality, transition to a circular economy, and zero pollution.

To reach climate neutrality in Europe, the European Commission encourages disruptive materials science that can provide solutions at the industrial scale, e.g. in the form of catalytic systems that will overcome challenges in current renewable energy systems (generation, conversion and storage). Such new production concepts will combine high efficiency with changing and more variable feedstock (CO2 and waste) and as such will support the decarbonisation of energy and the material needs of EU industries.

Energy efficiency is also a contributor to climate neutrality and therefore lightweight, functional and smart materials are of importance. In addition, materials that are capable to mimic biological functions will be desirable for a wide range of commercial product applications.

Developing new sustainable materials will further reduce Europe's dependency on critical raw materials, and research and innovation on the circularity of materials and recycling systems will contribute to achieve this goal.

The development of advanced materials for innovative medical products and devices directly contributes to the well-being of European citizens. In addition, advanced materials will provide solutions for challenges related to health, fire performance and sustainability of building materials contributing to the safety of Europe's citizens.

The materials development cycle is long and entails several steps such as characterisation, modelling, processing, upscaling and engineering, including a lengthy assessment in industrial environments. To enable uptake by industry, especially SMEs and start-ups, there is a need for an innovation ecosystem of materials technology infrastructures, including open innovation testbeds and pilot lines.

Furthermore, the European Commission recognises that regulation, corresponding testing methodologies and risk assessment standards must be improved and updated to keep pace with innovation as well as conform to the circular economy.

In the following sections, the NMP subdomains for Advanced Materials are described taking account of the strategic research and innovation priorities of the European level initiatives listed in Section 2.1.

3.1.1 Material Modelling and Simulation

Modelling and simulation of advanced materials encompasses new research on novel modelling strategies and/or simulation tools that help to establish the processing-structure-properties link in materials from atomic to macroscale. In particular, this includes research that:

- Addresses innovative theoretical or computational studies of material structure and behaviour, examining materials evolution at the electronic-, atomic- and meso-scale, in relation to mechanical, chemical, electronic, optical, biological or biomedical properties.
- Develops innovative multiscale modelling strategies (atomistic-continuum, transition state theory, homogenization, etc).
- Applies machine learning, learning systems, and data-driven tools for microstructural analysis, processing and properties simulation and materials discovery.
- Uses new software-enabled methods, analysis tools, cyber-infrastructure, high-throughput computational strategies for materials characterisation, discovery and design.

Moreover, these modelling and simulation methods are applied to a broad range of domains including:

- Interfaces, coatings and surfaces,
- Fracture, tribology, corrosion and fatigue phenomena,
- Materials under extreme conditions,
- High performance composites,
- Light-weight materials,
- Materials modelling health monitoring through sensors,
- Functional materials and meta-materials,
- 3D printing and additive manufacturing, for simulation of the physical processes and study of the resulting microstructure,
- Soft and biomaterials, including living materials,
- Batteries (Li, Na, redox flow, others),
- Other energy or low carbon materials: e.g. photovoltaics, fuel cells, hydrogen storage, thermoelectricity.

Currently, only a small proportion of materials are designed by modelling and computational methods. To encourage broader adoption of computational materials design by industry, Open Source models and material databases need to become more widely available and accessible. In turn, this would stimulate reliable and cheap material modelling for new processes, components and systems.

3.1.2 Material Surfaces, Coatings and Interfaces

Research into surfaces, coatings and interfaces deals with modifying the surface properties of materials to protect them from demanding contact conditions or aggressive environments, or for enhanced functional performance. This field of research ranges from the fundamental in nature through to the direct application of metallic, inorganic, organic and composite coatings. Nevertheless, the research can be categorised between *processes* and *properties/performance*:

- Processes: Physical and chemical vapour deposition techniques, thermal and plasma spraying, surface modification by directed energy techniques such as ion, electron and laser beams, thermo-chemical treatment, wet chemical and electrochemical processes such as plating, sol-gel coating, anodization, and plasma electrolytic oxidation.
- Properties/performance: friction performance, wear resistance (e.g., abrasion, erosion and fretting), corrosion and oxidation resistance, thermal protection, diffusion resistance, hydrophilicity/hydrophobicity, and properties relevant to smart materials behaviour and enhanced multifunctional performance for environmental, energy and medical applications.

Surface and coating technology is a key enabler for new solutions across many industrial sectors: automotive, aerospace, power, electronic, biomedical, textile, petroleum, petrochemical, chemical, steel, cement, machine tools and construction. Recent examples include:

- Development of long-time stable antipathogen coatings for biomedical implants.
- Development of environmental-friendly electrodes for Li-ion battery cells.

3.1.3 High Performance Composites

Composites are engineered materials and coatings - including hybrids - composed of two or more constituents. For example, a polymer or metallic matrix reinforced by a fibre, particle, container or filler that meets requirements that cannot be fulfilled by one component alone. The matrix, fibres, particles and fillers can be from mineral, synthetic or biological sources. Fibres, particles, containers, and fillers can be on the nanoscale.

High performance composites are designed to have functional properties for specific engineering applications such as transportation, construction, packaging and energy. Typically, they combine two or more of the following properties:

- High strength and stiffness to weight-ratio.
- Durability (e.g., good resistance to creep, fatigue and humidity)
- Tailored thermal or electrical properties.
- Self-healing functionalities
- Electronic and/or ionic conductivity.
- Electrochemical energy storage properties.
- Biocompatible or anti-microbial properties.
- Biodegradable and compostable properties.
- Recyclability/Reuse for circular economy.
- Fire retardant properties with environmentally friendly substances.
- Resistant to aggressive environments.

Recent research on composites has focused on the following material design, manufacturing and recycling issues:

- Molecular design, functionalisation and characterisation for improved reinforcement/matrix interaction.
- Development of new bio-based resins and/or bio-based fibres or fillers, and their composites.
- Materials use optimization. Use of recycled materials to develop composites.
- Methodology and validation tools for design-optimisation.
- Determination of long-term properties (e.g., creep, fatigue and ageing).
- Retaining economic value and energy of materials as long as possible to promote the circular economy.
- Scalable and rapid manufacturing techniques, such as fast curing, low viscosity resins, thermoforming, and roll-to-roll processing, among others.
- Automation, robotisation and cost-efficient manufacturing techniques.
- Composites suitable for various processing techniques.
- Functional (bio)polymers in energy and environment applications.
- Fibre-based battery materials

- Joining, assembly and repair, including solutions for optimising the interface between dissimilar materials.

3.1.4 Functional Materials

Functional materials are materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli (temperature, electric/magnetic field, etc.) and are therefore applied in a broad range of high-performance technological devices such as memories, displays and telecommunication.

European product innovation relies strongly on a deep theoretical knowledge of functional materials and more efficient technologies with new physical properties and performance. Unsurprisingly, functional materials are an important economic and employment generator in Europe.

Research into functional materials covers a broad range of areas and applications:

- Materials for sensing and actuation: smart materials, stretchable materials and metamaterials with controlled electrical, magnetic, thermal, optical, and mechanical properties, photonic materials, where possible enabling low power or autonomous device/systems.
- Materials for smart and zero-energy buildings: thermal insulation materials and efficient heat radiation solutions, smart windows.
- Electrochemical energy conversion: new materials for supercapacitors, fuel cells, electrolysers and photo catalysis.
- Membranes for energy efficient separation and process intensification
- Next generation materials for batteries: solid state batteries, and materials and systems enabling high-power and/or high-energy, long-cycle-life operation, recyclable and biodegradable battery materials, bio-sourced materials, materials for flexible batteries, materials for structural batteries.
- Dynamic, self-healing smart materials to enable longer service lifetime like detecting defective components and local spots to be repaired in batteries and triggering self-healing processes.
- Waste-energy harvesting materials and solutions: new energy harvesting materials based on advanced thermoelectric, caloric, piezoelectric, phase change, triboelectric and others. New designs and architectures for increased energy efficiency.
- Photovoltaics: new concepts and architectures for efficient solar cells, novel solar cell materials.
- “Soft chemistry” and other low energy materials synthesis routes.

3.1.5 Graphene

Graphene is the world's thinnest material – it is only one atom thick, one million times thinner than a human hair. However, it is extremely strong: stronger than steel and diamond. This makes it attractive to use in composite materials for applications requiring outstanding stiffness and durability. However, graphene is also very flexible, which opens the door to its application to wearable devices and foldable electronics. Furthermore, graphene is a great conductor of electricity and heat. Some producers have exploited these two principles to make conductive inks and paints for electronic circuits and gels that dissipate heat. Since graphene is light, the automotive and aviation industries are eager to investigate uses of graphene to make cars and planes less heavy and thereby reduce fuel consumption and carbon emissions. Since being first isolated in 2004, graphene has found used in hundreds of innovative applications: from sensors and electronics to energy storage and healthcare.

European research into graphene has been coordinated since 2013 by the Graphene Flagship according to the following divisions.

Enabling Science & Materials

- Exploratory studies of graphene and layered materials leading to new concepts and applications.
- Exploring graphene's potential in spintronics applications for data transfer, processing and storage.
- Developing scalable synthesis methods for graphene and layered materials.

Health, Medicine & Sensors

- Profiling graphene's biosafety and setting standards for its safe use in research and industry.
- Designing graphene-enabled technology for diagnosis, medical monitoring and treatment.
- Using graphene and layered materials to develop and improve physical and biological sensing devices.

Electronics & Photonics Integration

- Fabricating and developing circuits and devices for the future of electronics.
- Using graphene and related materials to develop photonic and optoelectronic components and integrated systems.
- Sustainable development of electronic circuits on flexible, stretchable or conformable substrates.
- Integrating graphene into silicon wafer manufacturing processes.

Energy, Composites & Production

- Developing industrially competitive photovoltaic panels and hydrogen fuel cells.
- Developing batteries and supercapacitors based on graphene and layered materials.
- Developing new foams and coatings for environmental remediation.
- Developing new composites for industrial applications based on commercial demand.
- Producing new materials for aerospace, fire protection, corrosion prevention and more.

3.1.6 Materials for Additive Manufacturing

Additive Manufacturing (AM) comprises of disruptive processes to directly build 3D parts and components based on a digital model by successively adding material. It strives to produce finished components with improved performance together with reduced overall costs, energy consumption and longer lifespans as compared to the state-of-the-art. Thanks to its material efficiency and almost limitless design freedom, AM is a rapidly developing industrial field. However, the full commercial exploitation of AM is being held back due to the limited availability of feedstock as well as the lack of standards and in-process quality certification.

AM research spans the development of AM materials (e.g. metals, ceramics, polymers, composites and multi-materials) through to AM processes (e.g. modifying composition, micro-structure, morphology and powder size distribution), in order to improve or modify the properties of manufactured products. Lately, European research has focused on the following areas:

- Modelling of materials and processes (including microstructures), mechanical and corrosion properties, surface finishing, internal stress and warpage reduction, electrical and thermal conductivity;
- Development of materials and processes designed to improve mechanical performance and quality of AM parts and enhance the process productivity;

- Development of novel materials and processes to enable innovative applications for AM parts (e.g. batteries, implants), which could include multifunctional, hierarchically structured or composite materials;
- New strategies to improve the quality of the parts by including instrumentation, process monitoring, post-processing, collecting material data, modelling, simulation and setting up a digital twin;
- Improvement of lifespan of products by repair or remanufacturing with different AM technologies;
- New technologies for reconditioning of feedstock material for re-use;
- New feedstock materials (e.g. powder, slurry, wire, filament) for decreasing the dependency on critical raw materials;
- New feedstock materials using waste from other processes;
- New materials for parts with complex geometry or for lightweight structures in demanding high-quality applications, e.g. aerospace or medical.

3.1.7 Materials for Healthcare

New and advanced materials and coatings play a key enabling role towards the development of innovative diagnostics, clinical treatments, surgical treatments, and therapeutics. Example applications include prosthesis, medical devices, drug delivery systems, implants, regenerative and reparative medicine, cell and gene therapies, and real-time monitoring in vivo sensors. Biocompatibility is a vital issue as the materials and coatings may come into contact with the human body on different levels.

Research on materials for healthcare is interdisciplinary by nature and thus attracts cross-collaboration between material scientists, engineers, biologists, clinicians, immunologists, regulatory scientists, toxicologists, social scientists and industrial partners. Currently, European funding for research on materials for healthcare has prioritised the following areas:

- Scaffolds to replace, restore and regenerate physiological functions, tissues and organs.
- Materials and coatings with functionalised, adaptable or stimuli-responsive elements, hierarchical structures to modulate 3D cell growth and structural or topographic modifications to direct specific cell responses.
- Interactions between newly developed materials or coatings and the biological environment/surrounding tissues.
- Evolution of the mechanical, physical, and chemical properties of the materials and coatings.
- Biodegradation, biological performances, toxicity, and inflammatory/immune response over the short, medium and long term.

3.1.8 Materials for Energy

Innovative materials are required to enable the sustainable production of renewable electricity (e.g. biomass combustion), the introduction of a new generation of nuclear energy plants, the efficient storage of energy (e.g. fuel cells), and the increased energy efficiency of new construction and existing building stock (e.g. enabling energy neutral buildings). Depending on the application, the materials research can involve investigating ferritic and austenitic steels, Ni-based superalloys, Ti-based alloys, ceramics and/or ceramic matrix composites.

Recent research priorities for materials for energy have included:

- Modelling of high-temperature microstructure degradation processes and surface protection against steam oxidation,
- Simulation of manufacturing processes for large components to ensure optimal properties during scale up from laboratory samples to industrial use,
- Development of structural and functional materials for low carbon energy technologies, e.g. for dispatchable thermal power or non-dispatchable wind and solar to give improved performance and durability,
- Development of improved insulation materials and high efficiency lighting systems for energy efficient buildings;
- Creation of phase change materials providing thermal inertia,
- Development of advanced materials photovoltaic systems, wind turbines, and new piezoelectric polymers to produce power from vibrations and heat.

3.1.9 Materials for Transport

Materials research for transport is primarily oriented towards automotive and aerospace applications. It entails the modelling, characterisation and development of new structural and functional materials based upon advanced ferrous metals, non-ferrous metals, ceramics, polymers, composites, functionally graded materials and/or hybrid materials. Typically, the research focuses on improving material properties such as weight; strength; temperature resistance; damage tolerance; wear, corrosion and oxidation resistance. An example is the development of high-strength special steels for the automotive sector to meet the EU's latest crashworthiness and fuel-consumption targets. Alternatively, the material research may be for the development of improved catalyst technologies and alternative fuels for transportation.

3.2 MANUFACTURING TECHNOLOGIES

The European Commission regards innovative manufacturing technologies as a strategic means for increasing enhancing job quality, productivity and reducing environmental footprints in Europe by:

- Expanding the creation of new, value-added job creation through technology-driven innovations in design, engineering, logistics and end-of-life management; innovative business approaches, such as customisation and product-service systems; and applications of emerging technologies such as AI and human-robot collaboration that provide the basis for improving the quality of jobs.
- Strengthening and creating value chains based on digital industrial platforms, benefitting the production sectors from automotive and aerospace to health and food processing.
- Capitalising on the digital transformation to raise productivity and realise shorter innovation cycles, new business models, urban and distributed manufacturing, higher quality products and enhanced workplace skillsets.
- More circular economy, with products reused in new value chains through "zero-waste" manufacturing, de-and re-manufacturing, including smart recycling, re-use of raw materials, repair and refurbishment.

In the following sections, the NMP subdomains for Manufacturing Technologies are described, which are directly aligned the strategic priorities of the European Partnership Made in Europe.

3.2.1 Smart factories & supply chains

Contributing to more efficient, responsive and smart factories and supply chains is a specific objective of the strategic research and innovation agenda of the Made in Europe Partnership under Horizon Europe. Manufacturing companies need to produce from very small lot-sizes to big volumes and there is a growing need for the ability to quickly scale up from small to big lot-sizes whilst retaining the required quality in zero-defect and first-time-right production. Thus, the research and innovation priorities – and their technology enablers - for this specific objective are defined as follows:

Research and innovation priorities	Technology enablers
1. Zero-defect and zero-down-time high precision manufacturing, including predictive quality and non-destructive inspection methods.	• Advanced and smart material processing technologies and process chains. • Smart mechatronic systems, devices, and components. • Data analytics, including artificial intelligence and deployment of digital platforms for data management and sharing (data integration). • Migration approaches from as-is situation towards innovative solutions. • Simulation and modelling (digital twins) covering the material processing level up to manufacturing system and, factory level. • Innovative sensors, sensor materials and innovative inception methods (machine vision in combination with AI). • In-situ online inspection.
2. Manufacturing for miniaturisation and functional integration.	• New and improved micro- and nanomanufacturing processes which are precise, repeatable, fast and easy to be scaled up. • Further integration of physical processes with digital technologies in-situ inspection methods.

3. Scalable, reconfigurable and flexible first-time-right manufacturing.	• Intelligent and autonomous handling and robotics, assembly and logistic technologies. • Smart mechatronic systems, devices and components. • Advanced and smart material processing technologies and process chains. • Simulation and modelling (digital twins) covering the material processing level up to manufacturing system level (also supporting virtual commissioning), including hybrid models: scientific knowledge (physical laws) and contextual data and knowledge (AI). • Robust and secure industrial real-time communication technologies, and distributed control architectures. • Interoperability, architectures (OPC-UA, etc). • In-situ, real-time process monitoring. • Data acquisition, cleaning analytics, artificial intelligence, and deployment of digital platforms for data management and sharing, on edge and on cloud, aiming at high predictability, repeatability. • Migration approaches focusing on technological issues.
4. Artificial intelligence for productive, excellent, robust and agile manufacturing chains.	• Data acquisition, cleaning, data analytics, including AI, both on edge and cloud, and deployment of digital platforms for data management and sharing. • AI in industry requires the capability to work with rather small data sets, using context knowledge and transfer learning. • Use of AI in real processes will have to meet the highest standards with regards to safety, reliability, quality and precision. AI algorithm robustness, as a combination of explainability and repeatability, is one of the main challenges. • Simulation and modelling (digital twins) covering the material processing level up to manufacturing system level (also supporting virtual commissioning), including hybrid models: scientific knowledge (physical laws) and contextual data and knowledge (AI). • Advanced and smart material processing technologies and process chains. • Smart mechatronic systems, devices, and components. • Robust and secure industrial real-time communication technologies. • Migration approaches from as-is situation towards innovative solutions.
5. Advanced manufacturing processes for smart and complex products.	• Advanced and smart material processing technologies and process chains. • Application of functional printing to manufacture the products of the future, including in-mold electronics and printed electronics (e.g. 3D printed, screen printed, etc) as a mechanism of adding value to the mechanical components. • Material identification/characterisation and processing technologies (additive manufacturing, structuring, joining, shaping and functional materials). • Nano- and micro-manufacturing (miniaturisation, sensors materials, functional surfaces). • New, emerging and converging of technologies (biohybrid etc.). • Intelligent and autonomous handling and robotics, assembly and logistic technologies.
6. Data 'highways' and data spaces in support of smart factories in dynamic value networks.	• Robust and secure industrial real-time communication technologies. • Data analytics, artificial intelligence, and deployment of digital platforms for data management and sharing. • Migration approaches from as-is situation towards innovative solutions.

3.2.2 New integrated business, product-service and production approaches

Coupling more tightly the design, manufacturing and configuration of products with the services that are associated with these products is another of the specific objectives of the strategic research and innovation agenda of the Made in Europe Partnership. This is because the service component of the revenues generated by products - in particular B2B products - continues to increase. Consequently, the research and innovation priorities – and their technology enablers - for this specific objective are defined as follows:

Research and innovation priorities	Technology enablers
1. Collaborative product-service engineering for costumer driven manufacturing value networks.	• Simulation and modelling (digital twins) covering the material processing level up to manufacturing system, factory and value network level. • Advanced and smart material processing technologies and process chains. • Smart mechatronic systems, devices and components. • New business and organisational approaches, including links with regulatory aspects such as data ownership, liability, and safety. • Robust and secure industrial communication technologies. • Data analytics, artificial intelligence, and deployment of digital platforms for data management and sharing. • Migration approaches from as-is situation towards innovative solutions.
2. Manufacturing processes and approaches near to customers or consumers (including urban manufacturing).	• Advanced and smart material processing technologies and process chains (additive, joining, assembly, shaping, structuring, surface tailoring, etc.). • New business and new organisational approaches (in particular metrics or Key Performance Indicators).
3. Transparency, trust and data integrity along the product and manufacturing life-cycle.	• Robust and secure industrial real-time communication technologies, and distributed control architectures. • New business and new organisational approaches, including links with regulatory aspects such as data ownership, liability, and safety. • Interoperability. • Data integration, data governance. • Digital platforms. • Identifying appropriate metrics and parameters which allow understanding and optimization between sectors, disciplines and along the life-cycle. • Community building, cross-sector collaboration. • Migration approaches from as-is situation towards innovative solutions.
4. Secure communication and IP management for smart factories in dynamic value networks.	• Robust and secure industrial real-time communication technologies, and distributed control architectures. • New business and new organisational approaches; including links with regulatory aspects such as data ownership, liability, and safety. • Migration approaches from as-is situation towards innovative solutions.

3.2.3 High Performance Composites

Humans are at the core of the innovation process, increasingly supported by data analytics and decision support systems. Innovation is a process where different processes and disciplines (technological and non-

technological) converge into concrete solutions and implementations. This explains why another of the specific objectives in the strategic research and innovation agenda of the Made in Europe Partnership is to develop new approaches and tools that strengthen the capability of industrial actors to draw value from external sources of creativity, including start-up companies. The objective is implemented through the following research and innovation priorities and their associated technology enablers:

Research and innovation priorities	Technology enablers
1. Digital platforms and engineering tools supporting creativity and productivity of research & development processes.	• Delivering integrated, easy-to-use tools and more efficient testing and validation methods. • Simulation and modelling (digital twins) covering the material processing level up to the manufacturing system, factory, and value network level. • Low barrier, cost efficient tool for Data acquisition, data analytics, artificial intelligence, and the deployment of digital platforms for data management and sharing. • New business and organisational approaches, including links with regulatory aspects such as data ownership, liability, and safety.
2. Improving human device interaction using augmented and virtual reality and digital twins.	• Simulation and modelling (digital twins) covering the material processing level up to the manufacturing system and factory level. • Migration approaches from as-is situation towards innovative solutions.
3. Human & technology complementarity and excellence in manufacturing.	• Smart mechatronic systems, devices and components. • Intelligent and autonomous handling and robotics, assembly and logistic technologies (including Assistive technologies). • Simulation and modelling (digital twins) covering the material processing level up to manufacturing system, factory, and value network level.
4. Manufacturing Innovation and change management.	• Migration approaches from as-is situation towards innovative solutions (blending social innovation with technological innovation).
5. Technology validation and migration paths towards full industrial deployment of advanced manufacturing technologies by SMEs.	• Migration approaches from as-is situation towards innovative solutions. • Low-barrier, low cost, high productivity solutions. • Improving instruments and tools for digital investment decisions.

3.3 CLEAN INDUSTRIES AND CIRCULAR INDUSTRIES

Energy-intensive industries have a central role in European industrial value chains. Heavily reliant on energy and non-energy raw materials, the European Commission wants to transform industrial plants by 2030 so that they produce sustainably with zero greenhouses gas and polluting emissions and zero waste, while being globally competitive.

Such deep decarbonisation will require breakthrough technologies in all major emitting industrial sectors in terms of the underlying production processes (e.g. for steel, cement and chemicals); substitutes for carbon-intensive products; and decarbonised energy and feedstock. The essential technologies include process and heat electrification, switch to decarbonised energy and feedstock, usage of hydrogen, CO2 capture and usage, catalysis and artificial photosynthesis, waste heat recovery, and materials for re-use and recycling.

In a circular economy, the value of products, materials and resources is maintained for as long as possible and waste is minimised. The European Commission's Circular Economy Action Plan includes a wide range of initiatives for a sustainable, low-carbon, resource efficient and competitive economy. Notably, the plan recommends measures to tackle:

- Design of circularity enabled products, implementation of circular supply chains and systematic cradle-to-cradle life cycle assessment both for new and existing products;
- Product life extension through predictive maintenance, repair, re-use, and refurbishment leading to value loops at European scale;
- Advanced solutions and conditions for the sustainable exploration, extraction and processing of raw materials; and also their substitution, recycling and recovery in industrial symbiosis settings;
- New automated technologies to sort, dismantle and remanufacture or recycle products; and efficient processes to handle mixed waste sources;
- Digital and industrial technologies like robotics, artificial intelligence, and digital platforms for energy-intensive industries leading e.g. to fully fledged cognitive plants.

In the following sections, the NMP subdomains for Clean Industries and Circular Industries are described taking account of the strategic research and innovation priorities of the European level initiatives listed in Section 2.3.

3.3.1 Sustainable raw materials

Since 2011 European research into raw materials for sustainable development and the circular economy has been coordinated by ERA-MIN, a pan-European network of research funding organisations. In its most recent calls for proposals, the network has prioritised research in the following topics:

Topic 1. Supply of raw materials from exploration and mining
The availability of primary resources and waste from exploration and mining activities remains a major prerequisite to satisfy the growing global demand for raw materials. Consequently, exploration and mining will not disappear in a circular economy and so it is vital to increase efficiency in the supply of raw materials while reducing impacts on the environment.

Within this topic, new techniques and knowledge is sought for the improved exploration, assessment and extraction of primary and secondary resources from onshore and offshore sites. Specifically, the research is focused on new concepts, technologies and improved models to be used in mineral exploration (e.g. geophysical and geochemical techniques), upgrading geological knowledge and databases on the evolution of the lithosphere, especially in Europe.

Topic 2. Circular Design
This topic is focused on circular product design that contributes to the efficient use of raw materials (eco-design), or the substitution of critical materials in products and components, e.g. innovative materials for green technologies, resistance in extreme conditions, use in bulk applications or in electronic devices.

Research on sustainable use of raw materials through innovative design and production of products and assets will often consider aspects such as increased resource efficiency, durability, functionality, modularity, upgradability, easy disassembly and repair or the use of materials that are reusable or recyclable.

Topic 3. Processing, Production and Remanufacturing
Production efficiency and remanufacturing processes in a circular economy provide a high potential to increase resource efficiency for primary and secondary sources. Thus, research is focused on ways to recycle waste during the production phase so that it becomes a resource. As an alternative to the production of new products, used products can be remanufactured and therefore contribute to a higher efficiency of the raw materials use. Specific related research projects have tackled the following challenges:

- Re-design of complete industrial processes to adapt to a circular economy e.g. remanufactured products.
- Development of metallurgical processes for low-grade or non-conventional ore deposits, bioleaching, advanced purification/extraction processes based on bio-, hydro- or pyro-metallurgy, or a combination of them.
- Reduction of waste and/or recycling of waste, like scraps, ashes, or industrial effluents, for more direct and less energy- and resource consuming processes.
- Environmental impact assessment across the entire product life cycle.

Topic 4. Recycling and Re-use of End-of-Life Products
Recycling of raw materials from complex products is particularly challenging (e.g. electric and electronic equipment, batteries, permanent magnets and complex metal alloys). Thus, the research focus of this topic is on new concepts, technologies and services which increase the supply of raw materials - especially critical raw materials - recovered from products and components at the end of their life. This includes:

- Reusing, repairing, refurbishing, repurposing, remanufacturing and recovery of raw materials for end-of-life or products and immovable assets (e.g. buildings and infrastructures).
- Developing collection and (reverse) logistic methods; efficient and innovative separation, physical sorting and pre-treating techniques; innovative and efficient hydro- and pyro-metallurgical processes for critical raw materials separation and recovery from end-of-life products.
- Developing innovative business models (e.g. product-as-a-service, reuse and sharing models) for used products or products made from recycling material to overcome economic, legal or psychological barriers.

3.3.2 Sustainable process industry

The Processes4Planet (P4Planet) Partnership under Horizon Europe is about transforming European process industries to make them circular and achieve overall climate neutrality at EU level by 2050, while enhancing their global competitiveness. The partnership has defined five specific objectives which determine operational objectives for research and innovation.

Specific objectives	Operational objectives
1. Integrating renewable energy	Develop new electrified processes and enhance energy efficiency, ensuring process flexibility and capturing the full potential of renewable energies. Replace fossil fuels and feedstock by renewable H2 and biomass in processes.
2. Reducing emissions through CO/CO2 capture and use.	Develop new efficient CO/CO2 capture and purification technologies. Develop efficient CO2 valorisation routes to chemicals, fuels and minerals (building materials).
3. Ensure full circularity and overhaul the use of waste.	Design processes for maximum resource efficiency, including the development of materials for circularity. Develop new processes for circularity of secondary materials from wastes/residues for all industrial processes. Develop new processes to ensure full valorisation of wastewater, recycled water, energy and solutes recovery. Seed Hubs for Circularity to foster circularity within and beyond process industries.
4. Moving towards commercially viable climate neutral and circular industry solutions	Drive the Partnership's innovation portfolio up to "First-Of-A-Kind" demonstrators to de-risk investment
5. Fostering new skills & jobs and reducing barriers for market uptake.	Foster new framework conditions to generate a market for climate neutral and circular solutions. Foster new skills and types of jobs and business development, including SMEs, through Processes4Planet programmes and Hubs for Circularity (H4Cs).

3.3.3 Electric batteries

The Batteries European Partnership under Horizon Europe gathers - on the public side - the European Commission and - on the private side - all the interested stakeholders of the European battery community, regrouped in Batteries European Partnership Association (BEPA). The partnership ambition is to prepare and equip Europe to manufacture and commercialise by 2030 the next-generation of battery technologies - through a results-oriented innovation programme - which will enable the rollout of the zero-emission mobility and renewable energy storage.

The partnership has three specific objectives which provide the framework for the partnership's research priorities.

Specific objective 1:
To provide the European industry with differentiating technologies in battery materials, cell design and manufacturing and recycling, supporting the development of an innovative, competitive and sustainable battery manufacturing industry in Europe. Research over the foreseeable future will be focused on the following targets and measurable outcomes.

Detailed targets for Specific objective 1	**Measurable outcomes by 2030**
Raw materials	New methods for sustainable processing of battery-grade primary and secondary raw materials applied in processing facilities.
Advanced materials	New cathode and/or anode materials tested at least in first industrial deployment scale. Disruptive batteries electrolytes or other non-active materials used in large scale manufacturing. High throughput data-driven materials and interfaces development.
Cell design	Enabled smart functionalities for specialised markets and/or on first industrial pilots for mass manufacturing. Reaching maximum efficiencies through alternative design concepts applied in mass manufacturing. Digitalisation of cell design put in place. Advanced and disruptive concepts for high cell performances are fully developed.
Manufacturing processes	Innovative concepts to increase manufacturing efficiencies are applied in mass-scale manufacturing. Environmentally sustainable, fully automated and flexible manufacturing techniques applied in mass-scale manufacturing. Digitalisation and increased use of virtual tools applied in mass-scale manufacturing. New approaches applied to decrease capex and opex for battery manufacturing. Resource-efficient intelligent electrode and cell production machinery applied in mass-scale manufacturing.
Recycling technologies	Best-in-world recycling facilities established in Europe. Recyclability rates maximised and applied in recycling facilities. Methodologies developed and implemented to upgrade recycling/refining facilities to meet waste streams and new recycling methods, e.g. direct recycling. Increased levels and improved purity of secondary raw materials are used in manufacturing. New concepts for automated sorting, dismantling and recycling concepts for high-throughput with variable input of batteries are fully applied in large-scale recycling facilities.

Specific objective 2:
To develop sustainable and affordable battery solutions for clean mobility, including the transport sector. Research over the foreseeable future will be focused on the following targets and measurable outcomes.

Detailed targets for Specific objective 2	**Measurable outcomes by 2030**
Greater usability and guaranteed safety for	Ultra-high performance battery technologies integrated in the modes of transport available on the market (road, rail, air, water)

citizens	Battery technologies compatible with ultra-fast charging infrastructure (in liaison with 2ZERO, Waterborne). Optimised tailored battery systems, including battery management (in liaison with 2ZERO, Waterborne, Clean Aviation, Shift2rail). Comprehensive safety assessment methodologies developed and adopted.
Reduced cost level	New digitalisation and modelling tools fully integrated in testing and validation process of batteries. New digitalisation and modelling tools fully integrated in testing and validation process of batteries.

Specific objective 3:
To enable a cost-effective integration of renewable energy sources in the power grid. Research over the foreseeable future will be focused on the following targets and measurable outcomes.

Detailed targets for Specific objective 3	Measurable outcomes by 2030
Sufficient level of flexibility to the power grid	Scalable stationary batteries for utility-scale applications with multi-service flexibility made available. Significant level of market roll-out of stationary energy storage solutions among industry sector. Affordable stationary batteries for residential applications made available for individuals. Level of market roll-out of stationary energy storage among households. Full economic, technical and environmental assessment of second-life applications through demonstration and LCA. Comprehensive safety assessment methodologies developed and adopted.

3.3.4 Clean hydrogen

Research in this domain is led by the Clean Hydrogen Partnership for Europe. Via the partnership's strategic research and innovation agenda, research is grouped under three main pillars - hydrogen production; hydrogen storage, transport and distribution; and end use – which are described in more detail below:

Pillar 1: Hydrogen production
Most of the hydrogen that is currently being produced in the EU and worldwide is produced from fossil fuels – either by steam reforming of natural gas or gasification of coal. If hydrogen is to realise its potential to be an energy vector in a decarbonised economy, it needs to be produced on a mass scale in a sustainable and cost-competitive way.

European research into hydrogen production is divided between:

- Hydrogen production by water electrolysis: Development of new materials and manufacturing processes to reduce the cost of electrolyser technology (e.g. catalysts and solid oxide electrolysis). Development of electrolysis for large-scale energy storage.
- Other modes of hydrogen production: Development of biomass & waste gasification, biological production from algae and direct solar.

Pillar 2: Hydrogen storage, transport and distribution
By 2030, the Clean Hydrogen Partnership for Europe anticipate that there will be a mix of onsite production (e.g. at industrial sites or power-to-gas sites) and centralized production sites (e.g. located near renewable generation plants or underground storage). Since those locations will not necessarily coincide with demand centres, it is vital to develop ways to transport and distribute hydrogen in a cheap and effective way. Thus, research under this pillar is focused on the

- Large scale hydrogen storage: Development of novel materials and container designs for on-the-ground storage. New designs and infrastructure for underground storage.
- Developing existing hydrogen transport means: Transportation by pipeline, road and ship as well as intermodally.
- Hydrogen in the gas grid: Investigation of blending hydrogen with methane or converting to 100% hydrogen grid.
- Liquid hydrogen carriers: Development of materials and technology for liquefaction (e.g. cryogenic vessels) and development of novel chemistries for liquid carriers.
- Hydrogen compression, metering, purification and separation: Development of novel technologies for compression (including chemical and electrochemical compression). Development of high-purity hydrogen purification and separation methods (e.g. Pt and Pd free solutions).
- Hydrogen refuelling stations (HRS): Development of improved interfacing technology between hydrogen vehicles and HRS. Development of high throughput stations for large scale vehicles.

Pillar 3: End use
On the end use side there are already some hydrogen applications that have already, to some degree, proven to be on the verge of being ready for market deployment. Fuel cell material handling vehicles, fuel cell buses and - to a lesser degree – fuel cell electric vehicle passenger cars, have been successfully developed, demonstrated and deployed with limited subsidies needed. However, a number of technology routes still need further improvements to reduce costs and increase efficiency in order to be competitive with incumbent technologies. Thus, research is being focused on:

- Improvement of main technology building blocks that can be applied across a range of different applications such as fuel cell stacks and hydrogen tanks;
- Adapting fuel cell systems from other vehicles (urban buses / cars) for long distance coaches and heavy-duty vehicles;
- Components for freight and shunting locomotive applications;
- Marinization of fuel cell components;
- Development of tanks and fuel cell technologies specifically adapted for aviation.

3.3.5 Clean energy transition

The European Partnership for Clean Energy Transition under Horizon Europe aims to make Europe a frontrunner in energy innovation and eventually the first climate-neutral continent. The partnership will facility joint R&I programmes from regional to national and global level, co-supported by industry, public organisations, research and citizens' organisations.

The partnership's strategic research and innovation agenda – which will define targets and measurable impacts for clean energy transition to be achieved by 2020 - is currently being prepared. Nevertheless, it is expected it will focus on the following thematic priorities:

- Integrated regional energy systems (including energy communities)
- Storage Solutions
- Innovative renewable energy technologies
    - Bioenergy
    - Concentrated Solar Power/Solar Thermal Electricity
    - Geothermal
    - Ocean
    - Solar Photovoltaics
    - Wind
- Heating and Cooling
- Carbon Capture Use and Storage
- Digital Transformation (cross-cutting area for thematic priorities)
- Inclusive energy transition (cross-cutting area for thematic priorities)

3.3.6 Clean/low carbon steel

The Clean Steel Partnership under Horizon Europe is designed to tackle two major challenges: climate change and sustainable growth for the EU. The partnership aims to facilitate major technological breakthroughs to sufficiently decrease carbon dioxide emissions from the steel sector compared to 1990 levels. To support this, the partnership aims to help remove R&D and systemic bottlenecks, e.g. the transition from the pilot phase to industrial-scale deployment, high technology risks, large capital requirements and higher production costs.

The research and innovation activities of the Clean Steel Partnership are centred around 12 Building Blocks.

Building Block	Research and innovation focus
1. Gas injection technology for clean steel production	New process technologies and control techniques for co-injection and new injection ports, e.g. for blast furnaces, direct reduced iron plants and electric arc furnace.
2. CO2-neutral iron-ore reduction for clean steel production	Metal reduction processes using hydrogen, renewable electricity (including use of plasma technology and electrolytic reduction at low or high temperature), or biomass (including carbonisation and pyrolysis processes, biomass use and biogas injection technology).
3. Melting of pre-reduced and reduced ore, scrap and iron rich low value residues for clean steel production	Low-carbon dioxide emission technologies for melting iron-bringing feed materials with variable content of carbon and variable metallization, including low-value iron-based sources.
4. Adjustment of today's production to prepare for the transition towards climate neutrality	Techniques and tools to support the immediate decrease of the carbon footprint on industrial level, e.g. by the integration of first shares of hydrogen or renewable electricity into already existing industrial plants.
5. CO/CO2 utilisation, CO2 capture and storage in steelmaking	Preparation of the gaseous stream containing CO/CO2 depending on its subsequent use, e.g. cleaning, compressions, drying, sulphur removal,

	separation, conversion, reforming and concentration.
6. Raw material preparation for clean steel production	Technologies for the upgrade and the use of low-quality iron ores as well as technologies for the reduction of impurities in post-consumer scrap.
7. Heat generation for clean steel processes	New materials and combustion processes to enable energy efficiency, energy recovery and energy carriers without fossil carbon.
8. Energy management / Energy vector storage (e.g. H2, electricity, intermediate materials) for clean steel production	Chemical (H2, intermediate materials), electricity and heat storage (e.g., for waste heat recovery from slag) and transportation
9. Steel-specific circular economy solutions	Valorisation of low-quality scrap streams. Improving the yield of the iron and steel making by recovering metal contents from metal oxides. Residue valorisation.
10. Enablers (skills, digitisation) for clean steel development	New digital tools for monitoring and control, e.g. IoT. New measurement techniques covering the new processes, conditions and resources.
11. Low CO2 emissions downstream processes	High efficiency, low emission multi-fuel burners technology. Metallic-bundled heat recuperator technology.
12. Innovative steel applications for low CO2 emissions	Renewable energy generation, light weight mobility, and steel content optimised buildings and infrastructure.

4. NMP TOP INNOVATORS

For each of the NMP subdomains described in Section 3, FIT-4-NMP's experts reviewed carefully the reports and documentation of the relevant European level initiatives described in Section 2. This enabled the experts to define lists of approximately 50-100 scientific and technological keywords and keyword combinations for each NMP subdomain.

Using the keyword lists, searches of the Web of Science database were conducted to identify research publications for each NMP subdomain and the organisations responsible for them. Similarly, searches of the PATSTAT database were made to reveal EPO and PCT patent applications for each NMP subdomain and the organisations behind them. Research publications tend to be produced by public research organisations and universities while patents tend to be filed by private companies. Thus, FIT-4-NMP's database searches of both research publications and patents helped to provide a balanced picture of research and innovation organisations active in the NMP subdomains.

Next, lists were created containing the most prolific publishing and patenting organisations – i.e. top innovators - for each NMP subdomain. Depending on how broad or narrow the NMP subdomain, each list contained between 20-40 organisations with slightly more than half of them being either public research organisations or universities. The lists for the NMP subdomains can be found in Section 4. Annexes.

Using Microsoft Power BI, the geographic locations of the top innovators have been plotted on an interactive map, which is accessible to public users – including talented newcomers - via the FIT-4-NMP website. The interactive map allows a user to choose to view the top innovators from one NMP subdomain or several concurrently, as well as to zoom in on specific countries or regions of Europe. Each top innovator is represented by an orange circle on the map and, when the user hovers the cursor on the circle, the name and address of the top innovator is shown along with a weblink to the organisation's website address and Horizon Europe contact person. The interactive map thereby supports talented newcomers to learn about and contact more easily top innovators who they would like to collaborate with in NMP research for Horizon Europe.

In the pages overleaf, example screenshots of the interactive map are provided for several NMP subdomains and views.

Domain

- 1.7 Materials for Healthcare
- 1.8 Materials for Energy
- 1.9 Materials for Transport
- 2. Manufacturing Technologies
  - 2.1 Smart factories & supply chains
  - 2.2 New integrated business, product-service and production approaches
  - 2.3 Human-centered and human-driven manufacturing innovation
- 3. Clean Industries and Circular Industries
  - 3.1 Sustainable raw materials
  - 3.2 Sustainable process industry
  - 3.3 Electric batteries
  - 3.4 Clean hydrogen
  - 3.5 Clean energy transition
  - 3.5 Clean/low carbon steel

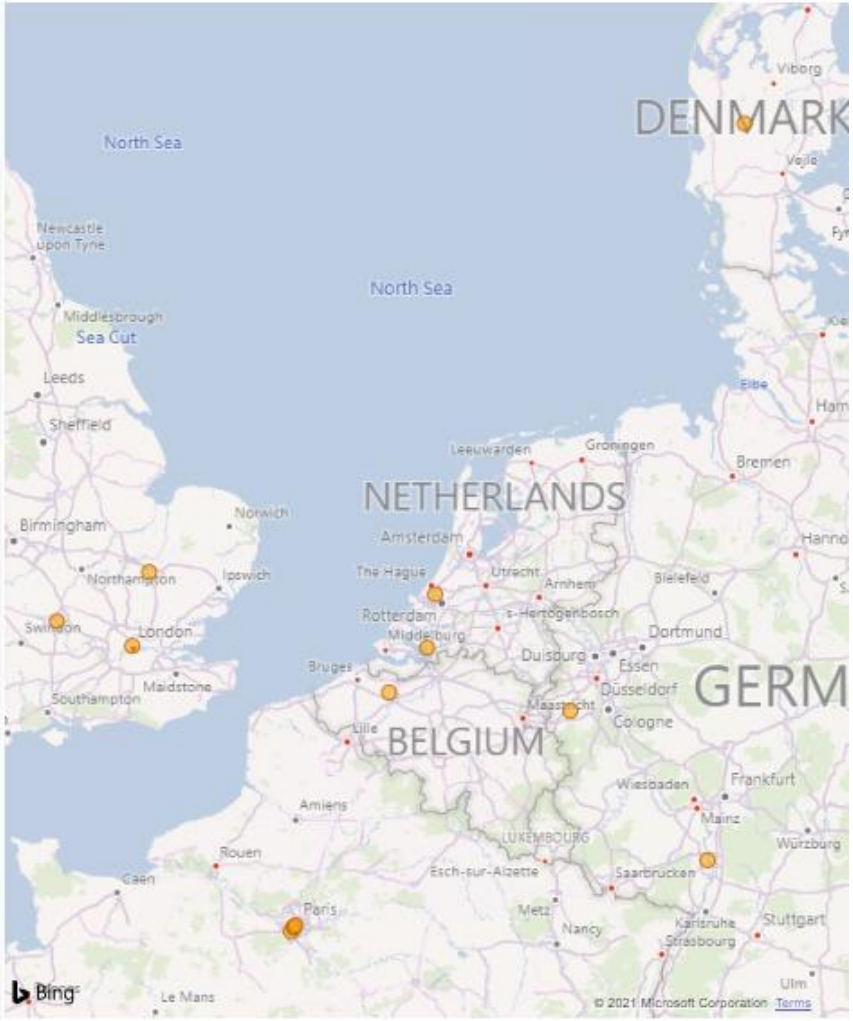
Organisation	City	Country	Web
AALBORG UNIVERSITY	Aalborg East	Denmark	https://www.en.aau.dk
AALTO UNIVERSITY	Espoo	Finland	https://www.aalto.fi
ABB SCHWEIZ AG	Baden	Switzerland	https://new.abb.com/ch
AUDI AG	Ingolstadt	Germany	https://www.audi.com
BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT	Munich	Germany	https://www.bmw.com
BLUE SOLUTIONS	Ergué-Gabéric	France	https://www.blue-solutions.com
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	Paris	France	https://www.cnrs.fr
CHALMERS UNIVERSITY OF TECHNOLOGY	Goteborg	Sweden	https://www.chalmers.se
CNRS INSTITUTE OF CHEMISTRY (INC)	Paris	France	https://inc.cnrs.fr
COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	Paris	France	https://www.cea.fr
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	Madrid	Spain	https://www.csic.es
CONSIGLIO NAZIONALE DELLE RICERCHE CNR	Rome	Italy	https://www.cnr.it

Top Innovators in Electric Batteries (small scale view)

Domain

- 1.7 Materials for Healthcare
- 1.8 Materials for Energy
- 1.9 Materials for Transport
- 2. Manufacturing Technologies
  - 2.1 Smart factories & supply chains
  - 2.2 New integrated business, product-service and production approaches
  - 2.3 Human-centered and human-driven manufacturing innovation
- 3. Clean Industries and Circular Industries
  - 3.1 Sustainable raw materials
  - 3.2 Sustainable process industry
  - 3.3 Electric batteries
  - [x] 3.4 Clean hydrogen
  - 3.5 Clean energy transition
  - 3.5 Clean/low carbon steel

Organisation	City	Country	Web
AIR LIQUIDE S.A.	Paris	France	https://www.airliquide.com
ARIANEGROUP SAS	Issy-les-Moulineaux	France	https://www.ariane.group
AVECOM NV	Wondelgem	Belgium	https://www.avecom.be
BASF SE	Ludwigshafen am Rhein	Germany	https://www.basf.com
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	Paris	France	https://www.cnrs.fr
COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	Paris	France	https://www.cea.fr
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	Madrid	Spain	https://www.csic.es
CONSIGLIO NAZIONALE DELLE RICERCHE CNR	Rome	Italy	https://www.cnr.it
DELFT UNIVERSITY OF TECHNOLOGY	Delft	Netherlands	https://www.tudelft.nl
FORSCHUNGSZENTRUM JULICH	Jülich	Germany	https://www.fz-juelich.de
HALDOR TOPSOE A/S	Kongens Lyngby	Denmark	https://www.topsoe.com
MCPHY ENERGY S.A.	La Motte-Fanjas	France	https://www.mcphy.com
NEL HYDROGEN A/S	Herning	Denmark	https://www.nelhydrogen.com
POLISH ACADEMY OF SCIENCES	Warsaw	Poland	https://www.pan.pl



Top Innovators in Clean Hydrogen (medium scale view)

Domain

- 1. Advanced Materials
  - 1.1 Material Modelling and Simulation
  - 1.2 Material Surfaces, Coatings and Interfaces
  - 1.3 High Performance Composites
  - 1.4 Functional Materials
  - 1.5 Graphene
  - 1.6 Materials for Additive Manufacturing
  - 1.7 Materials for Healthcare
  - 1.8 Materials for Energy
  - 1.9 Materials for Transport
- 2. Manufacturing Technologies
  - [x] 2.1 Smart factories & supply chains
  - 2.2 New integrated business, product-service and production approaches
  - 2.3 Human-centered and human-driven manufacturing innovation

Organisation	City	Country	Web
ABB SCHWEIZ AG	Baden	Switzerland	https://new.abb.com/ch
ASML NETHERLANDS B.V.	Veldhoven	Netherlands	https://www.asml.com
AUTOSTORE TECHNOLOGY AS	Nedre Vats	Norway	https://www.autostoresystem.com
BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT	Munich	Germany	https://www.bmw.com
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	Paris	France	https://www.cnrs.fr
COMPAGNIE GÉNÉRALE DES ETABLISSEMENTS MICHELIN	Clermont-Ferrand	France	https://www.michelin.com
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	Madrid	Spain	https://www.csic.es
CONSIGLIO NAZIONALE DELLE RICERCHE CNR	Rome	Italy	https://www.cnr.it
DSM IP ASSETS B.V.	Heerlen	Netherlands	https://www.dsm.com
ETH ZURICH	Zurich	Switzerland	https://www.ethz.ch
FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	Munich	Germany	https://www.fraunhofer.de
HELMHOLTZ ASSOCIATION	Bonn	Germany	https://www.helmholtz.de

Top Innovators in Smart Factories and Supply Chains (large scale view)

Interestingly, the interactive map also helps to visualise clusters of top innovators across Europe, e.g. clusters of organisations around Paris, Stuttgart and Munich involved in electric batteries.

Being online and comparatively easy to modify, it is anticipated the interactive map will be updated during the FIT-4-NMP project with the details of additional leading European research and innovation organisations. Such updates would be especially welcome for private industrial companies involved in the European Partnerships dealing with NMP research and innovation.

4. ANNEXES

4.1 TOP INNOVATORS - ADVANCED MATERIALS

Material Modelling and Simulation				
Patent Search			Research Publication Search	
Organisation	Patents		Organisation	Publications
KONINKLIJKE PHILIPS N.V.	169		UNIVERSITY OF PARIS-SACLAY	1908
SIEMENS AKTIENGESELLSCHAFT	130		IMPERIAL COLLEGE LONDON	1815
SERVICES PÉTROLIERS SCHLUMBERGER	101		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	1814
ROBERT BOSCH GMBH	62		SWISS FEDERAL INSTITUTE OF TECHNOLOGY IN ZÜRICH	1683
SCHLUMBERGER TECHNOLOGY B.V.	51		UNIVERSITY COLLEGE LONDON	1632
ABB SCHWEIZ AG	39		TECHNICAL UNIVERSITY OF MUNICH	1578
ASML NETHERLANDS B.V.	38		UNIVERSITY OF OXFORD	1556
STRATASYS LTD.	34		RWTH AACHEN UNIVERSITY	1520
TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)	28		UNIVERSITY OF CAMBRIDGE	1499
SAFRAN AIRCRAFT ENGINES	25		POLYTECHNIC UNIVERSITY OF MILAN	1480
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	25		CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	1362
ARCAM AB	24		UNIVERSITÉ GRENOBLE ALPES	1355
COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES	24		DELFT UNIVERSITY OF TECHNOLOGY	1311
SIGNIFY HOLDING B.V.	22		POLISH ACADEMY OF SCIENCES	1284
SIEMENS HEALTHCARE GMBH	21		UNIVERSITY OF MANCHESTER	1182
SIRONA DENTAL SYSTEMS GMBH	21		TECHNICAL UNIVERSITY OF DENMARK	1144
DASSAULT SYSTÈMES	20		KU LEUVEN	1143
BAE SYSTEMS PLC	35		CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	1102
EOS GMBH ELECTRO OPTICAL SYSTEMS	15		DRESDEN UNIVERSITY OF TECHNOLOGY	1069
			POLYTECHNIC UNIVERSITY OF TURIN	1065

Material Surfaces, Coatings and Interfaces				
Patent Search			Research Publication Search	
Organisation	Patents		Organisation	Publications
ROBERT BOSCH GMBH	698		CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	8214
SIEMENS AKTIENGESELLSCHAFT	520		HELMHOLTZ ASSOCIATION	3853
KONINKLIJKE PHILIPS N.V.	434		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	2796
BASF SE	431		CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	2225
SAINT-GOBAIN GLASS FRANCE	337		CNRS INSTITUTE OF CHEMISTRY (INC)	2046
SABIC GLOBAL TECHNOLOGIES B.V.	301		MINISTRY OF EDUCATION SCIENCE OF UKRAINE	1885
COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX	284		MAX-PLANCK-GESELLSCHAFT	1848

ÉNERGIES ALTERNATIVES				
ARCELORMITTAL	281		UNIVERSITY OF PARIS-SACLAY	1529
HENKEL AG & CO. KGAA	279		COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	1458
COMPAGNIE GÉNÉRALE DES ETABLISSEMENTS MICHELIN	259		POLISH ACADEMY OF SCIENCES	1388
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	258		CZECH ACADEMY OF SCIENCES	1342
UNILEVER PLC	209		CNRS INSTITUTE FOR ENGINEERING AND SYSTEMS SCIENCES (INSIS)	1329
FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	206		NATIONAL ACADEMY OF SCIENCES UKRAINE	1313
ARKEMA FRANCE	192		KARLSRUHE INSTITUTE OF TECHNOLOGY	1265
COVESTRO DEUTSCHLAND AG	191		ETH ZURICH	1264
L'OREAL	189		UNIVERSITY OF LONDON	1166
ABB SCHWEIZ AG	181		FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	1163
BASF COATINGS GMBH	181		COMMUNAUTÉ UNIVERSITÉ GRENOBLE ALPES	1156
SCHAEFFLER TECHNOLOGIES AG & CO. KG	177		UNIVERSITÉ GRENOBLE ALPES	1146
SIKA TECHNOLOGY AG	173		RWTH AACHEN UNIVERSITY	1094

High Performance Composites				
Patent Search			**Research Publication Search**	
Organisation	**Patents**		**Organisation**	**Publications**
SABIC GLOBAL TECHNOLOGIES B.V.	1131		CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	1923
L'OREAL	925		HELMHOLTZ ASSOCIATION	837
BASF SE	830		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	735
COMPAGNIE GÉNÉRALE DES ETABLISSEMENTS MICHELIN	608		MINISTRY OF EDUCATION SCIENCE OF UKRAINE	612
UNILEVER PLC	607		CNRS INSTITUTE OF CHEMISTRY (INC)	557
HENKEL AG & CO. KGAA	565		CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	514
L'ORÉAL	554		CNRS INSTITUTE FOR ENGINEERING AND SYSTEMS SCIENCES (INSIS)	502
ARKEMA FRANCE	553		DRESDEN UNIVERSITY OF TECHNOLOGY	437
UNILEVER N.V.	537		NATIONAL ACADEMY OF SCIENCES UKRAINE	430
BOREALIS AG	487		POLISH ACADEMY OF SCIENCES	407
SIKA TECHNOLOGY AG	386		POLYTECHNIC UNIVERSITY OF TURIN	400
COVESTRO DEUTSCHLAND AG	272		FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	392
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	237		IMPERIAL COLLEGE LONDON	379
BASF SE	204		WARSAW UNIVERSITY OF TECHNOLOGY	367

HENKEL IP & HOLDING GMBH	202		DELFT UNIVERSITY OF TECHNOLOGY	360
SOCIÉTÉ DES PRODUITS NESTLÉ S.A.	198		KARLSRUHE INSTITUTE OF TECHNOLOGY	355
ARCELORMITTAL	170		UNIVERSITY OF NAPLES FEDERICO II	346
MERCK PATENT GMBH	165		UNIVERSITY POLITEHNICA OF BUCHAREST	340
SIEMENS AKTIENGESELLSCHAFT	154		AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY	332
WACKER CHEMIE AG	149		UNIVERSITY OF PORTO	330

Functional Materials				
Patent Search			**Research Publication Search**	
Organisation	**Patents**		**Organisation**	**Publications**
ROBERT BOSCH GMBH	192		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	539
KONINKLIJKE PHILIPS N.V.	174		CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	482
COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES	212		POLISH ACADEMY OF SCIENCES	389
BASF SE	117		UNIVERSITY OF CAMBRIDGE	331
CNH INDUSTRIAL BELGIUM NV	112		DRESDEN UNIVERSITY OF TECHNOLOGY	329
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	89		SWISS FEDERAL INSTITUTE OF TECHNOLOGY IN ZÜRICH	324
MERCK PATENT GMBH	87		IMPERIAL COLLEGE LONDON	317
SIEMENS AKTIENGESELLSCHAFT	82		RWTH AACHEN UNIVERSITY	277
SAINT-GOBAIN GLASS FRANCE	81		POLYTECHNIC UNIVERSITY OF MILAN	267
FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	72		DELFT UNIVERSITY OF TECHNOLOGY	258
SABIC GLOBAL TECHNOLOGIES B.V.	60		UNIVERSITÉ GRENOBLE ALPES	258
VALEO SYSTEMES THERMIQUES	53		ECOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE (EPFL)	255
SYNGENTA PARTICIPATIONS AG	46		UNIVERSITY COLLEGE LONDON	253
ECOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE (EPFL)	40		UNIVERSITY OF OXFORD	249
SIKA TECHNOLOGY AG	37		FORSCHUNGSZENTRUM JULICH	248
ARKEMA FRANCE	35		TECHNICAL UNIVERSITY OF MUNICH	245
HENKEL AG & CO. KGAA	34		TECHNICAL UNIVERSITY OF DENMARK	239
HUTCHINSON	30		UNIVERSITY OF MANCHESTER	234
SOITEC	30		TECHNICAL UNIVERSITY OF DARMSTADT	233
HENKEL IP & HOLDING GMBH	29		UNIVERSITY OF PARIS-SACLAY	228

Graphene				
Patent Search			**Research Publication Search**	
Organisation	**Patents**		**Organisation**	**Publications**
THE UNIVERSITY OF MANCHESTER	39		CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	668
NOKIA TECHNOLOGIES OY	35		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	545
SABIC GLOBAL TECHNOLOGIES B.V.	25		CONSEJO SUPERIOR DE INVESTIGACIONES	540

			CIENTIFICAS CSIC	
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	22		UNIVERSITY OF MANCHESTER	284
BASF SE	19		HELMHOLTZ ASSOCIATION	237
ARCELORMITTAL	18		ISTITUTO ITALIANO DI TECNOLOGIA (IIT)	221
COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES	13		MAX-PLANCK-GESELLSCHAFT	193
CAMBRIDGE ENTERPRISE LIMITED	13		CNRS INSTITUTE OF CHEMISTRY (INC)	180
ROBERT BOSCH GMBH	12		CZECH ACADEMY OF SCIENCES	164
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS (CSIC)	10		POLISH ACADEMY OF SCIENCES	161
FONDAZIONE ISTITUTO ITALIANO DI TECNOLOGIA	9		BARCELONA INSTITUTE OF SCIENCE AND TECHNOLOGY	154
AIXTRON SE	8		NATIONAL ACADEMY OF SCIENCES UKRAINE	147
INSTYTUT TECHNOLOGII MATERIALÓW ELEKTRONICZNYCH	8		WARSAW UNIVERSITY OF TECHNOLOGY	146
INSTITUCIÓ CATALANA DE RECERCA I ESTUDIS AVANÇATS	8		AUTONOMOUS UNIVERSITY OF BARCELONA	141
DIRECTA PLUS S.P.A.	8		UNIVERSITY OF LONDON	139
DANMARKS TEKNISKE UNIVERSITET	7		UNIVERSITY OF PARIS-SACLAY	135
FORSCHUNGSZENTRUM JÜLICH GMBH	7		RWTH AACHEN UNIVERSITY	132
CONSIGLIO NAZIONALE DELLE RICERCHE	7		BASQUE FOUNDATION FOR SCIENCE	130
REPSOL, S.A.	7		MINISTRY OF EDUCATION SCIENCE OF UKRAINE	128
MAX-PLANCK-GESELLSCHAFT ZUR FÖRDERUNG DER WISSENSCHAFTEN	6		DRESDEN UNIVERSITY OF TECHNOLOGY	128

Materials for Additive Manufacturing				
Patent Search			**Research Publication Search**	
Organisation	**Patents**		**Organisation**	**Publications**
SIEMENS AKTIENGESELLSCHAFT	172		CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	284
CL SCHUTZRECHTSVERWALTUNGS GMBH	121		FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	215
SABIC GLOBAL TECHNOLOGIES B.V.	77		POLYTECHNIC UNIVERSITY OF TURIN	158
STRATASYS LTD.	70		FRIEDRICH-ALEXANDER-UNIVERSITÄT ERLANGEN-NÜRNBERG	151
ARCAM AB	61		POLYTECHNIC UNIVERSITY OF MILAN	147
EOS GMBH ELECTRO OPTICAL SYSTEMS	44		HELMHOLTZ ASSOCIATION	115
RENISHAW PLC	42		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	112
CONCEPT LASER GMBH	40		UNIVERSITY OF NOTTINGHAM	102
ADDUP	37		RWTH AACHEN UNIVERSITY	99
COVESTRO DEUTSCHLAND AG	33		ETH ZURICH	93
RENISHAW PLC.	32		UNIVERSITY OF SHEFFIELD	87
COMPAGNIE GÉNÉRALE DES ETABLISSEMENTS MICHELIN	22		DRESDEN UNIVERSITY OF TECHNOLOGY	86

ADDITIVE INDUSTRIES B.V.	22		CNRS INSTITUTE FOR ENGINEERING AND SYSTEMS SCIENCES (INSIS)	81
ESSILOR INTERNATIONAL	20		UNIVERSITY OF MANCHESTER	76
HERAEUS ADDITIVE MANUFACTURING GMBH	18		NORWEGIAN UNIVERSITY OF SCIENCE TECHNOLOGY	75
MATERIALISE N.V.	15		CRANFIELD UNIVERSITY	73
AKTIEBOLAGET SKF	15		TECHNICAL UNIVERSITY OF MUNICH	73
SAFRAN AIRCRAFT ENGINES	15		UNIVERSITY OF PADUA	70
MTU AERO ENGINES AG	15		IMPERIAL COLLEGE LONDON	69
ROLLS-ROYCE PLC	15		DELFT UNIVERSITY OF TECHNOLOGY	68

Materials for Healthcare				
Patent Search			**Research Publication Search**	
Organisation	**Patents**		**Organisation**	**Publications**
KONINKLIJKE PHILIPS N.V.	42		UNIVERSITY OF LONDON	1372
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	38		CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	1303
L'ORÉAL	30		NATIONAL INSTITUTE OF HEALTH AND MEDICAL RESEARCH (INSERM)	1106
AESCULAP AG	28		ASSISTANCE PUBLIQUE - HÔPITAUX DE PARIS	954
ALCON INC.	22		UNIVERSITY OF HEALTH SCIENCES TURKEY	813
BIOTRONIK AG	20		FREE UNIVERSITY OF BERLIN	776
KULZER GMBH	19		SAPIENZA UNIVERSITY OF ROME	762
MED-EL ELEKTROMEDIZINISCHE GERAETE GMBH	18		HELMHOLTZ ASSOCIATION	744
FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	17		HEIDELBERG UNIVERSITY	728
NOVARTIS AG	17		HUMBOLDT UNIVERSITY OF BERLIN	719
BIOSENSE WEBSTER (ISRAEL) LTD.	17		LUDWIG MAXIMILIAN UNIVERSITY OF MUNICH	717
F. HOFFMANN-LA ROCHE AG	16		UNIVERSITY COLLEGE LONDON	713
CRISPR THERAPEUTICS AG	16		CHARITE MEDICAL UNIVERSITY OF BERLIN	691
HERAEUS DEUTSCHLAND GMBH & CO. KG	16		UNIVERSITY OF MILAN	669
SABIC GLOBAL TECHNOLOGIES B.V.	15		UNIVERSITY OF COPENHAGEN	646
STRAUMANN HOLDING AG	14		CONSORCIO CENTRO DE INVESTIGACIÓN BIOMÉDICA EN RED, M.P, CIBER	643
ECOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE (EPFL)	14		UNIVERSITE DE PARIS	630
JOTEC GMBH	14		KAROLINSKA INSTITUTE	611
UNIVERSITÉ DE STRASBOURG	13		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	609
SIRONA DENTAL SYSTEMS GMBH	13		JAGIELLONIAN UNIVERSITY	586

Materials for Energy				
Patent Search			**Research Publication Search**	
Organisation	**Patents**		**Organisation**	**Publications**
ROBERT BOSCH GMBH	21		CENTRE NATIONAL DE LA RECHERCHE	200

			SCIENTIFIQUE CNRS	
COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES	16		HELMHOLTZ ASSOCIATION	198
JOHNSON MATTHEY FUEL CELLS LIMITED	10		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	121
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	9		TECHNICAL UNIVERSITY OF DENMARK	86
WOBBEN PROPERTIES GMBH	8		FORSCHUNGSZENTRUM JULICH	80
VOLKSWAGEN AG	8		CNRS INSTITUTE OF CHEMISTRY (INC)	74
AUDI AG	8		CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	73
THYSSENKRUPP AG	6		COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	64
COMPAGNIE GÉNÉRALE DES ETABLISSEMENTS MICHELIN	6		KARLSRUHE INSTITUTE OF TECHNOLOGY	60
ILIKA TECHNOLOGIES LIMITED	5		ADVANCED ENERGY TECHNOLOGY INSTITUTE (ITAE) "NICOLA GIORDANO"	55
FRAUNHOFER GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	4		COMMUNAUTÉ UNIVERSITÉ GRENOBLE ALPES	50
FLUORCHEMIE GMBH FRANKFURT	4		UNIVERSITÉ GRENOBLE ALPES	50
DANMARKS TEKNISKE UNIVERSITET	4		UNIVERSITY OF BIRMINGHAM	50
DAIMLER AG	4		RWTH AACHEN UNIVERSITY	47
TEKNOLOGIAN TUTKIMUSKESKUS VTT OY	4		FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	45
SIEMENS AKTIENGESELLSCHAFT	4		CNRS INSTITUTE FOR ENGINEERING AND SYSTEMS SCIENCES (INSIS)	44
RENAULT S.A.S.	4		POLYTECHNIC UNIVERSITY OF TURIN	43
IMERYS GRAPHITE & CARBON SWITZERLAND LTD.	4		DEUTSCHES ZENTRUM FÜR LUFT- UND RAUMFAHRT E.V.	42
VALEO SYSTEMES THERMIQUES	4		IMPERIAL COLLEGE LONDON	41
HENKEL IP & HOLDING GMBH	4		AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY	40

Materials for Transport				
Patent Search			**Research Publication Search**	
Organisation	**Patents**		**Organisation**	**Publications**
CONSTELLIUM ISSOIRE	24		CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	61
UMICORE	4		HELMHOLTZ ASSOCIATION	56
AIRBUS DEFENCE AND SPACE GMBH	3		RWTH AACHEN UNIVERSITY	35
SAFRAN LANDING SYSTEMS UK LTD	3		UNIVERSITY OF WARWICK	32
AGC GLASS EUROPE	3		TECHNICAL UNIVERSITY OF MUNICH	26
DYNITEC GMBH	2		FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	23
EATON INTELLIGENT POWER LIMITED	2		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	22
EICKHOFF GIESSEREI GMBH	2		POLYTECHNIC UNIVERSITY OF TURIN	22

EUROPEAN SPACE AGENCY (ESA)	2		MINISTRY OF EDUCATION SCIENCE OF UKRAINE	21
IEE INTERNATIONAL ELECTRONICS & ENGINEERING S.A.	2		LUBLIN UNIVERSITY OF TECHNOLOGY	20
IMERYS GRAPHITE & CARBON SWITZERLAND LTD.	2		UNIVERSITY OF LEOBEN	18
KGT GRAPHIT TECHNOLOGIE GMBH	2		UNIVERSITY OF SHEFFIELD	18
PRINCE MINERALS ITALY S.R.L.	2		KARLSRUHE INSTITUTE OF TECHNOLOGY	17
SABIC GLOBAL TECHNOLOGIES B.V.	2		UNIVERSITÉ FÉDÉRALE TOULOUSE MIDI-PYRÉNÉES	16
SAF-T-GLO LIMITED	2		CNRS INSTITUTE FOR ENGINEERING AND SYSTEMS SCIENCES (INSIS)	15
SETRAL CHEMIE GMBH	2		SILESIAN UNIVERSITY OF TECHNOLOGY	15
TESA SE	2		UNIVERSITY OF LONDON	15
			FORSCHUNGSZENTRUM JULICH	14
			UNIVERSITÉ FÉDÉRALE TOULOUSE MIDI-PYRÉNÉES	14

4.2 TOP INNOVATORS - MANUFACTURING TECHNOLOGIES

Smart factories & supply chains				
Patent Search			Research Publication Search	
Organisation	Patents		Organisation	Publications
ABB SCHWEIZ AG	61		CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	789
SIEMENS AKTIENGESELLSCHAFT	28		HELMHOLTZ ASSOCIATION	578
KUKA DEUTSCHLAND GMBH	26		FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	408
ASML NETHERLANDS B.V.	24		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	331
MEDICAL MICROINSTRUMENTS S.P.A.	14		RWTH AACHEN UNIVERSITY	317
UNILEVER PLC	13		POLYTECHNIC UNIVERSITY OF MILAN	306
KUKA SYSTEMS GMBH	13		UNIVERSITY OF LONDON	292
COMPAGNIE GÉNÉRALE DES ETABLISSEMENTS MICHELIN	12		ETH ZURICH	290
ROBERT BOSCH GMBH	12		UNIVERSITY OF LISBON	264
HUSQVARNA AB	11		KARLSRUHE INSTITUTE OF TECHNOLOGY	239
UNILEVER N.V.	11		POLYTECHNIC UNIVERSITY OF TURIN	238
AUTOSTORE TECHNOLOGY AS	10		TECHNICAL UNIVERSITY OF DENMARK	229
SABIC GLOBAL TECHNOLOGIES B.V.	10		IMPERIAL COLLEGE LONDON	224
BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT	10		UNIVERSITY OF MANCHESTER	223
SALZGITTER FLACHSTAHL GMBH	9		UNIVERSITY OF CAMBRIDGE	220
XTREEE	9		TECHNICAL UNIVERSITY OF MUNICH	219
SOFTBANK ROBOTICS EUROPE	9		CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	214
DSM IP ASSETS B.V.	8		UNIVERSITY OF NAPLES FEDERICO II	203
VOLKSWAGEN AKTIENGESELLSCHAFT	8		KTH ROYAL INSTITUTE OF TECHNOLOGY	202
			KU LEUVEN	200

New integrated business, product-service and production approaches				
Patent Search			Research Publication Search	
Organisation	Patents		Organisation	Publications
TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)	607		TECHNICAL UNIVERSITY OF MUNICH	186
NOKIA TECHNOLOGIES OY	308		RWTH AACHEN UNIVERSITY	185
NOKIA SOLUTIONS AND NETWORKS OY	194		POLYTECHNIC UNIVERSITY OF MILAN	140
SIEMENS AKTIENGESELLSCHAFT	187		SWISS FEDERAL INSTITUTE OF TECHNOLOGY IN ZÜRICH	140
DEUTSCHE TELEKOM AG	146		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	136
VALEO SYSTEMES THERMIQUES	98		UNIVERSITY OF CAMBRIDGE	129
ALCATEL LUCENT (CURRENTLY NOKIA)	97		POLYTECHNIC UNIVERSITY OF TURIN	119
L'AIR LIQUIDE SOCIÉTÉ ANONYME POUR L'ETUDE ET L'EXPLOITATION DES PROCÉDÉS GEORGES CLAUDE	57		UNIVERSITY OF STUTTGART	112

COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES	49		UNIVERSITY COLLEGE LONDON	109
KONINKLIJKE PHILIPS N.V.	47		UNIVERSITÉ GRENOBLE ALPES	105
SERVICES PÉTROLIERS SCHLUMBERGER	41		IMPERIAL COLLEGE LONDON	104
GENERAL ELECTRIC TECHNOLOGY GMBH	38		UNIVERSITY OF PADUA	104
ABB SCHWEIZ AG	34		DRESDEN UNIVERSITY OF TECHNOLOGY	102
MAHLE INTERNATIONAL GMBH	33		KU LEUVEN	101
ROBERT BOSCH GMBH	29		UNIVERSITY OF MANCHESTER	95
LENZING AKTIENGESELLSCHAFT	29		UNIVERSITY OF PARIS-SACLAY	95
SABIC GLOBAL TECHNOLOGIES B.V.	29		TECHNICAL UNIVERSITY OF DENMARK	92
LINDE AKTIENGESELLSCHAFT	27		GHENT UNIVERSITY	90
ORANGE	26		UNIVERSITY OF SHEFFIELD	90
			CHALMERS UNIVERSITY OF TECHNOLOGY	89

Human-centered and human-driven manufacturing innovation				
Patent Search			**Research Publication Search**	
Organisation	**Patents**		**Organisation**	**Publications**
SIEMENS AKTIENGESELLSCHAFT	249		POLYTECHNIC UNIVERSITY OF MILAN	818
ROBERT BOSCH GMBH	104		RWTH AACHEN UNIVERSITY	696
SERVICES PÉTROLIERS SCHLUMBERGER	97		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	691
KONINKLIJKE PHILIPS N.V.	89		UNIVERSITY OF LISBON	685
ASML NETHERLANDS B.V.	72		POLYTECHNIC UNIVERSITY OF TURIN	683
NOKIA TECHNOLOGIES OY	64		TECHNICAL UNIVERSITY OF MUNICH	682
HENKEL AG & CO. KGAA	85		UNIVERSITY OF CAMBRIDGE	633
ABB SCHWEIZ AG	53		IMPERIAL COLLEGE LONDON	608
SCHLUMBERGER TECHNOLOGY B.V.	49		DELFT UNIVERSITY OF TECHNOLOGY	596
STRATASYS LTD.	47		UNIVERSITY COLLEGE LONDON	585
TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)	39		SWISS FEDERAL INSTITUTE OF TECHNOLOGY IN ZÜRICH	578
F. HOFFMANN-LA ROCHE AG	35		TECHNICAL UNIVERSITY OF DENMARK	571
COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES	33		UNIVERSITY OF PADUA	560
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	32		DRESDEN UNIVERSITY OF TECHNOLOGY	543
TETRA LAVAL HOLDINGS & FINANCE S.A.	29		UNIVERSITY OF PORTO	535
BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT	26		UNIVERSITY OF MANCHESTER	529
EOS GMBH ELECTRO OPTICAL SYSTEMS	24		CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	514
ZF FRIEDRICHSHAFEN AG	24		KU LEUVEN	511
SCANIA CV AB	23		GHENT UNIVERSITY	506
			CHALMERS UNIVERSITY OF TECHNOLOGY	476

4.3 TOP INNOVATORS - CLEAN INDUSTRIES AND CIRCULAR INDUSTRIES

Sustainable raw materials				
Patent Search			Research Publication Search	
Organisation	Patents		Organisation	Publications
ROBERT BOSCH GMBH	73		CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	88
BASF SE	53		HELMHOLTZ ASSOCIATION	46
COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES	45		AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY	31
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	46		CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	31
SAINT-GOBAIN GLASS FRANCE	30		CNRS INSTITUTE OF CHEMISTRY (INC)	29
WACKER CHEMIE AG	22		KU LEUVEN	25
CL SCHUTZRECHTSVERWALTUNGS GMBH	21		RWTH AACHEN UNIVERSITY	25
UMICORE	21		AALTO UNIVERSITY	23
COMPAGNIE GÉNÉRALE DES ETABLISSEMENTS MICHELIN	20		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	23
OUTOTEC (FINLAND) OY	18		YILDIZ TECHNICAL UNIVERSITY	20
SIEMENS AKTIENGESELLSCHAFT	17		CHALMERS UNIVERSITY OF TECHNOLOGY	17
PURAC BIOCHEM BV	14		POLISH ACADEMY OF SCIENCES	17
IFP ENERGIES NOUVELLES	14		COMMUNAUTÉ UNIVERSITÉ GRENOBLE ALPES	16
BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT	13		MAX-PLANCK-GESELLSCHAFT	16
SABIC GLOBAL TECHNOLOGIES B.V.	12		TECHNISCHE UNIVERSITÄT BERLIN	15
UPM-KYMMENE CORPORATION	11		UNIVERSITÉ GRENOBLE ALPES	15
EVONIK DEGUSSA GMBH	11		COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	13
BASF COATINGS GMBH	10		ISTANBUL TECHNICAL UNIVERSITY	13
SOLVAY SA	9		KARLSRUHE INSTITUTE OF TECHNOLOGY	13
COVESTRO DEUTSCHLAND AG	9		KTH ROYAL INSTITUTE OF TECHNOLOGY	13

Sustainable process industry				
Patent Search			Research Publication Search	
Organisation	Patents		Organisation	Publications
SIEMENS AKTIENGESELLSCHAFT	26		AALTO UNIVERSITY	46
SABIC GLOBAL TECHNOLOGIES B.V.	11		POLYTECHNIC UNIVERSITY OF MILAN	44
HALDOR TOPSØE A/S	9		DELFT UNIVERSITY OF TECHNOLOGY	41
UNILEVER PLC	9		GHENT UNIVERSITY	41
UNILEVER N.V.	9		TECHNICAL UNIVERSITY OF DENMARK	37
NOKIA TECHNOLOGIES OY	8		UNIVERSITY OF AVEIRO	36
L'AIR LIQUIDE SOCIÉTÉ ANONYME POUR L'ETUDE ET L'EXPLOITATION DES PROCÉDÉS GEORGES CLAUDE	7		CHALMERS UNIVERSITY OF TECHNOLOGY	33
ABB SCHWEIZ AG	7		CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	31
AIR LIQUIDE DEUTSCHLAND GMBH	7		POLYTECHNIC UNIVERSITY OF TURIN	30

TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)	6		TECHNISCHE UNIVERSITÄT WIEN	30
AVL LIST GMBH	6		LUND UNIVERSITY	29
THYSSENKRUPP AG	5		UNIVERSITY OF BOLOGNA	27
THYSSENKRUPP INDUSTRIAL SOLUTIONS AG	5		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	25
BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT	5		KU LEUVEN	25
UNIVERSIDAD DE SEVILLA	5		UNIVERSITY OF TWENTE	25
VEOLIA WATER SOLUTIONS & TECHNOLOGIES SUPPORT	4		SILESIAN UNIVERSITY OF TECHNOLOGY	24
SAIPEM S.P.A.	4		UNIVERSITY OF MANCHESTER	24
MITSUBISHI HITACHI POWER SYSTEMS EUROPE GMBH	4		KTH ROYAL INSTITUTE OF TECHNOLOGY	23
FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	4		RWTH AACHEN UNIVERSITY	23
			UNIVERSITAT POLITÈCNICA DE CATALUNYA	23

Electric batteries				
Patent Search			**Research Publication Search**	
Organisation	**Patents**		**Organisation**	**Publications**
ROBERT BOSCH GMBH	270		HELMHOLTZ ASSOCIATION	747
RENAULT S.A.S.	171		CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	540
BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT	119		KARLSRUHE INSTITUTE OF TECHNOLOGY	365
AUDI AG	100		RWTH AACHEN UNIVERSITY	219
SIEMENS AKTIENGESELLSCHAFT	95		FORSCHUNGSZENTRUM JULICH	189
VALEO SYSTEMES THERMIQUES	61		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	185
ABB SCHWEIZ AG	61		CNRS INSTITUTE OF CHEMISTRY (INC)	184
PSA AUTOMOBILES SA	52		FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	176
GENERAL ELECTRIC TECHNOLOGY GMBH	51		TECHNICAL UNIVERSITY OF MUNICH	166
BLUE SOLUTIONS	46		POLYTECHNIC UNIVERSITY OF TURIN	159
VOLVO TRUCK CORPORATION	46		CHALMERS UNIVERSITY OF TECHNOLOGY	152
VOLKSWAGEN AKTIENGESELLSCHAFT	46		DEUTSCHES ZENTRUM FÜR LUFT- UND RAUMFAHRT E.V.	145
DAIMLER AG	44		ETH ZURICH	140
COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES	36		POLYTECHNIC UNIVERSITY OF MILAN	139
SCANIA CV AB	33		CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	137
JAGUAR LAND ROVER LIMITED	32		IMPERIAL COLLEGE LONDON	137
CONTINENTAL AUTOMOTIVE GMBH	30		TECHNICAL UNIVERSITY OF DENMARK	126
THYSSENKRUPP AG	26		UNIVERSITY OF LONDON	121
VALEO EQUIPEMENTS ELECTRIQUES MOTEUR	23		AALBORG UNIVERSITY	120
MAHLE INTERNATIONAL GMBH	19		AALTO UNIVERSITY	117

Clean hydrogen				
Patent Search			Research Publication Search	
Organisation	Patents		Organisation	Publications
Commissariat à l'Énergie Atomique et aux Énergies Alternatives	22		CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	1087
SABIC Global Technologies B.V.	15		CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	1080
L'Air Liquide Société Anonyme pour l'Etude et l'Exploitation des Procédés Georges Claude	10		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	920
Nel Hydrogen A/S	8		UNIVERSITY OF CAMBRIDGE	705
BASF SE	8		TECHNICAL UNIVERSITY OF DENMARK	674
Haldor Topsoe A/S	3		FORSCHUNGSZENTRUM JULICH	647
McPhy Energy	3		DELFT UNIVERSITY OF TECHNOLOGY	583
ArianeGroup SAS	2		UNIVERSITY COLLEGE LONDON	572
Avecom NV	2		POLISH ACADEMY OF SCIENCES	562
			UNIVERSITY OF OXFORD	536

Clean energy transition				
Patent Search			Research Publication Search	
Organisation	Patents		Organisation	Publications
SIEMENS AKTIENGESELLSCHAFT	18		IMPERIAL COLLEGE LONDON	148
COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES	18		UNIVERSITY OF SEVILLE	127
VESTAS WIND SYSTEMS A/S	7		CHALMERS UNIVERSITY OF TECHNOLOGY	103
BASF SE	6		DELFT UNIVERSITY OF TECHNOLOGY	97
RIPASSO ENERGY AB	6		SWISS FEDERAL INSTITUTE OF TECHNOLOGY IN ZÜRICH	97
ABB SCHWEIZ AG	5		TECHNICAL UNIVERSITY OF DENMARK	89
DEUTSCHES ZENTRUM FÜR LUFT- UND RAUMFAHRT E.V.	4		POLYTECHNIC UNIVERSITY OF MILAN	84
SIEMENS CONCENTRATED SOLAR POWER LTD.	4		POLYTECHNIC UNIVERSITY OF TURIN	76
SIGNIFY HOLDING B.V.	4		CONSIGLIO NAZIONALE DELLE RICERCHE CNR	74
COCKERILL MAINTENANCE & INGÉNIÉRIE S.A.	4		DEUTSCHES ZENTRUM FÜR LUFT- UND RAUMFAHRT E.V.	74
SABIC GLOBAL TECHNOLOGIES B.V.	3		UNIVERSITY OF EDINBURGH	71
ABENGOA SOLAR NEW TECHNOLOGIES, S.A.	3		RWTH AACHEN UNIVERSITY	69
GRAFMARINE	3		UTRECHT UNIVERSITY	69
SALZGITTER MANNESMANN PRÉCISION ETIRAGE SAS	3		AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY	66
AISLAMIENTOS SUAVAL, S.A.	2		TECHNICAL UNIVERSITY OF MADRID	66
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2		NATIONAL TECHNICAL UNIVERSITY OF ATHENS	65
HANDKE BRUNNENBAU GMBH	2		AALBORG UNIVERSITY	61
			UNIVERSITY OF LISBON	60
			NORWEGIAN UNIVERSITY OF SCIENCE TECHNOLOGY	58
			UNIVERSITY OF SHEFFIELD	57

Clean/low carbon steel				
Patent Search			Research Publication Search	
Organisation	Patents		Organisation	Publications
THYSSENKRUPP AG	16		POLYTECHNIC UNIVERSITY OF MILAN	10
COMPAGNIE GÉNÉRALE DES ETABLISSEMENTS MICHELIN	10		AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY	5
ARCELORMITTAL	7		OPOLE UNIVERSITY OF TECHNOLOGY	5
TRUMPF WERKZEUGMASCHINEN GMBH + CO. KG	6		POLISH ACADEMY OF SCIENCES	5
TATA STEEL IJMUIDEN B.V.	5		RZESZÓW UNIVERSITY OF TECHNOLOGY	5
SMS GROUP GMBH	5		SWISS FEDERAL INSTITUTE OF TECHNOLOGY IN ZÜRICH	5
S.A. LHOIST RECHERCHE ET DEVELOPPEMENT	5		ESKISEHIR OSMANGAZI UNIVERSITY	4
SALZGITTER FLACHSTAHL GMBH	4		KOSZALIN UNIVERSITY OF TECHNOLOGY	4
SABIC GLOBAL TECHNOLOGIES B.V.	4		NATIONAL CENTRE FOR METALLURGICAL RESEARCH (CENIM) CSIC	4
CENTRE DE RECHERCHES MÉTALLURGIQUES ASBL - CENTRUM VOOR RESEARCH IN DE METALLURGIE VZW	4		RWTH AACHEN UNIVERSITY	4
THYSSENKRUPP STEEL EUROPE AG	4		SILESIAN UNIVERSITY OF TECHNOLOGY	4
PARALLOY LIMITED	4		UNIVERSITY OF THE BASQUE COUNTRY	4
TATA STEEL UK LIMITED	4		UNIVERSITY OF BIRMINGHAM	4
L'AIR LIQUIDE SOCIÉTÉ ANONYME POUR L'ETUDE ET L'EXPLOITATION DES PROCÉDÉS GEORGES CLAUDE	4		UNIVERSITY OF LEEDS	4
KIRCHHOFF AUTOMOTIVE DEUTSCHLAND GMBH	4		UNIVERSITY OF LJUBLJANA	4
BASF SE	4		UNIVERSITY OF LORRAINE	4
HERAEUS ELECTRO-NITE INTERNATIONAL N.V.	3		UNIVERSITY OF ROME TOR VERGATA	4
PAUL WURTH S.A.	3		UNIVERSITY OF SHEFFIELD	4
TMT - TAPPING MEASURING TECHNOLOGY SÀRL	3		CZECH TECHNICAL UNIVERSITY IN PRAGUE	3
			CZESTOCHOWA UNIVERSITY OF TECHNOLOGY	3

FIT-4-NMP

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