GEMSTONE
ROADMAP

GrEen Manufacturing SupporTing recOvery and resilieNcE of industrial SME

Funded by
the European Union

EURO CLUSTERS

TABLE OF CONTENTS

GEMSTONE

Green Manufacturing Supporting Recovery and Resilience of Industrial SMEs

FOREWORD

Joint Cluster Initiatives (EUROCLUSTERS) for Europe's recovery is pleased to present the GEMSTONE roadmap - a way to increase companies' awareness of the potential and economic viability of green manufacturing. Creating a resilient, easy-to-use and transparent system to enable companies to increase productivity through the transformation of manufacturing integrating green, smart and sustainable solutions.

Manufacturing is a fundamental pillar of Europe's economy. In order to remain competitive and to enhance contribution to green growth, companies need to uptake innovative technologies and to embrace new business models allowing clean and sustainable production.

The GEMSTONE objective is to support manufacturing companies, and in particular industrial equipment and tool providers, in their resilience initiatives by raising awareness and mobilizing them on the solutions offered by Green Manufacturing.

The environmental transition of manufacturing companies is a resilience issue, especially in the current context of post-COVID-19 recovery and war in Ukraine impacting the value chains. Green Manufacturing is a toolbox offering a wide and various range of innovative solutions whose knowledge, development and control calls for an effort to raise awareness and encourage their adoption. GEMSTONE focuses its efforts primarily on suppliers as the keystone of industrial value chains, thus being better able to understand the challenges of innovation.

Within the settled frameworks of the Green Deal, the New Industrial Strategy for Europe and the Green Deal Industrial Plan for the Net-Zero Age, the project GEMSTONE aims to define, deepen and apply a common methodology on issues related to Green Manufacturing in 5 identified industrial sectors: **Aeronautics/Defence**, **Energy, Mobility, Agriculture/Agri-food, Materials.** This ambition is driven by the thoughtful association of European clusters with complementary ecosystems both in terms of expertise and priority targets, bringing together organizations and people facilitating innovation.

The GEMSTONE roadmap reflects support activities based on three main pillars - "**Train**", "**Innovation**" and "**Explore**", which offer companies the opportunity to finance European cooperation projects, calls for funding projects.

The roadmap will be the backbone of the project's ambitions and the partners will ensure its dissemination to their respective ecosystems. It will also be the basis for the reflection of the European Cluster Alliance for Green Manufacturing that the partners undertake to create.

This document is based on a situation linked to the period of its writing and publication, and also anticipates certain developments within the manufacturing value chains. In order to always be as faithful as possible to the needs of companies and to offer the most up-to-date vision possible, this document will be questioned until the end of the project, in particular within the framework of the creation of the Alliance, in order to be updated.

PROJECT STRATEGY

As a priority GEMSTONE sets the industrial equipment and tool providers in the acquisition of knowledge and skills of Green Manufacturing considering these stakeholders as the keystones of industrial value chains both understanding the needs expressed by end-user companies and identifying/developing the right technological solutions to meet them. The twin transition is a decisive lever for the future of manufacturing SMEs in Europe but, as mentioned in the European Strategy for SMEs, its implementation will require a reinforced effort to translate the relevant European policies and strategies into action. This effort will result in the strengthening of the role of clusters as intermediary organizations of innovation by working on the implementation of a joint service offer which will be the central tool of the future European Cluster Alliance for Green Manufacturing which will emerge from the project.

GEMSTONE roadmap is a guide through the evolution of the project and the development of its deliverables, precisely defines the methods and tools necessary to help manufacturing companies identify their needs and the challenges in terms of green transition. The roadmap carries a trans-sectoral and trans-European vision to be able to reach a wide audience.

GEMSTONE is based on three main pillars: **Train, Innovate, Explore**. In order to respond to the challenges behind these objectives, the project partners have developed a coherent and efficient support process. The methodology presented as the backbone of GEMSTONE supports the development of portfolios of services made available to manufacturing companies around **vocational training**, **technological innovation** and the **internationalization of their activities**. The supported companies will have a Resilience Plan calling for the implementation of identified solutions. **A direct financing mechanism will provide the means of action for companies and will facilitate their efforts towards an effective environmental and digital transition.**

TAKE PART IN GREEN TRANSITION

Starting date: September 2023

EXPLORE — Up to 1500 €

Support participation to business fairs and international events

- European SMEs
- Individual
- 40 project funded

TRAIN — Up to 2000 €

Facilitate connexion between training providers and SMEs for green skills

- European SMEs
- Individual
- 45 project funded

GREEN INNOV — Up to 60K €

Support the development of new green technologies or processes

- European SMEs
- Individual or collaborative
- 5 project funded
- 6 months

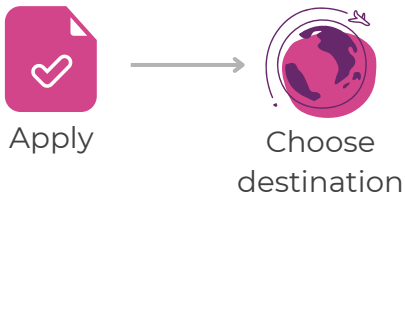
GREEN ADOPT — Up to 40K €

Foster the implementation of business process innovations

- European SMEs
- Collaborative
- 15 project funded
- 6 months

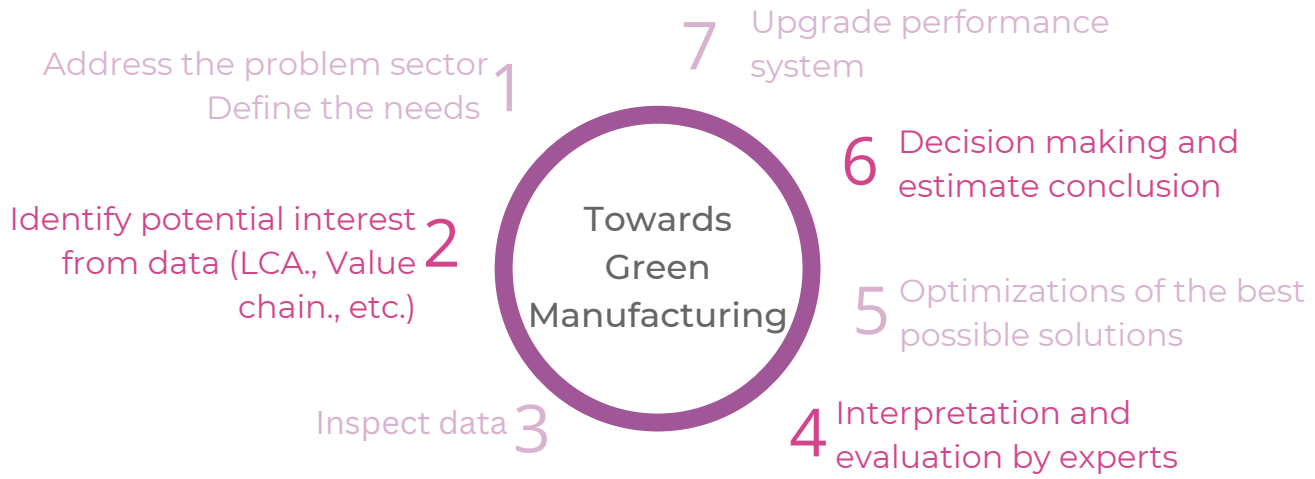
Explore

GEMSTONE project will support SMEs internationalisation strategy by facilitating their participation to business fairs and other international event deemed interesting for their activities, in targeted countries. Support SMEs internationalisation development of tools boost circular economy business solutions to strengthen resilience and to drive the recovery growth of European SMEs



Train

GEMSTONE will facilitate the connexion between training providers and SMEs and provide funding to support the SMEs capacity building. GEMSTONE project will use diagnostic to collect SMEs needs and orient them toward proper training. Training will help to define areas of innovation and ideas to be used in innovation support stage.



Innovate

GEMSTONE project will provide a range support and services to favour emergence of new concrete solutions and sustainable value chains, within technology areas identified at the early stage of the GEMSTONE roadmap and developed in the services portfolios.

This will be done through two types of support instruments adapted for the different positioning of the beneficiaries. 2 calls for proposal will be launch on **GreenInnov** and **GreenAdopt.**

GreenAdopt

GreenAdopt will facilitate the adoption of green smart solution by industrial European SMEs.

GreenInnov

GreenInnov has been designed to provide solution providers with support in the exploration and development of advanced green solution for industries.

OBJECTIVES

The objective of GEMSTONE is to mobilize manufacturing companies, in particular innovative SMEs, on the challenges of “Green manufacturing” by developing a dedicated joint service offer and operational and financial support tools around the 3 pillars “Train, Innovate, Explore “.

Network

Objectives

Support manufacturing companies, and in particular industrial equipment and tool providers, in their resilience initiatives by raising awareness and mobilizing them on the solutions offered by Green Manufacturing

Actions

Contribute to the birth of a **European Cluster Alliance for Green Manufacturing** to accelerate the implementation of the Twin Transition across industrial sectors

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Innovate

Objectives

Identify the "Green Manufacturing" needs and challenges in the 5 industrial sectors **(Aeronautics/Defense, Energy, Mobility, Agriculture/Agrifood, Materials)** to open up new avenues of innovation for industrial companies, in particular SMEs

Actions

Implementation:

- GEMSTONE Roadmap and Project Strategy
- Brainstorm sessions
- Development of a Service Portfolio
- Innovation vouchers

Adopt

Objectives

Design operational and financial support tools around the 3 pillars "Train-Innovate-Explore" to encourage and empower manufacturing companies in their environmental and digital transition process

Actions

Business Resilience Diagnosis, Adopt vouchers.

Train

Objectives

Deepen the knowledge and skills of cluster managers and teams to provide improved and precise support for members of their ecosystems around the challenges of Green Manufacturing

Help manufacturing companies to assess their needs for new skills related to Green Manufacturing and guide them towards the relevant vocational training offers and providers

Actions

- 10 capacity-building workshops,
- Joint transregional “Green Manufacturing” service offer,
- Development of a Service Portfolio,
- Train vouchers.

Go International

Objectives

Provide services and tools to manufacturing companies to create opportunities for international development in terms of business and innovation around Green Manufacturing

Actions

- Development of a Service Portfolio
- Explore vouchers

EUROPEAN STRATEGIES FRAMEWORK

The world economy and society are undergoing major changes affecting the way we live, work and behave. The recent crises (COVID-19 pandemic, the war against Ukraine) and other disruptions highlight the need to strengthen the European industry. They have also reinforced the need to address key societal challenges like sustainability. An unprecedented increase in the speed of development in science and technology, fast diffusion of knowledge, the scarcity of resources and a new generation of consumers will drive a new paradigm shift at global level and will pose new challenges and opportunities for European manufacturing sectors and stakeholders. These changes are all the more important as European industry must not lose its ambitions in terms of competitiveness, productivity, and technology leadership. Environmental awareness is increasing and will remain a strong force for future manufacturing development. An increasing proportion of the new generation consumers are more environmentally sensitive, shifting their consumption patterns towards the sharing paradigm (e.g., sharing cars instead of owning a car) and “circular” value streams.

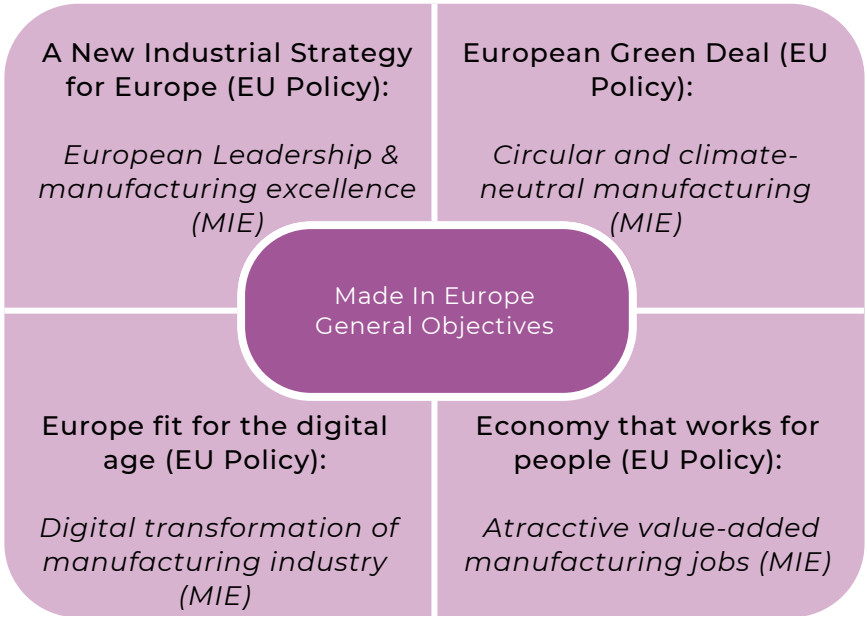
The GEMSTONE project is part of a particular European political context and aligns its thoughts and objectives with the ambitions of the European Union in terms of green transition for industry. The EU is the locomotive of the green transition at global level by proposing ambitious strategies, standards and objectives whose the Green Deal is the keystone of the policy and strategic agenda accross the continent. Its implementation has major repercussions for manufacturing.

By 2050, the EU is committed to achieving the ultimate goal of climate neutrality, delivering on the commitments under the Paris Agreement. The Green Deal gathers several policy initiatives that all have a major impact of the future development of European industry and compel actors in industrial value chains to amplify their efforts to reach the objectives set up by the European Commission: Fit for 55, EU biodiversity strategy for 2030, ‘Farm to fork’ strategy, Circular economy action plan, A new industrial strategy for Europe… Even more recently, published in February 2023, the Green Deal Industrial Plan for the Net-Zero Age underlines the «once in a generation opportunity to invest in the clean energy economy and industry of the net-zero age» and «aims to simplify, accelerate and align incentives to preserve the competitiveness and attractiveness of the EU as an investment location for the net-zero industry ». This European strategic corpus finds concrete meaning when the industrial ecosystems and the manufacturing players appropriate it and set up initiatives for collaboration and emergence of projects.

Two partnerships associating EU and associated countries, the private sector, foundations and other stakeholders in order to deliver on global challenges and modernise industry are well in line with the ambitions of GEMSTONE.

MADE IN EUROPE:

it aims to address the entire manufacturing value chain in Europe and concentrate on spreading manufacturing excellence among companies, especially SMEs and including product design, engineering and manufacturing start- and scale-ups. This partnership will guarantee the competitiveness, sustainability and sovereignty of Europe's manufacturing industry, defend Europe's technology leadership in the world as well as the prosperity and well-being of employees, consumers, and society.



Made In Europe General Objectives

PROCESSES4PLANET – TRANSFORMING THE EUROPEAN PROCESS INDUSTRY FOR A SUSTAINABLE SOCIETY:

it aims to make European energy intensive process industries circular and climate neutral by 2050 and enhance their global competitiveness. The systemic shift required to green transition calls for more than technological innovation.

Processes4Planet 10 target sectors

The notions and concepts developed and mentioned in all these documents will be an integral part of the reflections and proposals issued by the GEMSTONE project, which aims to be a tool for manufacturing companies, a concrete manifestation of European strategies and policies.

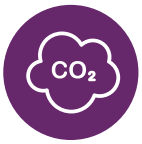
MANUFACTURING AND GREEN MANUFACTURING

Manufacturing is the backbone of the European economy. In 2019 the manufacturing sector accounted for two million enterprises, €2,078 billion in gross value added, and 32.1 million jobs in the EU-27 area.[1] The European Union is the world's biggest exporter of manufactured goods and is a global market leader for high-quality products. Around 10 percent of all enterprises in the EU's non-financial business economy are classified as manufacturing.[2] Machinery, transport equipment and chemicals are responsible for the highest share in European exports.

Manufacturing can significantly contribute to sustainability, on the other hand, manufacturing has high impacts on consumption of resources and pollution:

it consumes the 30% of energy produced

it uses raw materials and other natural resources as input (on the last century, the world extraction of raw materials was multiplied by 10 – from 7 to 68 billion tons).



it generates environmental emissions (manufacturing remains the first cause of CO2 gas emissions in Europe in 2021, representing about 21% of the total CO2 gas emissions).[3]

In this light, GREEN MANUFACTURING is a top-priority for Europe

GREEN MANUFACTURING CHALLENGES

Europe is a global leader in knowledge production, also in the field of sustainable manufacturing technologies and methods. It has also an advanced environmental culture and regulation in terms of sustainable and green manufacturing. But

- There are historical weaknesses in bringing new knowledge in industry
- The fragmentation and vast number of SMEs make even more complicated the innovation process.
- Manufacturing has high impacts on consumption of resources and pollution.

[1] European Commission (2019). Advanced Manufacturing. Accessed in February 2023.
[2] Eurostat (2018). Manufacturing Statistics – NACE Rev. 2. Accessed in February 2023
[3] ManuFUTURE Vison 2030: Competitive, Sustainable and Resilient European Manufacturing, Report from the ManuFUTURE High-Level Group, December 2018, ISBN 978-989-95853-7-9.

GREEN MANUFACTURING CHALLENGES

In January 2023, the project members organized feedback sessions to clarify what are the challenges faced by European SME`s in order to implement the transition to green production. Most of the participants pointed out that there is a lack of a specific support system, both financial and regulatory, which would stimulate or even oblige them to transform their business model in more sustainable ways. The need for common labels and certificates (as long as they reflect a real development process that respects the environment and people) was emphasized. Thus, improving the value of the company's image and maintaining competitive advantages in the market. The main challenge areas were defined:

- need for financial support (develop better targeted and personalized strategic support offers);
- unpredictable and fluctuating electricity and heating prices, availability of raw materials (especially in times of crisis);
- need to establish a better sharing of experiences, good practices (but also failures) between actors of the ecosystem;
- securing the supply of raw materials (need to rethink its supply by changing its materials to find solutions closer to the place of production);
- limited access to specialists in who can justify the company that will be affected by the transition to more sustainable production (strengthen support for companies, set up reliable indicators, raise awareness on approaches such as LCA);
- create/maintain employment and its quality/meaning for workers (attractiveness issues are a challenge for the industry, particularly among younger generations who are better aware and more able to make employment choices related to personal beliefs);
- training, business reflection-creation of value (lack of training, lack of attractiveness of the industrial sector, difficult work organization);
- changing the paradigm of consumption, accelerating awareness;
- difficulty of making customers understand and assume price increases (the commercial benefits are insignificant, little business impact of labels and certifications);
- unclear support systems and insufficient benefits to introduce green energy technologies in the company (there is a lack of knowledge about choosing the most appropriate technologies and or it is too costly to obtain it);
- Reduce waste production (track recoverable waste sources and oblige manufacturers at all levels to provide the corresponding information);
- Non-existence or lack of knowledge of recycling channels (Too unresponsive waste management companies regarding waste sorting).

MANUFACTURING

Manufacturing is a complex ecosystem covering vast range of activities and production techniques from small and larger companies, creating a strong capacity to deliver high added-value solutions through constant innovation and, hence, creating jobs and sustainable growth. Manufacturing enables many high added-value services justifying the creation of up to two indirect jobs for each direct job in manufacturing.

- product design
- software development
- supply chain & logistics
- other support services

GREEN MANUFACTURING

Green manufacturing is both a path and an end combining redesigned production processes and environmentally friendly operations covering all stages and all actors of the manufacturing value chains, from design to end of life, and enabling the transition to truly circular business models and the emergence of longer-lived processes, products or equipment in existing and emerging value chains.

Green manufacturing is a global approach to be understood in the multitude of its challenges, objectives and impacts on the use of energy resources, the consumption of raw materials in a finite world context, the reduction of air pollution, water and soil, waste management, the balance of biodiversity... These multiple aspects, the consideration and evaluation of which are necessary to make any industrial approach greener, imply that the notion of ecosystem is at the heart of heart of green manufacturing reflections by integrating the place of the human, as a citizen and worker, and that of the territory in these reflections.

GREEN TRANSITION FOR MANUFACTURING

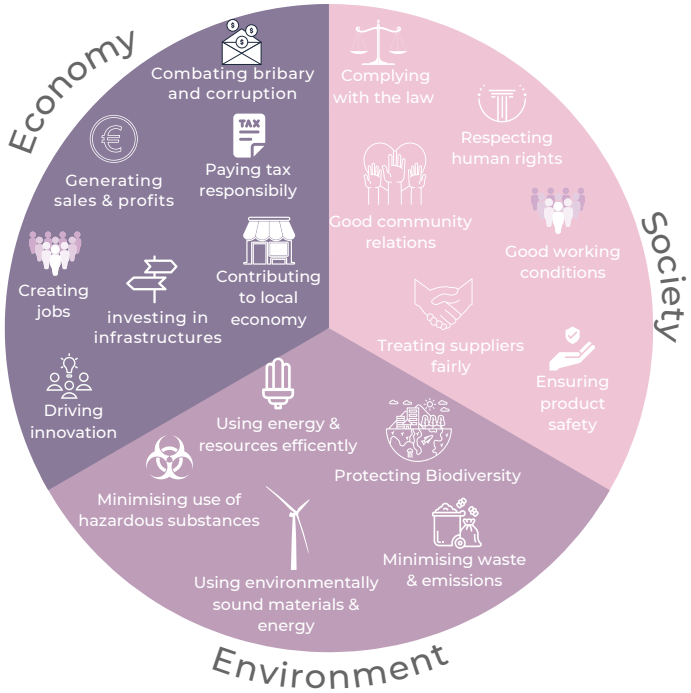
Green manufacturing has an essential role towards green transition. Europe's new growth strategy The European Green Deal aims to make Europe climate neutral by 2050, boost the economy through green technology, create sustainable industry and transport, and cut pollution. In other words, Green transition aims to use turning climate and environmental challenges into opportunities that will make the transition just and inclusive for all.

GREEN MANUFACTURING TOOLS

Green manufacturing or sustainable manufacturing can be defined as a method for manufacturing that minimises waste, reduces the environmental impact through product design, process design and operational principles. In order to be able to effectively promote the transition to greener production, it is necessary to use already existing tools, the systems of which are clearly identifiable for more sustainable production or service provision.

SUSTAINABLE MANUFACTURING

Sustainable manufacturing promotes the removal of industrial by-products through efficient and ecologically-friendly processes. In other words "Manufacturing goods and services using processes and systems that are non-polluting, conserving of energy and natural resources, economically viable, safe and healthful for employees, communities and consumers, and socially and creatively rewarding for all working people".

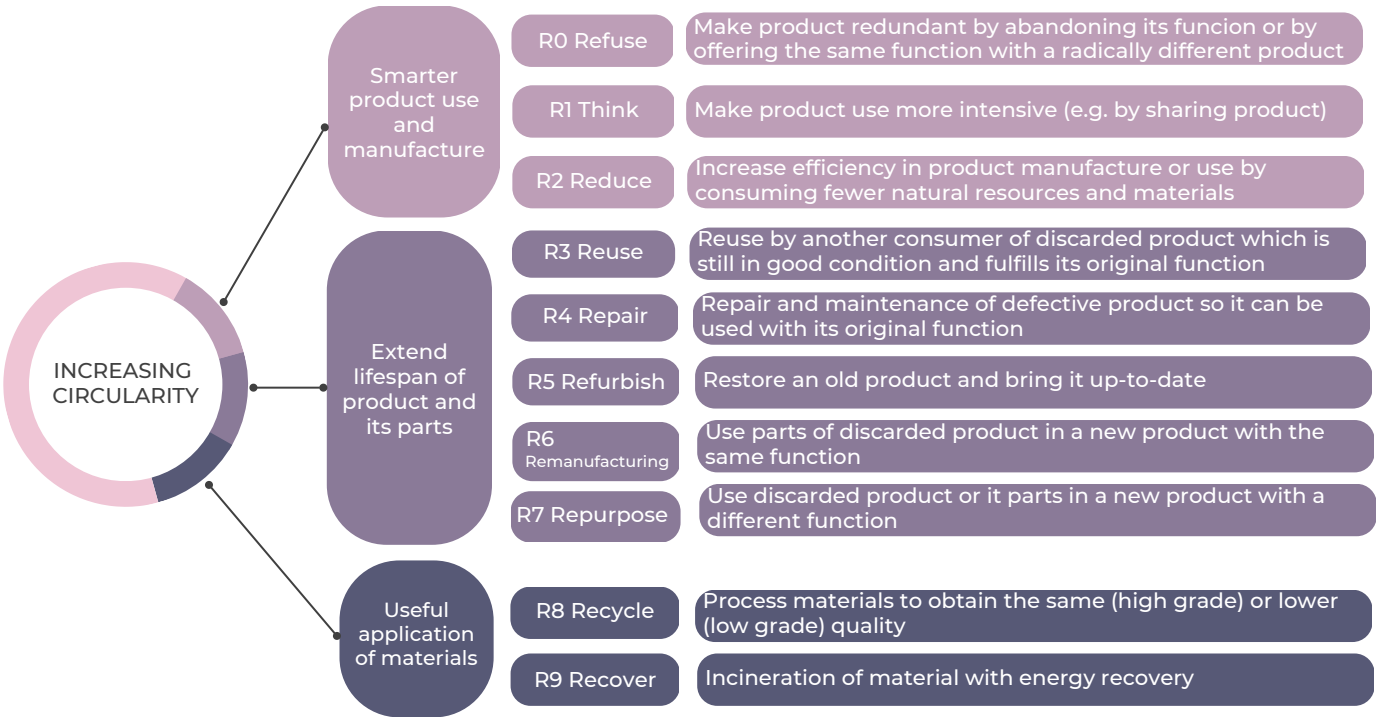


Three-dimensional aspects of sustainable manufacturing

Sustainable product design and manufacturing are critical for rapid industrialization and providing consumers with preferable products. At the moment, product design and manufacturing are struggling with the challenge of durability which is also regarded as an essential component of the present economic system. Sustainable product design and production have become a social and environmental concern, enforced mainly by government legislation and climate impacts. For this reason sustainable manufacturing may be defined as a system that integrates product and process design issues with issues of manufacturing, planning and control in such a manner as to identify, quantify, assess, and manage the flow of environmental waste.

FROM 3R TO 9R

Sustainable manufacturing must integrate sustainable activities at all levels of manufacturing as product, process and system. Currently we are well known with the 3R as reduce, reuse and recycle, but green manufacturing insists on more creative ways to combine knowledge and systems to achieve more R's, such as, reduce, reuse, recycle, recover, redesign, remanufacturing, repurpose, refurbish, refuse, etc.



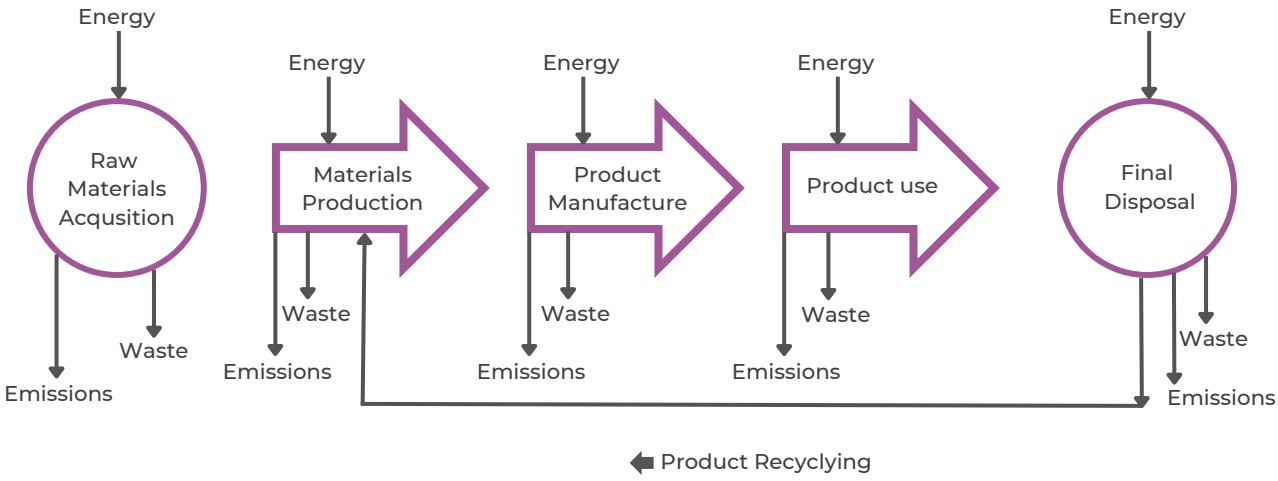
9R dimension

LIFE CYCLE ANALYSIS

Life Cycle Assessment (known as LCA) is a tool that aims to identify and assess all the environmental impacts associated with the production process of a product or service at all stages of its life cycle. These environmental impacts are assessed from the extraction of raw materials, through manufacturing, distribution, use, recycling and the end of life of the product. The aim is to analyse the impact of all inputs and outputs of the material flows used and the optimal use of resources. The purpose of LCA is to provide a decision-making tool for business managers by inviting them to consider the production system in a holistic and systemic way.

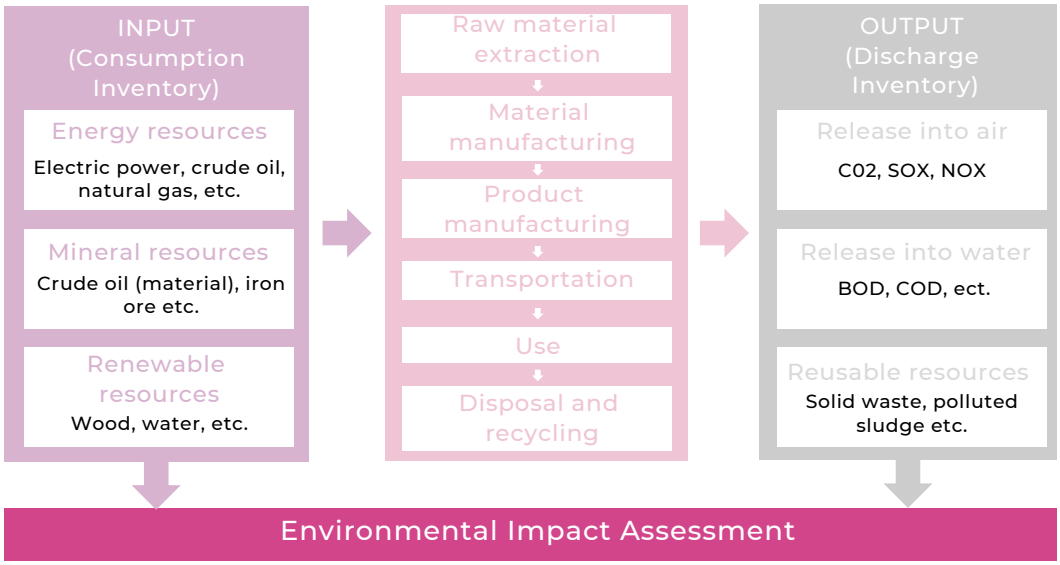
LCA assessments identify the overall benefits and costs of a product or process, enabling decision-makers to choose the most efficient solution. The LCA process is a systematic approach that includes four implementation phases: definition and scoping of objectives, inventory analysis, impact assessment and interpretation.

Some aspects of LCA are integrated into the ISO 14000 series of environmental management standards, in particular ISO 14040 and 14044.



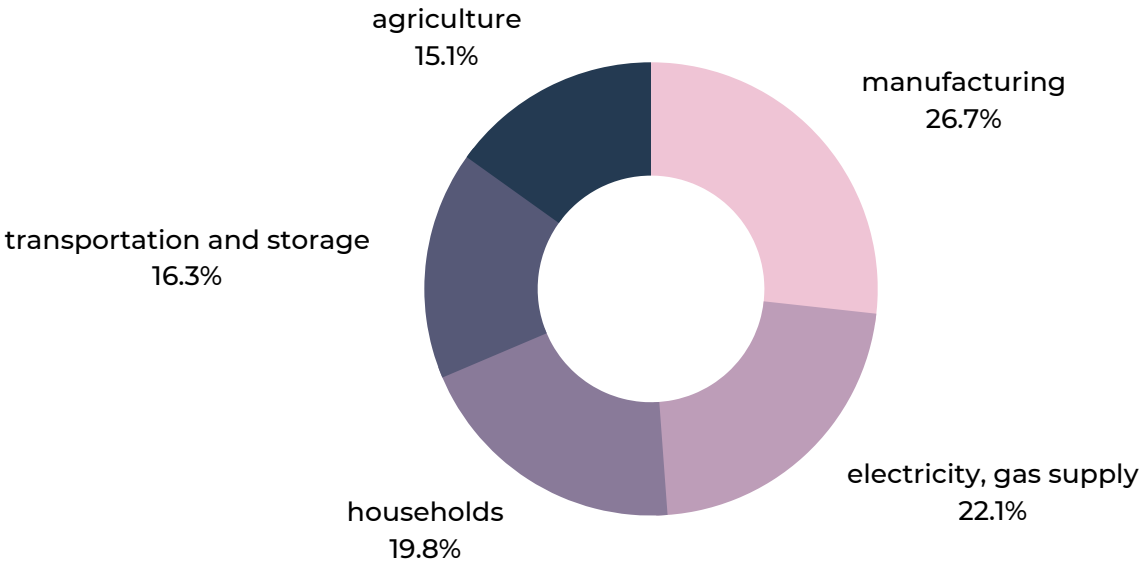
LCA is concerned with identifying the environmental impact of a given product or process at each of these life stages. Full implementation of LCA allows the engineer to make a quantitative comparison of the stages of a product's life, determine where the greatest environmental benefit is to be gained, and ultimately monitor the long-term effect of changes in design and/or manufacturing.

MANUFACTURING USES RAW MATERIALS AND OTHER NATURAL RESOURCES AS INPUT



The environmental impact - depletion of resources, global warming, acid rain and other phenomena - is quantitatively analysed based on data on consumption and discharge at each stage.

MANUFACTURING GENERATES ENVIRONMENTAL EMISSIONS



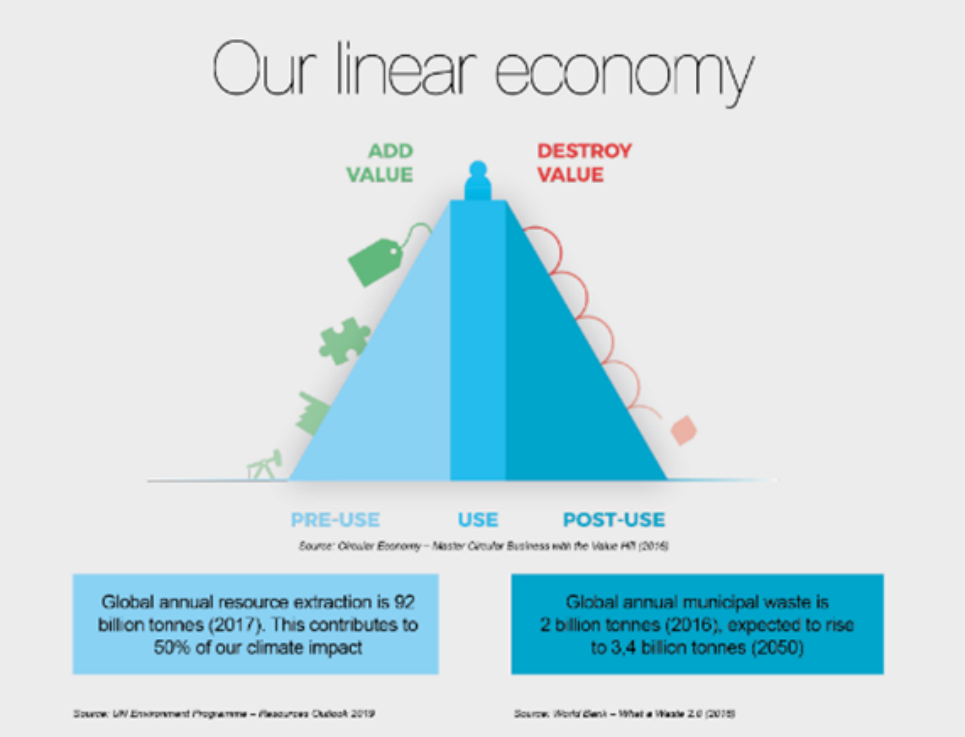
EU economy greenhouse gas emissions in Q2 2022

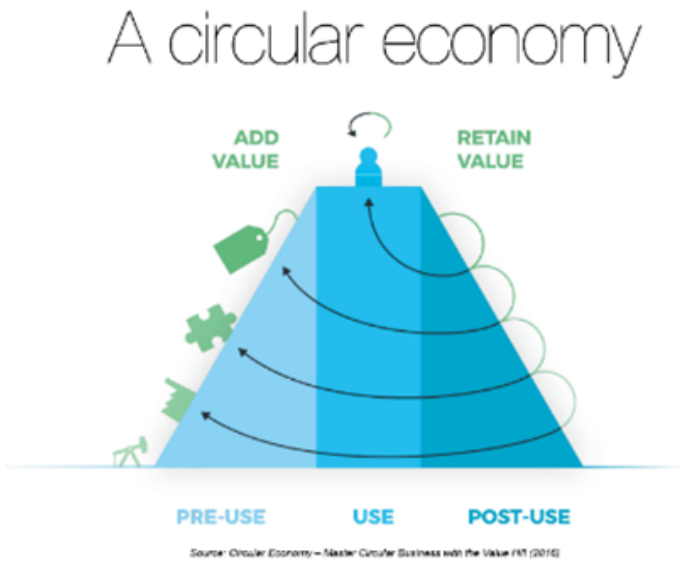
Sustainability and carbon management is one of the most pressing issues of today. To achieve the goal of climate neutrality set by the European Union, it is important that the principles of green manufacturing are integrated in all stages of production, and more resource-efficient and cleaner production processes are implemented. The first step towards reducing a manufacturing industry's carbon footprint is to understand a product's carbon footprint, which measures the total greenhouse gas emissions produced by a product. By evaluating the environmental impact of each manufacturing step and supply chain process, we can assess which activities are contributing to negative impacts. By integrating resource-efficient manufacturing processes, we ensure emissions can be reduced. For example, to use renewable energy resources by integrating eco-design principles, material substitution, remanufacturing plans, additive manufacturing and reduce yield losses.

CIRCULAR ECONOMY

The circular economy plays a vital role in the transformation to green manufacturing, in order to make both existing products more durable over time, in other words, the product's lifetime longer, and to inspire the development of new products and business models.

The University of Delft has developed graph which insists on the "value" of the product: the shorter the way is, the more valuable it is for a company. As well for the company as for the planet, it is more profitable to first repair, then to reuse/redistribute, refurbish, remanufacture and finally recycle.





The Value in a Circular Economy

Green manufacturing is a completely new solution, which will be introduced when designing future sustainable products enabling durability, energy-saving, and the replacement of scarce or hazardous materials. Manufacturing system capabilities need to follow product and material roadmaps to enable the viable and sustainable manufacturing of high-tech products. Circular economy roadmap aims to enhance parallel product and manufacturing engineering and the design for end-of-life/reuse/recycling, which contributes to sustainable products, services and manufacturing networks.

ECODESIGN

Eco-design consists of the systematic integration of environmental aspects from the design and development of products (goods and services, systems) with the objective of reducing negative environmental impacts throughout their life cycle for equivalent or better service. This approach from the very beginning of a design process aims to find the best balance between environmental, social, technical, and economic requirements in the design and development of products.

According to the European Commission the current Ecodesign Directive 2009/125/EC has a long track record of delivering benefits to businesses, consumers and the environment. In 2021 the impact of the current ecodesign measures, covering 31 product groups, saved EUR 120 billion in energy expenditure for EU consumers and led to a 10% lower annual energy consumption by the products in scope. The proposal for a new Ecodesign for Sustainable Products Regulation, published on 30 March 2022, is the cornerstone of the Commission's approach to more environmentally sustainable and circular products.

The framework will allow for the setting of a wide range of requirements, including on


product durability, reusability, upgradability and reparability


presence of substances that inhibit circularity


energy and resource efficiency


recycled content


remanufacturing and recycling


carbon and environmental footprints


information requirements, including a Digital Product Passport

The new "Digital Product Passport" will provide information about products' environmental sustainability. It should help consumers and businesses make informed choices when purchasing products, facilitate repairs and recycling and improve transparency about products' life cycle impacts on the environment.

CIRCULAR DESIGN STRATEGIES

There are several strategies on how to incorporate circular economy principles into the design process. According to the European Commision It is estimated that over 80% of all product-related environmental impacts are determined during the design phase of a product. Eco-design aims at reducing the environmental impact of products, including the energy consumption throughout their entire life cycle.

Design to reuse

Design to repair

Design for disassembly/modularity

Design for rent

Design for multifunctionality

Design for access

Design with unwanted resource

Design to optimize

Design for material recovery

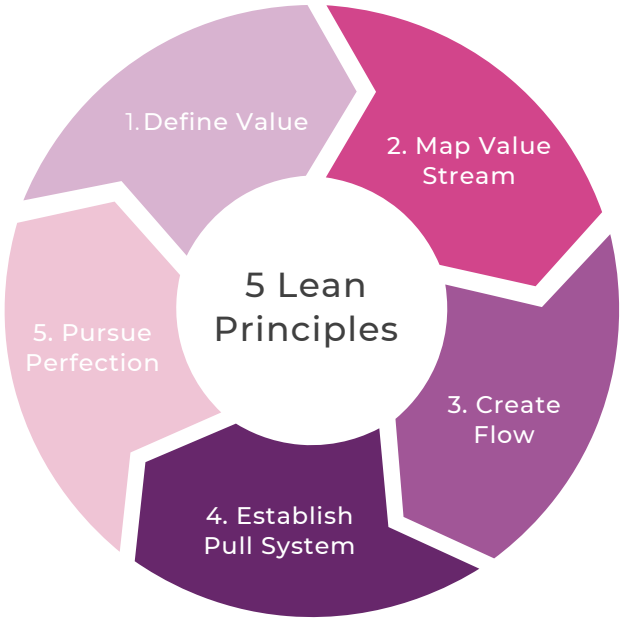
Design for regeneration

Design for the essential

LEAN MANUFACTURING

Towards green transition for the manufacturing industry one of the important approaches to look at is lean manufacturing which aims to reduce waste from the production process to cut costs and increase efficiency. Lean Manufacturing has its origins in the Japanese automotive industry, which aims to reduce waste and eliminate activities that are not valuable in the production process.

There are many benefits that arise from using Lean Manufacturing techniques such as waste minimization, cost reduction, meeting promised dates and improving quality. The commonly used five principles of lean manufacturing include defining value, mapping the value stream, creating flow, using a pull system, and pursuing perfection.



The five principles of lean manufacturing

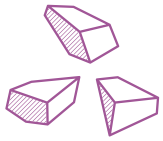
Already, Europe is moving beyond Lean Manufacturing with proposals that address the need of European manufacturing companies for a new, cost-effective model to transform the company into a lean environment. A system that responds to customer and market demands for added value, including sustainability, and customization. in terms of innovation and adaptation, quality and sustainable and affordable products. It will be called the Lean Product and Process Development (LeanPPD) paradigm.

PATHS TOWARDS GREEN MANUFACTURING

Redefining/defining the development of products and services

The new product development is a process that all new businesses and entrepreneurs follow to generate a customer-focused product that thrives in today's competitive marketplaces. When developing new product, design stage provides for the early identification of ecological traits in the production process. Eco-design considers environmental aspects at all stages of the product development process, striving for products with the lowest possible environmental impact throughout the product life cycle. This means that products and their packaging as well as services are designed to be safe and environmentally sound throughout their life cycle.

Raw material substitution



Replacing hazardous waste, environmentally damaging chemicals, non-renewable or limited materials with greener alternatives is one of the key issues of the green transition. The aim is to develop new, greener materials that emit less CO2 into the atmosphere, less waste, and less pollution. The ultimate goal is to develop materials that are more environmentally friendly and safer to process and use. Eco-friendly materials have made significant progress in cleansing the atmosphere, reducing pollution, substituting toxic materials, decreasing waste, converting components into resources, and utilising renewable resources. Research and innovation activities are carried out to develop new, innovative and sustainable bio-based materials to improve the circularity and recyclability of products. To be sustainable, the production of biobased products must be integrated into a life cycle assessment (LCA) and eco-design strategy. Currently, there is a growing interest in the development of sustainable biobased composites as a "new alternative to conventional non-renewable synthetic fibres such as (...) carbon-reinforced composites".

More resource - efficient production processes (energy, water, raw materials)

Resource efficiency in production processes is a function of the relationship between product output and resource input. It is an assessment of how efficiently resources are used to add economic value.

To be more environmentally friendly, competitive and profitable, it is necessary to use fewer resources and to optimise them. There are three main ways to improve the efficiency of production processes: "eco-efficient product design, resource-efficient manufacturing processes at the plant level and integrated optimisation of the manufacturing value chain". Through the twin transitions of green and digital, companies could reap the benefits of technological innovations. The introduction of more environmentally friendly techniques and infrastructure into the manufacturing process can become an integral part of the implementation of innovative methods. Technological innovation means taking an existing product and transforming it to meet the new requirements of the ecological transition so as to reduce waste of energy, water, raw materials and all operating supplies.

Cleaner production process

Cleaner production is the process by which resources and energy are used "efficiently, along with the elimination of toxic raw materials and the reduction of toxicity of all emissions and solid waste". Pollution and emissions include all chemical substances (solid, liquid and gaseous) that are caused by production and use, as well as all emissions to air, water and land, including emissions and excess heat from energy consumption. It involves reducing the amount and toxicity of emissions and waste at source during the production process as well as the conservation/reuse of energy sources such as heat. The methodology aims to anticipate and prevent emissions of pollutants. Appropriate technological innovations can be used in support by helping to reduce or eliminate pollution and waste at source through, among other things, technical improvements in the production process and use of materials.

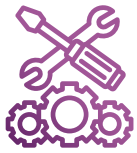
Waste management and promotion of product reuse and recyclability

The transition to a circular economy implies that "the value of products, materials and resources is maintained as long as possible, and the amount of waste generated is minimised". Waste is generated at all stages of the life cycle of materials, namely extraction, production and distribution, consumption of products and services, and then processing. To be cleaner and greener, manufacturing companies need to adopt a waste management strategy that promotes the reuse or recyclability of products. Reuse is an operation by which waste is reused, possibly by diverting its original use. Recycling is the operation by which the raw material of a waste product is used to make a new object. Technological innovation can be useful in developing innovative recycling tools. Digital tools can be deployed to support a waste management strategy. For example, "Digital technologies can track products, components and materials and make the resulting data securely accessible".

The development of new business models

The transition to a circular economy will accelerate in the coming years and is expected to become the dominant model by 2030 according to European strategy projections. Companies are being asked to rethink their business model in order to remain competitive in the future. The circular economy implies thinking about new business models that reduce the use of resources, limit pollution and waste production. The sharing economy is one of them. It is a concept that values renting or borrowing instead of buying or owning goods. It may involve sharing industrial equipment such as a conveyor belt, a forklift, machinery or space such as warehouses. Another model called "Product as a Service" aims to have the customer buy a service for a limited period of time, while the supplier retains ownership of the product and has an incentive to maintain, service, improve and transform it at the end of its use. Finally, industrial symbiosis is the process whereby the waste or by-products of one industry or industrial process become the raw materials of another. In this context of developing new business models, it is certain that the digital transition should play a major role in the logistical tracking of products.

Building Maintenance



Improved inventory planning, better tracking and monitoring of the production process, lowering damage from spills, leakage, and drag-out, and ensuring adequate equipment maintenance are all examples of building maintenance.

Improved Productivity

Improving productivity requires changing factory management to reduce waste, conserve raw materials, and utilize waste products. In addition, establishing a viable business in the manufacturing sector necessitates high levels of efficiency. This ensures that you meet your output targets on all occasions, as your bottom line relies on strong production to remain healthy.

BENEFITS FROM IMPLEMENTING GREEN MANUFACTURING

Anticipate future regulations

The world is now living extraordinary challenges and uncertainty. We can experience it directly with the various crisis we face related to pandemic, political and security, climate change and environmental degradation. Successful measures used in the past will not be sufficient, meaning that new measures will need to be implemented to maintain the economy and minimise the impact of the climate change and its consequences in the global society. As the COVID-19 crisis has shown, the factories that were the more resilient were the ones that had invested in advanced manufacturing technologies. It can be foreseen that investments in Green Manufacturing will help to address the disruptions and anticipate future environmental regulations.

Don’t miss a decisive turn: “Green” industry

Since the first industrial revolution, manufacturing continuously evolved. The industrial revolutions have always echoed the world economy and social transformation. European manufacturing is nowadays at the center of a twin ecological and digital transition. Industry is invited to play a role alongside other actors in meeting the challenges of the climate crisis and biodiversity. The sector is both driver and subject to these changes. Those transitions drive for structural changes and transformation of systems of production, management, and governance. The digital tool associated with an objective of ecological transition will lead to the development of a more advanced and more precise technology; the products and services proposed will necessarily be more ecological and certainly of better quality. These transformations will enable companies to have more efficient and resource and energy saving processes.

Improve attractivity of Manufacturing Industry sector

The green transition brings meaning to many people, especially the young generation. Political responses to the crisis, which encourage twin transition as support for growth and recovery, promote the emergence of new expertise and professions directly related to ecological transition. Manufacturing industry suffers in many European countries of strong difficulties for recruitment and a lack of attractiveness. Manufacturing is a strong-evolving industry, that helps raise the standards of living from society. Engaging into green transition may help to improve visibility of opportunities and meet the professional ambitions of people.

More appealing for your clients

Business-to-business (B2B) transactions are common in a typical supply chain as companies sell goods and products such as other inputs for use in manufacturing processes. Since the consumer is both at the beginning and at the end of the entire value chain cycle, any changes in the value chain in terms of consumer needs and expectations can affect the functioning of the value chain. Under the influence of global trends, consumers are also becoming more environmentally conscious and paying attention to the environmental impacts of companies. By implementing green manufacturing, companies can help save the Earth's natural and non-renewable resources and thus improve environmental conditions, for example, they adhere to the standards of the International Organization for Standardization (ISO), which are focused on companies' financial, social and environmental preservation. ISO standards provide for cooperation with other companies, such as one involving a manufacturer and a wholesaler or a wholesaler and a retailer, which ensures the delivery of a service or product in accordance with the quality, along with the ability to monitor the impact of the product on the environment and ensure the sustainability of our product at all stages of the supply chain.

Positive impact on your staff

When the administration acknowledges and even honors these eco-friendly accomplishments, it motivates employees to work harder. It reminds them that they are positively impacting the market and the ecosystem. The company's societal commitment is an important criterion that is often considered when choosing a position, even if it can be behind other criteria such as the remuneration or the interest of the missions proposed. This criterion could become more and more important, as currently the trends show that the "green" and "greening" professions (executives and non-executives) attract profiles of young graduates or experienced executives. For the staff already in place, motivation and involvement of workers can be enhanced when they have the feeling to contribute to accomplish positive impacts on the market and the ecosystem, and even more largely to the societal challenges related to environmental issues. Working in a company that has environmental protection as a value can help employees give meaning to their work and make them proud to be part of the organization.

Production optimization and financial benefits

Continuously improving performance will improve production processes and operations—quality control in the manufacturing process and fewer steps in the manufacturing process. The resilience potential (ability to tackle economic shocks and achieve long-term structural change in a fair and inclusive way) and the optimisation that can be brought by Green Manufacturing, especially via leverage of big data, automation, remote sensing and steering.

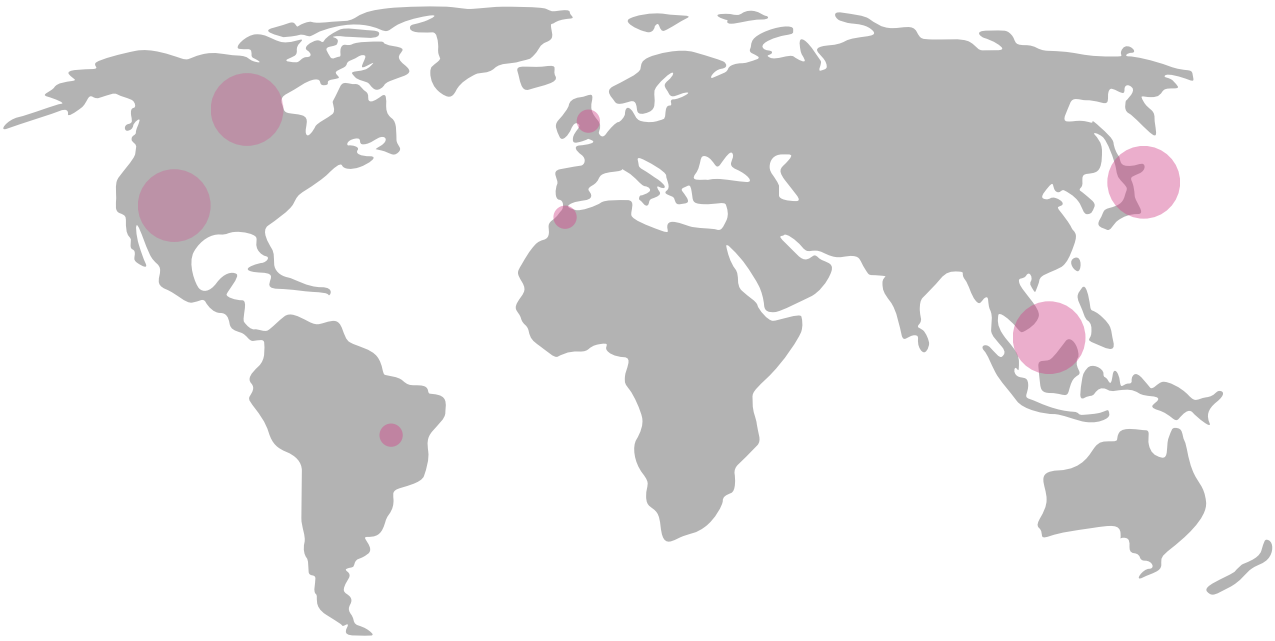
Greater control of production processes, with more data, data analytics, better predictive or forecasting models, may contribute to fighting inefficiencies, defects in products, and thus reduce waste, both of materials and energy. Sustainable production monitors every stage of the manufacturing method and applies the best strategy to reduce cost and unnecessary errors while saving from more efficient use of resources. Increased profit margins are achieved by lowering overhead due to being more sustainable. Another way that sustainability can help enhance profit margins is by reducing waste production and reducing the amount of expenditure spent on waste management.

Seize new business opportunities

Green Manufacturing can lead to new business opportunities. For example, Industrial symbiosis is the process by which wastes, or by-products, of an industry or industrial process become the raw materials for another. Concretely, it is a collaboration between two (or more) companies from different sectors to generate new business opportunities by exchanging materials, energy, and water or re-inserting waste into the value chain as by-products after its production. Direct benefits can be identified for companies such as: sharing of common services management, leading to potential reduction of costs related to infrastructures (water, energy and waste); leverage of industrial parks; collaboration between stakeholders within a region; new revenue from the sale of waste and by-products; reduction of use of virgin raw materials.

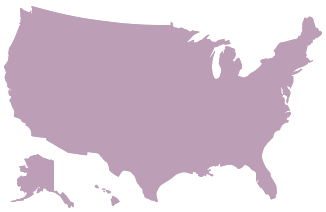
INTERNATIONALISATION

Internationalisation is important when achieving global goals, collaborating and exchanging best practices, to develop tools that boost Green Manufacturing business solutions, strengthen resilience and to drive the recovery growth of European SMEs. To facilitate SMEs internationalisation strategy, the GEMSTONE project will support SMEs participation in business fairs and other international events deemed interesting for their activities. The target countries are **North America** (Canada and USA), **Japan, ASEAN countries** (Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei, Vietnam, Laos, Myanmar, Cambodia). The open call for open call "EXPLORE" will consist of financial support of reimbursement for travel costs (flight ticket), accommodation (hotel costs) and business fair tickets. The selection criteria will be based on the fit of the participant internationalisation strategy and its goals for the mission and vouchers will give priority funding to companies that apply for the target countries.



Innovative and sustainable manufacturing strategies and tools at European level cannot be designed without considering its position and potential cooperation at global level. New levels of cooperation in research and innovation will emerge at the global level in response to common global needs. International cooperation is needed to support Europe's position and leading role in manufacturing, especially now when we have to face the growing costs of materials, resources, energy, research and Innovation and the lack of qualified employees and talented specialists. Therefore, it is important to identify countries outside the EU that have a strong competitiveness in terms of green manufacturing or that invest heavily in their development, and to assess their strengths and evaluate the possibility of cooperation with the EU based on complementarity, synergy and economy.

In recent decades, several countries have implemented strategies for the development of the technology and innovation economy, thanks to which new economies have emerged in countries such as China, Korea, South Africa, etc. Above all, the financial crisis clearly highlighted the importance of manufacturing as the main pillar of a competitive and prosperous economy, which motivated a strong re-industrialization movement at the global level. As an example, GEMSTONE target countries - North America, Japan, ASEAN countries are investing in research and development, innovation and education, as well as digital transformation. We will look closer at each target region to explore best practices and strategies for their green transition.



UNITED STATES OF AMERICA (USA)

USA is one of the most dynamic economies in the world, with a huge investment in manufacturing, with a strong automotive and mobility sector, aeronautics/defence and well-defined areas of competences. US is investing in green manufacturing, throughout improvement of engineering, sustainable manufacturing and green solutions.

The USA is a home for some of the most innovative companies in the world and green manufacturing is a major subject across all manufacturing sectors. The Advanced Manufacturing Partnership was launched to secure the US leadership in emerging technologies that will create high-quality manufacturing jobs and enhance US global competitiveness. It includes initiatives such as the coordination of all manufacturing related research programs, the creation of more than a dozen national manufacturing innovation networks, the provision of incentives for reshoring manufacturing operations back to the US and funding to fill the gap between fundamental research and commercialization. Manufacturing USA, a national network of 14 manufacturing innovation institutes, was created. Through Manufacturing USA, industry, academia and government partners are leveraging existing resources, working together and co-investing to nurture manufacturing innovation and accelerate commercialization. These institutes cover areas such as: Photonics, electronics, additive manufacturing, robotics, biotechnology, sensors, digitalisation, composites and energy.

CANADA

Canada has an excellent advanced manufacturing market, particularly around Quebec and Ontario. Green manufacturing is a key concern with many innovative companies in the area.

The Government of Canada remains committed to investing in local businesses and organizations as they adapt, become more sustainable and create jobs for the future. Canada has several initiatives and programmes that supports green transitions such as:

- CME SMART Prosperity Now - this program allows manufacturers with an export focus to commercialize new technologies, enter new domestic and foreign markets, invest in sustainable and green technology, purchase new or upgraded equipment and technology, and implement efficiency improvements;
- Excellence in Manufacturing Consortium - a unique not-for-profit organization dedicated to helping manufacturers gain a competitive 'Advantage through Excellence' emphasizing sustainability and the creation, retention and expansion of skilled manufacturing jobs here in Canada.
- Association for Manufacturing Excellence (AME) - The Association for Manufacturing Excellence (AME) is the premier organization for the exchange of knowledge in enterprise excellence. Members come together to explore Lean thinking and other enterprise improvement methods, exchange best practices and network in order to advance their careers and improve the competitiveness and overall value of their organizations.
- In 2022 initiatives such as Achieving Innovation and Manufacturing Excellence Green Initiative (AIME Green) were supported to up-skill and train the workforce to adopt green manufacturing solutions.

JAPAN

Japan has a strong manufacturing industry especially for clean and green manufacturing. Particularly it is well known for composite parts for diverse and lightweighting applications for improving environmental performance.

The Japanese Industrial Value Chains Initiative (IVI), as well as a Cross Ministerial Strategic Innovation Promotion (SIP) Programme focused on Innovative Design/Manufacturing Technologies, aim to promote manufacturing digitalisation. The Kohsetsushi Centres support SME manufacturers in technology development and innovation activities.

In 2014, the Japanese Prime Minister’s office promoted an Industrial Revitalisation Strategy putting the emphasis on the integration of advanced robotics and artificial intelligence in specialised supply chains, setting a goal to lead the world in “robots in the IoT era”. The Japanese Science and Technology Agency created the Programme ImPACT - Impulsing Paradigm Change through Disruptive Technologies, aiming to transform Japanese industry and society through the promotion of highrisk, high-impact R&D. The ImPACT programme has established 16 R&D programmes in areas such as ultra-thin and flexible tough polymers; green IT devices with long-life batteries; artificial cell reactor technology; and “Bionic Humanoids Propelling New Industrial Revolution.” Japan aims to achieve a “Society 5.0” in the future through the full use of technological innovation including IoT, AI and Big Data, derived from the fourth industrial revolution.

To achieve Society 5.0, industries must play a key role and the Japanese government announced the “Connected Industries” vision in 2017, a new concept framework in which industries will create new value added and the solutions to various problems in society through connectedness in various facets of modern life, including humans (in their roles as consumers and suppliers), machines, systems, companies.

According to the Japanese Ministry of Economy, Trade and Industry, five main areas are foreseen: Automated driving, energy management and mobility services, smart manufacturing and robotics, biotechnologies and materials, manufacturing plants and infrastructure safety management, using new technologies such as IoT and drones, and smart homes and life.

ASEAN COUNTRIES (INDONESIA, MALAYSIA, PHILIPPINES, SINGAPORE, THAILAND, BRUNEI, VIETNAM, LAOS, MYANMAR, CAMBODIA)

ASEAN countries are a strong region for manufacturing in general, but particularly on green manufacturing for mobility (and additive Manufacturing-World Reference). At the moment it is the most dynamic region in the world in terms of economic growth, huge investment in manufacturing. The region that shows its awareness of the climate change impacts as participation in the industrial transition. It has several free trade agreements between Vietnam and the EU, Free trade agreements between Singapore and the EU as well as USA.

The ASEAN 10 member countries are keenly focused on the adaptation of sustainability in manufacturing processes working together in ASEAN Comprehensive Recovery Framework (ACRF) that includes the transition towards a green and circular economy. ASEAN has developed the ASEAN Comprehensive Recovery Framework (ACRF) which serves as the consolidated exit strategy from the COVID-19 crisis. The approaches in this toolkit can support measures to promote transition towards a green and circular economy, an initiative of the ACRF implementation plan under the broad strategy on advancing towards a more sustainable and resilient future.

- In Malaysia: Credit Guarantee Corporation Malaysia (CGC) helps SMEs access funding by providing expert support, loan guarantees, financing facilities, and credit rating. While not specifically focussed on green investments, it aims to provide support to low carbon projects (Initiative, 2019[10]).
- In Indonesia: Indonesia’s Centre of Forest Development Financing (Pusat P2H) operates under the Ministry of Environment and Forestry. It provides soft loans to micro and small enterprises through a variety of structures, including directly and through intermediaries, and by establishing revenue sharing arrangements. It offers long payback periods (up to 16 years), grace periods, and below market interest rates.
- In Singapore, the Energy Efficiency Fund (E2F) supports businesses in improving environmental performance through a variety of different measures, including the resource efficient design of new facilities or major expansions, energy assessments for existing facilities, and support with the adoption of energy efficient equipment and technology.

Singapore is working on several interesting projects such as Eco-Solutions Manufacturing - Officially entitled the Green Lab, the facility aims to provide businesses with sustainable packaging solutions, such as biodegradable paper bags and compostable packaging – which is especially relevant for those operating in the food and beverage sector. Compostable bags are crafted from the recycled waste of cassava roots and other solutions that include packaging peripherals (banners, stickers, etc.) that are produced without the use of traditional chemicals, namely, polyvinyl chloride or PVC. Singapore is keen on achieving the goals set forth in the Singapore Green Plan 2030 as guided by the UN's Sustainable Development Agenda, these opportunities manifest well beyond that of the manufacturing industry, specifically in sectors like construction, real estate development, retail, etc.

GEMSTONE Project will allow explore other possibilities for companies to apply for funding for events in countries such as Brazil, Morocco and UK, if SMEs demonstrate the clear interest for their green transition.

CONCLUSION

The GEMSTONE project is part of a particular European political context and aligns its thoughts and objectives with the ambitions of the European Union in terms of green transition for industry. The EU is the leader towards green transition at global level by proposing ambitious strategies, standards and objectives whose the Green Deal is the keystone of the policy and strategic agenda accross the continent. Its implementation has major repercussions for manufacturing.

Joint Cluster Initiatives (EUROCLUSTERS) for Europe's recovery has developed GEMSTONE roadmap - a guide that defines the methods and tools necessary to help manufacturing companies identify their needs and the challenges in terms of green transition to achieve trans-sectoral and trans-European vision.

Roadmap methodology provides information:

- Green Manufacturing challenges on global and European level;
- manufacturing and green manufacturing definitions;
- tools and guidelines towards green transition for manufacturing;
- paths towards green manufacturing;
- benefits from implementing green manufacturing;
- internationalisation regarding Project target countries such as North America (Canada and USA), Japan, ASEAN countries (Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei, Vietnam, Laos, Myanmar, Cambodia);
- product innovation, process innovation and system innovation on issues related to green manufacturing in 5 identified industrial sectors: Aeronautics/Defence, Energy, Mobility, Agriculture/Agri-food, Materials.

The GEMSTONE roadmap will be shared with key players in manufacturing – European SME`s. Roadmap methodology provides information about support for "Train", "Innovation" and "Explore".

ANNEX

AERONAUTICS / DEFENCE

Challenge

Aeronautics is one of the most challenging industries to decarbonize. Very few other industries have as many challenges in reaching climate-neutral operations as aerospace, primarily because of the scale and the costs involved and the regulatory challenges of putting new technologies in the air. One of the most significant factors in addressing emissions is how an aircraft is powered through the air. Today, there's no other technology more efficient or economical than jet fuel. But jet fuel emits carbon. A return flight from London to New York City generates over 1 ton of carbon dioxide CO2 per passenger. That's nearly the same as what the average citizen in a developing country produces in a year.

The aeronautics industry is expected to grow substantially but faces challenges in decarbonizing as the world moves to net-zero emissions. Without action, the industry would contribute to significantly higher global CO2 emissions by 2050 and could face restrictions that could be detrimental to its revenues and jobs, such as the banning of flights less than 500 miles.

Decarbonization is a key business priority, as is developing alternatives and implementing environmentally sustainable practices. There are a range of solutions that have significant potential to drive meaningful emission reductions.

Two of them include **sustainable aviation fuels (SAFs)** and **electric propulsion:**
-SAFs are likely to be the best possible solution for reducing emissions in medium-to-long-haul flights;

-While electric propulsion could be the most feasible zero-emission solution for smaller aircraft and short-haul flights.

Product innovation

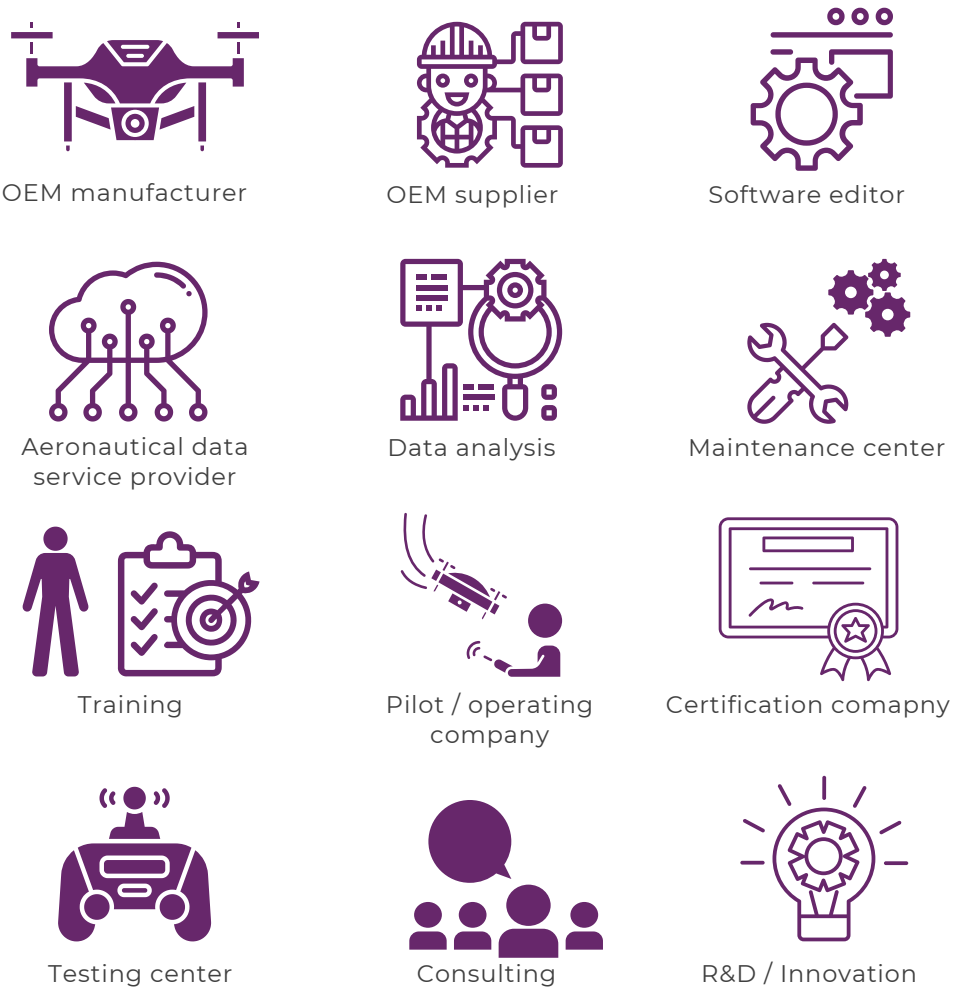
Sustainable aerospace manufacturing (reducing emissions) involves designing and building commercial and military aircraft through economically sound processes that minimize negative environmental impacts while conserving energy and natural resources.

The four main areas where sustainable practices can drive measurable improvements across the aerospace manufacturing value chain include improving product design and engineering using advanced technologies such as **digital twin**, **rapid prototyping,** and **additive manufacturing**; **ethically selecting** and **sourcing sustainable alternative materials;** forging the factory of the future by **combining smart technologies** and **green energy;** and **streamlining shipping** and **distribution through supply chain reconfiguration** and **rationalisation of trade routes.**

DRONE OPERATIONS

Following the Commission's Aviation Strategy of 2015, the EU adopted a comprehensive drone regulatory framework, contributing to the development of this promising sector. The Commission has since 2007 supported research and innovation to develop new drone technologies, including through the SESAR research and innovation programmes. Since 2021, thanks to a European partnership between the private and the public sector, the EU is investing more than €1.6 billion to accelerate the creation of a Digital European Sky, contributing to the safe integration of drone traffic within European airspace.

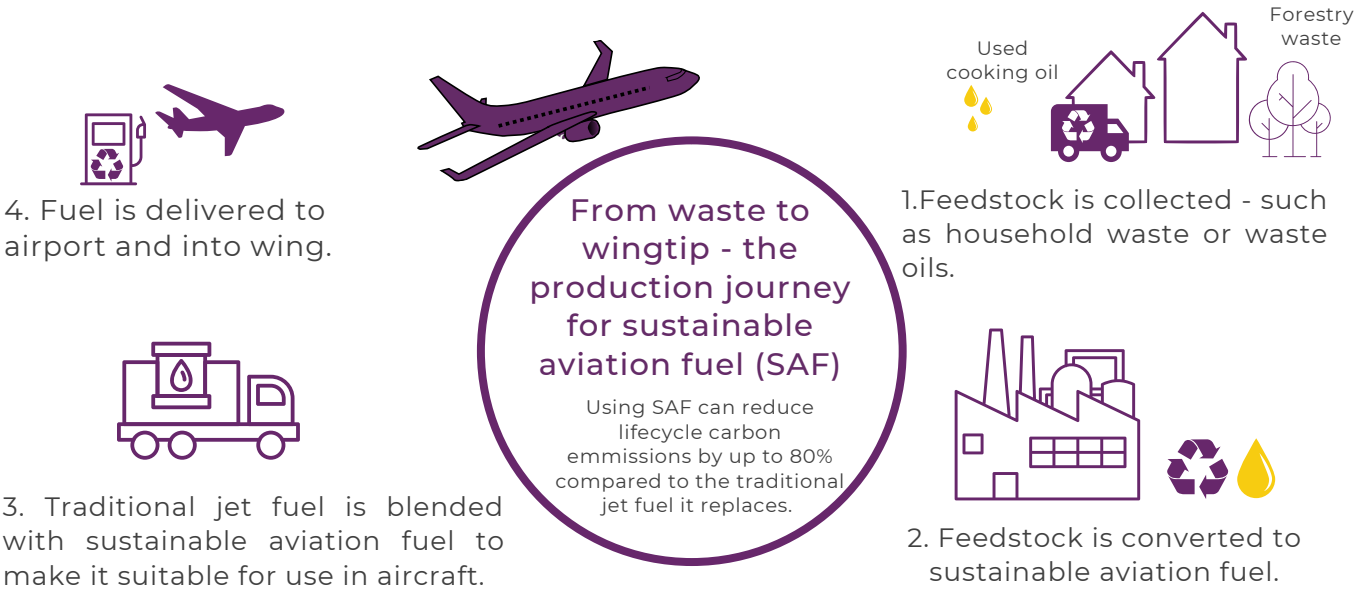
STRUCTURE OF THE VALUE CHAIN



For long-haul aircraft, the focus should be on scaling the production capabilities of SAFs (both bio-SAFs and synthetic SAFs) to drive down the price and increase demand. However, while bio-SAFs could only be a net-zero solution over the fuels' life cycle, synthetic SAFs hold the potential to be a zero-emission solution. Yet, SAFs alone won't enable the industry to reach aggressive carbon reduction goals, and the overall solution must include true zero-emission propulsion systems such as electric aircraft.

Electric propulsion could be a potential zero-emission propulsion solution for decarbonization in the long term, particularly for short-haul flights and urban air mobility. Because the challenge of scaling electric propulsion technology is so multifaceted, it requires seamless collaboration among all the key stakeholders across the entire aerospace value chain.

SUSTAINABLE AVIATION FUELS (SAFS)



Process innovation

There is a need to deploy and further develop new technology enablers to large scale cross-domain experiments, building the EU Data Sharing Space for Manufacturing, valorising EU values and legislation in privacy / confidentiality preservation. Long-life industries (machine tools, automotive, aeronautics, shipbuilding) will run their complex value chains and long-lasting lifecycles in a standard and trusted way.

System innovation

Europe will be the leader in **Green Manufacturing engineering for highly personalised and complex products and services** in a broad range of sectors, including aeronautics, automotive, production equipment, renewable energies, space, and defence.

Across the globe, aircraft and engine manufacturers are demonstrating great examples of greener manufacturing throughout their production supply chain. The aim is to improve the sustainability of these factories, suppliers and products for Green Manufacturing focus on waste, energy, water, safety and wellness, materials, suppliers and products.

ENERGY

Challenge

The production and use of energy account for more than 75% of the EU's greenhouse gas emissions. Decarbonising the EU's energy system is therefore critical to reach our 2030 climate objectives and the EU's long-term strategy of achieving carbon neutrality by 2050.

The European Green Deal focuses on 3 key principles for the clean energy transition, which will help reduce greenhouse gas emissions and enhance the quality of life of our citizens:

1. ensuring a **secure** and **affordable EU energy supply**
2. developing a **fully integrated, interconnected and digitalised EU energy market**
3. prioritising **energy efficiency**, improving the **energy performance of our buildings** and developing a power sector based largely on **renewable sources.**

energy efficiency | renewables | greenhouse gas emissions reductions | interconnections | research and innovation

GREEN ENERGY AND RENEWABLE ENERGY TECHNOLOGIES

The main sources are wind energy, solar power and hydroelectric power (including tidal energy, which uses ocean energy from the tides in the sea). Solar and wind power are able to be produced on a small scale at people's homes or alternatively, they can be generated on a larger, industrial scale.

Six most common types


1. Solar Power


2. Wind Power


3. Hydropower


4. Geothermal Energy


5. Biomass


6. Biofuels

The value of Green energy

Understanding the economic viability of green energy requires a comparison with fossil fuels. The fact is that as easily-reached fossil resources begin to run out, the cost of this type of energy will only increase with scarcity.

At the same time as fossil fuels become more expensive, the cost of greener energy sources is falling. Other factors also work in favor of green energy, such as the ability to produce relatively inexpensive localized energy solutions, such as solar farms. The interest, investment and development of green energy solutions is bringing costs down as we continue to build up our knowledge and are able to build on past breakthroughs.

As a result, green energy can not only become economically viable but also the preferred option.

European process industries will move from their current energy mix, which is dominated by fossil fuels and feedstocks, to a mix of various GHG emission-free energy sources. Today's processes are tailored to the reliable supply of fossil fuels that are of constant quality and can easily be stored. If the renewable energy is already converted into another form of energy (e.g., electricity or hydrogen), the transition will be defined by the technological adaptations/developmentsin the envisaged processes. However, directly integrating renewable energy generation with its use in the process industry can deliver higher overall efficiencies.

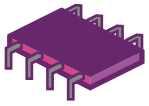
GEMSTONE aims to include new technologies and methods for circular, low-environmental impact and low-carbon approaches while increasing energy and resource efficiency in manufacturing.

Energy and power technologies will further enable resilient and sustainable manufacturing, by deploying integrated approaches which cover lifecycles and link different sectors, disciplines and ecosystems.

MANUFACTURING FOR MINIATURISATION AND FUNCTIONAL INTEGRATION

Miniaturization and functional integration has become an important development trend for global electronics, that reduces material costs, increases functional integration, and creates products that are easier to carry or transport. Products are becoming smaller, lighter, more robust and more energy-efficient – or even energy autonomous.


sensors


low-energy components


micro-mechanical systems


smart surfaces


microfluidics


bio-hybrid components

ULTRA-EFFICIENT, LOW ENERGY AND CARBON MANUFACTURING

The priority is to develop **sustainable and dynamic value networks** and **sustainable symbiotic manufacturing networks.**

Advanced smart material and product processing technologies and process chains

Innovative manufacturing processes for smart and carbon neutral materials in manufacturing.

Process chains (could include renewable energy integration and waste material/energy recuperation) - new business and organisational approaches.

Hybridization of technologies - renewable energies integration, including the incorporation of energy storage, linked or focused on improving energy efficiency and the selection / validation / optimization of technologies.

CCUS (Carbon capture, utilisation and storage), Industrial Symbiosis, decarbonising of energy intensive process, clean energy production

Smart mechatronic systems, devices and components

Renewable energy generation, energy storage and energy harvesting/recovery can contribute to reducing energy consumption and accelerate the transition towards a carbon-efficient economy.

Data analytics, artificial intelligence, machine learning and deployment of digital platforms for data management and sharing

Prediction and optimised planning of energy consumption, synchronisation of energy demand with fluctuating energy supply

Resource and energy efficient production and logistics equipment, production planning and control

System innovation

Simulation and modelling, digital twins

Product lifecycle management (PLM) for Collaborative Manufacturing, need for systemic analysis of problems across the industrial value chain.

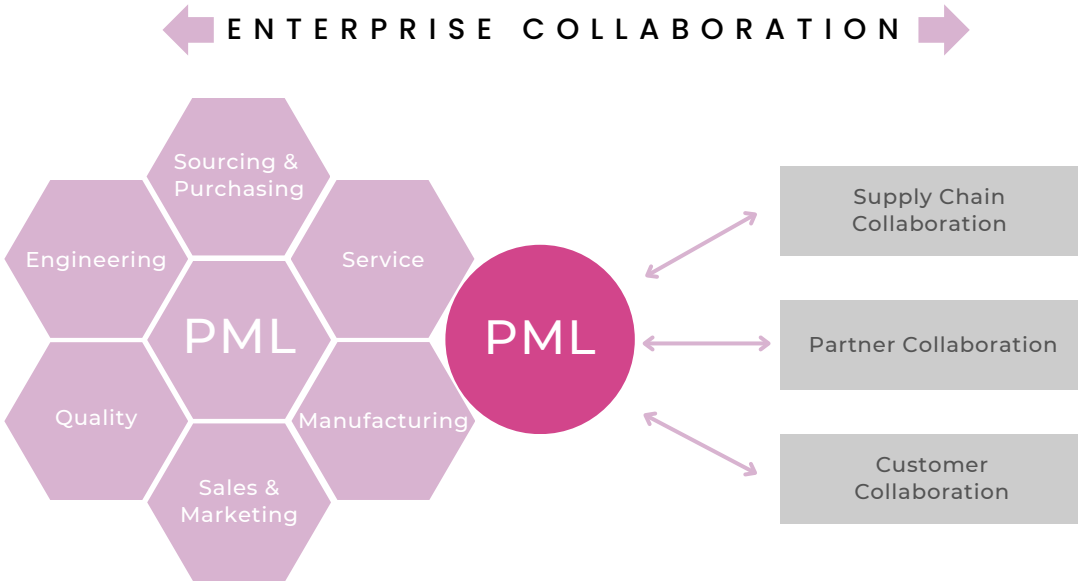
The issue of decarbonization of the industry, particularly under the development of measurement / traceability / modelling / simulation technologies for the carbon footprint in manufacturing processes and supply chains. This could be summed up under the term "Carbon Twin".

New tools and methodologies should be developed to allow companies (both large and SMEs) to assess their environmental footprint and to calculate their individual contribution to the overall product environmental impact.

New business and new organisational approaches

Incl. Assessment methodologies for realistic planning and follow-up of targets, from low-carbon dioxide to carbon-neutral.

Integration of renewables, waste energy/material valorisation and industrial symbiosis concepts.



PML STREAMLINES BUSSINES PROCESS BY CONNECTING YOUR PEOPLE AND INFORMATION

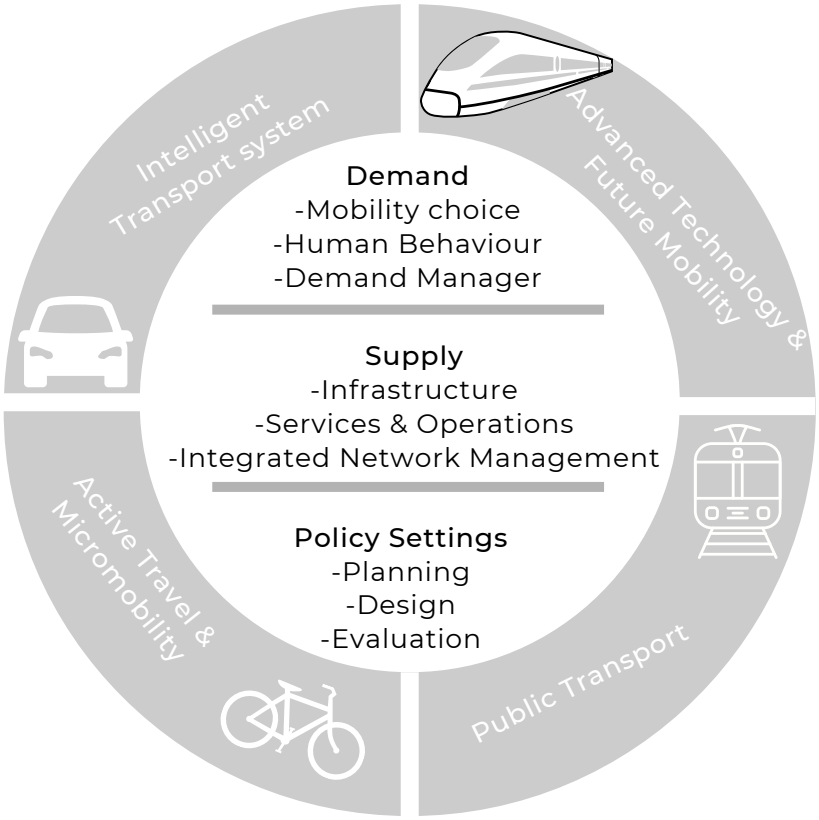
PML CONNECTS YOUR EXTENDED ENTERPRISE AND THE SYSTEMS THAT DRIVE YOUR BUSINESS

MOBILITY

Challenge

A CO2 neutral mobility and power generation is essential to achieve the climate goals as signed in the Paris agreement without compromising the needs of the society in terms of affordable mobility and power supply. The affected industries face the need for a significant change in structure and business models. Millions of well-qualified and well-paid jobs depend on a successful transition of these industries. Manufacturing and mechanical industries need to transform to service providers for drivetrain solutions.

SAFE, EFFICIENT AND SUSTAINABLE MULTIMODAL TRANSPORT SYSTEMS



Product innovation

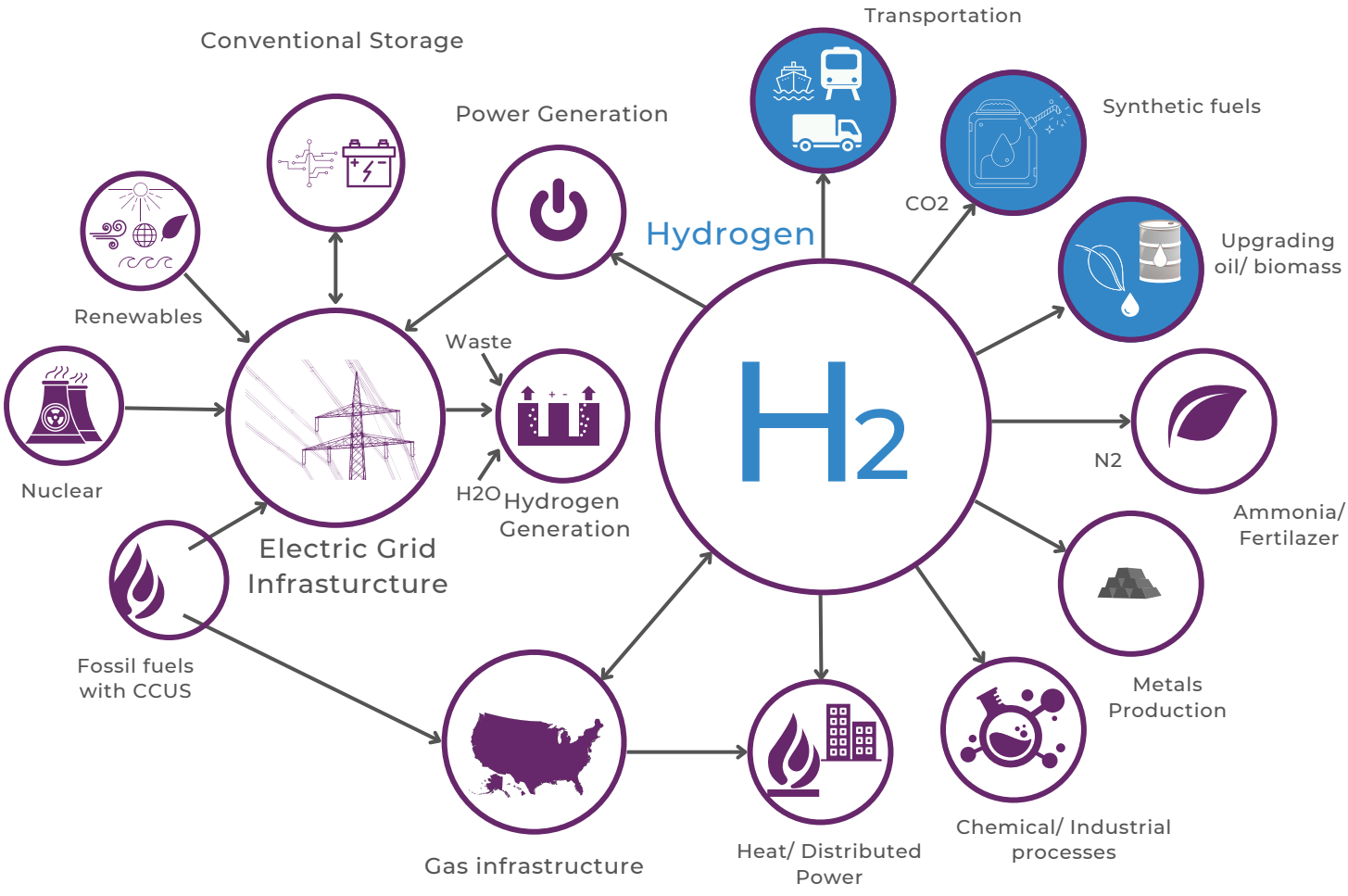
European society demands minimal environmental impact of industry. European industrial companies need to re-evaluate their resource efficiency and the carbon intensity of their entire supply chains. Changes of policy frameworks, markets and customer preferences induce structural changes in manufacturing value chains, for example the move to **electro-mobility** in the case of the automotive sector.

ENGINES RUNNING ON ALTERNATIVE FUELS

biodiesel fuel	gas	hydrogen	electric cars	hybrid cars

HYDROGEN

Hydrogen accounts for less than 2% of Europe's present energy consumption and is primarily used to produce chemical products, such as plastics and fertilisers. 96% of this hydrogen production is through natural gas, resulting in significant amounts of CO2 emissions.11 Renewable hydrogen can be obtained via electrolysis using renewable electricity to split water into hydrogen and oxygen. It will play a key role in decarbonising sectors where other alternatives might be unfeasible or more expensive. It can be used to replace fossil-based hydrogen for transport and industrial processes, and to start new industrial products, such as green fertilisers and steel. The European Clean Hydrogen Alliance was launched alongside the EU hydrogen strategy in 2020 as part of the new industrial strategy for the EU.



DOE office of fossil engineering, 2020

Batteries have a central role to play in Europe's transition from fossil fuels to renewable energy. In the transport sector, Europe's position as a global leader in the automotive market is being seriously challenged by the transition to electro-mobility in which batteries are estimated to count for up to 40% of the value of the car.

Although supporting the adoption of green energy for mobility, batteries requires a considerable effort (in terms of materials and energy) for their production and, today, have an expected life that is significantly shorter than the cars they are assembled onto. In this perspective, important research efforts are required to address the monitoring, diagnosis, reconditioning and recycling of the batteries.

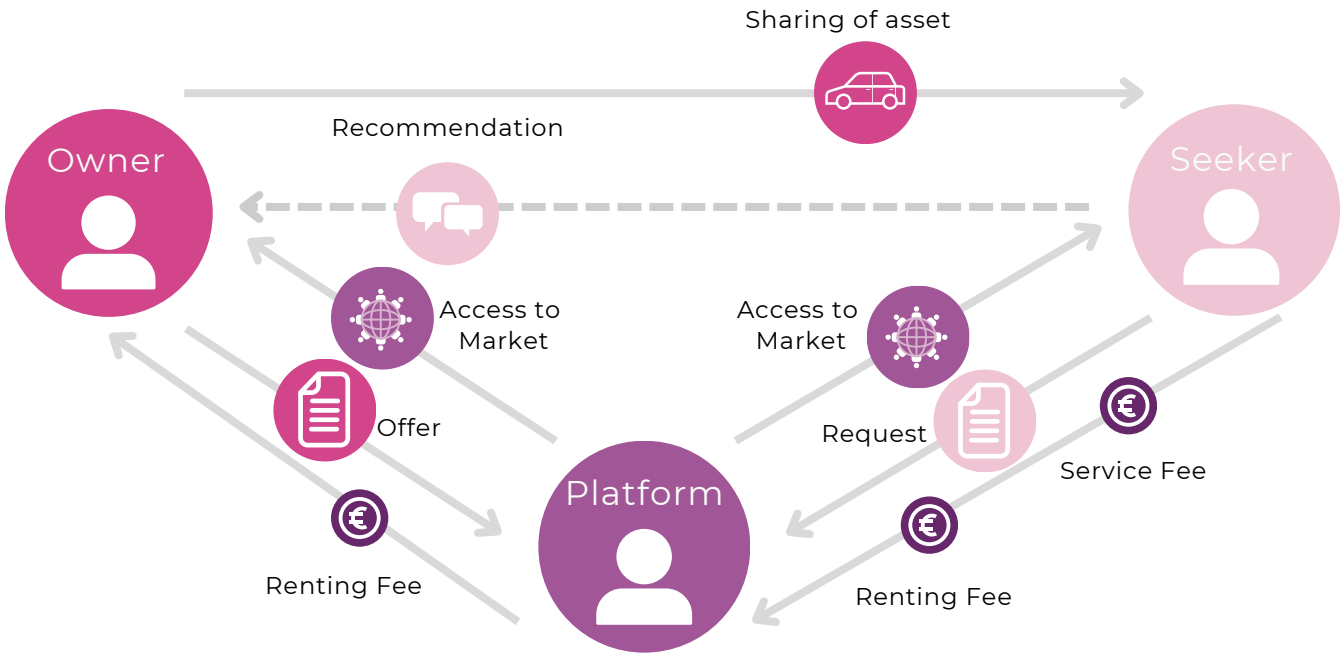
With this aim in view, the following scientific and technological objectives need to be addressed:

1. Manufacturing and recycling technologies for Li-Ion batteries.
2. New materials supporting reconditioning and recyclability.
3. Electro-chemical models to assess the ageing of batteries and estimate their remaining life and residual performance.
4. Self-healing models and treatments.

Process innovation

Mastering product complexity with on-demand, personalized products will require new collaboration structures and networks. In a circular economy, customer services will play a more important role and new business models and logics will emerge beyond paradigms such as the sharing economy and the outcome economy. These will become game changers and will be enabled by disruptive technologies such as high-performing clouds, artificial intelligence & machine learning, data analytics, swarm intelligence, bioprocessing, functional additive manufacturing, autonomous systems and many more.

SHARING ECONOMY



European Construction, built environment and energy efficient building Technology Platform (ECTP) suggest to implement multi-modal transport hubs and urban mobility infrastructures - Industrialised construction processes for the development of new multimodal transport hubs, minimising the disruptions and impacts to the urban activity and environment.

The interaction of value network players through these services can lead to horizontal integration is also an ongoing trend where service development will increase (for instance in the transport sector, supplying mobility as a solution rather than the vehicle).

AGRICULTURE / AGRI-FOOD

Challenge

The European Green Deal aims to improve the well-being and health of citizens and future generations by providing healthy and affordable food.

The European agriculture and food system, supported by the Common Agricultural Policy, is already a global standard in terms of safety, security of supply, nutrition and quality. Now, it must also become the global standard for sustainability. A shift to a sustainable food system can bring environmental, health and social benefits, as well as offer fairer economic gains. The recovery from the pandemic will put us onto a sustainable path.

The EU's goals are:

-to ensure food security in the face of climate change and biodiversity loss
-reduce the environmental and climate footprint of the EU food system
-strengthen the EU food system's resilience
-lead a global transition towards competitive sustainability from farm to fork

Product innovation

Chemical products, building blocks and materials are indispensable to almost all value chains and industries, from automotive, aeronautics, electronics, energy, construction, textiles, pulp and paper, to healthcare, agriculture and food. Sustainable chemistry being such a key enabler for the entire economy, has a major role to play to drive the changes and develop solutions to address pressing global challenges, such as climate change, the need for a more circular economy, the smarter use of resources, and environmental and health protection.

Sustainable advanced materials made by the chemical industry contribute to European industrial competitiveness, environmental performance and the circular economy, by improving energy and resource efficiency as well as via circularity-by-design. In the context of transitioning to a circular economy, some key challenges include the sustainable recycling of materials, which goes beyond materials innovation and includes synergy with advanced processes and the opportunities that digital technologies can offer.

Biological transformation of products, processes and value creation: New biological processes, technologies and value chains will allow the recovery of agricultural, forest and urban waste, enable the development of new materials, new sensors and actuators and inspire new value-added systems. Bio-manufacturing will open up new opportunities for using biomass from different sources to produce chemical, pharmaceutical and food products with reduced energy requirements and environmental impact.

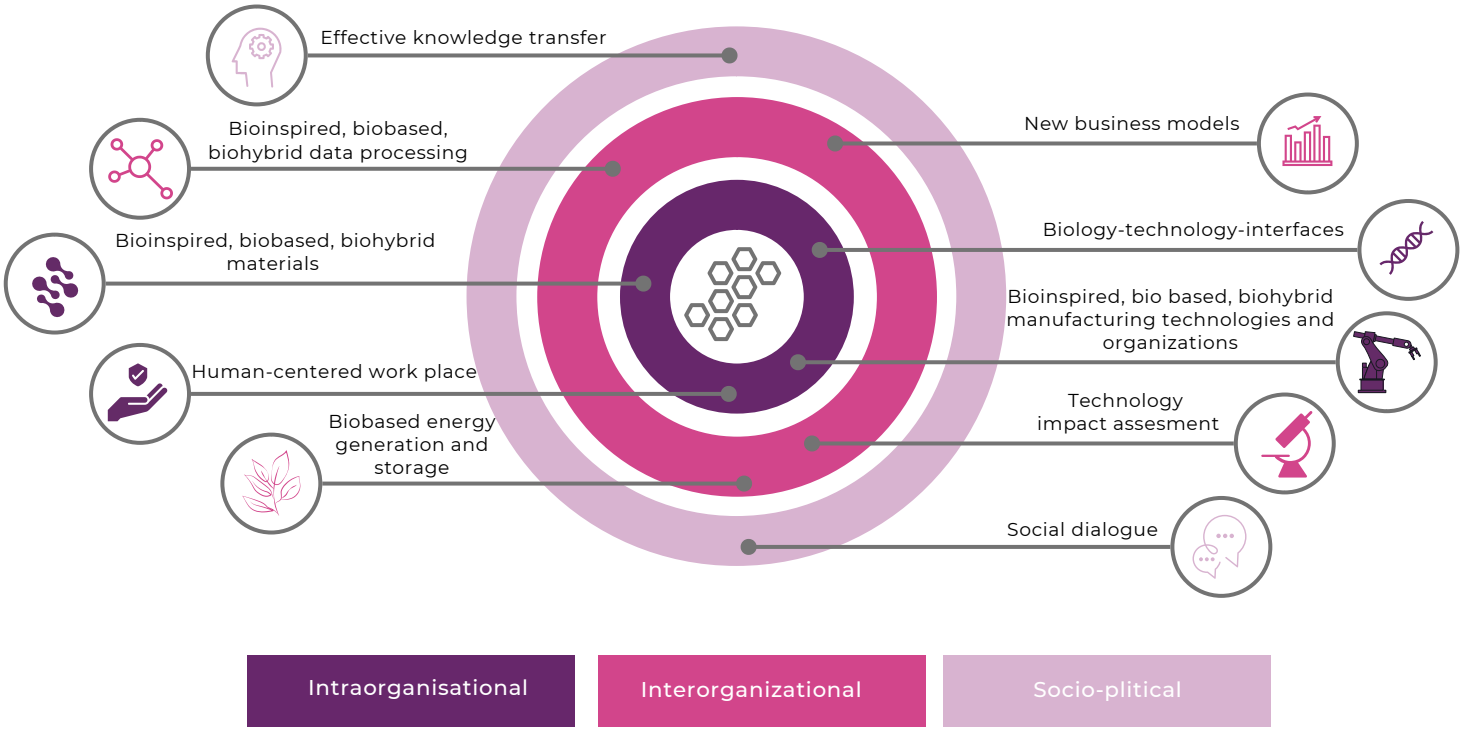
Bio technology will reduce Europe's raw material and energy requirements and boost the development of new energy harvesting and storage technologies.

Robotics is coming of age, not only in manufacturing but also and increasingly in other domains of industrial and human activity, such as agriculture, food and service sector.

Flexible automation, encompassing robotics, aims at **enhancing the efficiency, autonomy, autonomicity (homeostasis), flexibility, scalability, resilience and robustness** of manufacturing systems. The role of humans in future flexibly automated systems will remain essential.

Distributed manufacturing execution system architectures have to be developed to harmoniously integrate humans into the overall manufacturing system.

BIOLOGICAL TRANSFORMATION OF INDUSTRIAL VALUE CREATION



System innovation

There are five main sources for bio-based and/or circular resources that can be used by the process industries:

- wood-based biomass (e.g., trees),
- agricultural residues,
- functional crops (e.g., starch and sugar),
- non-recyclable waste materials,
- wastewater.

Agricultural residues, food waste and sewage sludge can be converted into biogas, which can be used as energy or as a resource.

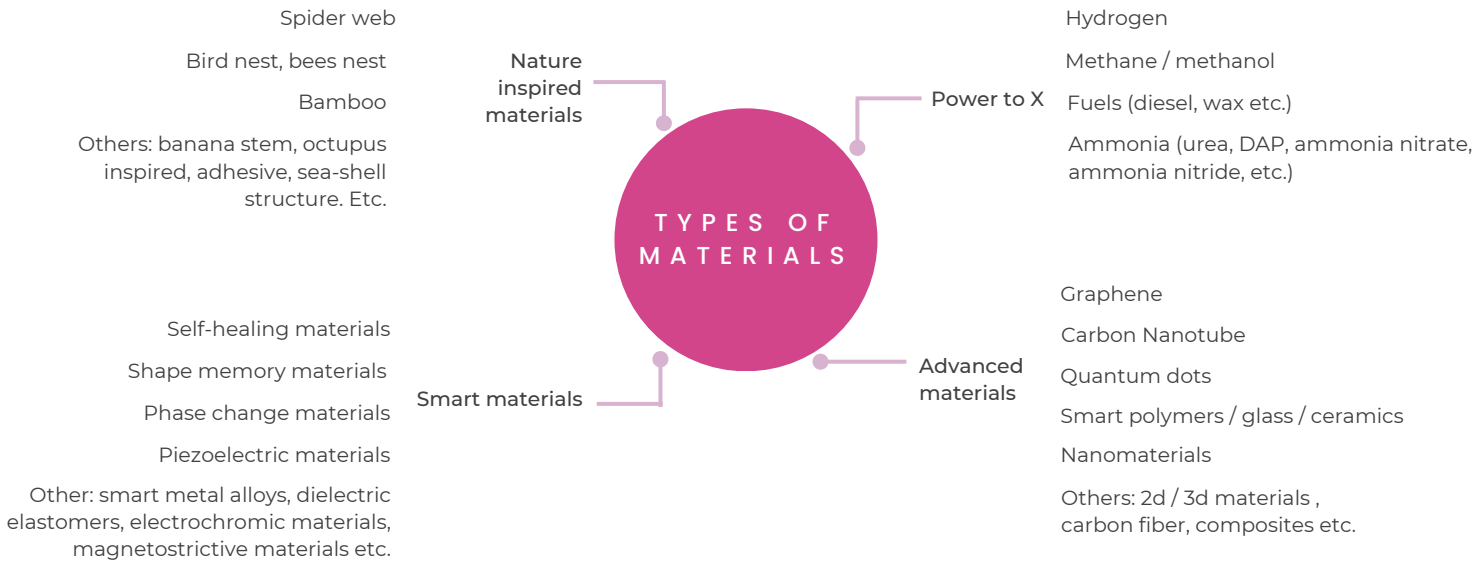
Green Manufacturing focuses on the increased use of these types of sustainable feedstocks either as direct energy sources in the process industries or as the source material to produce biofuels being used in other sectors (e.g., transport).

MATERIALS

Challenge

The manufacturing industry needs to respond quickly to market disruptions, changing customer demands, fluctuating characteristics of raw materials and, components, bio-based and composite materials, and advanced emerging technologies that can be potential differentiators. Simultaneously, the manufacturing industry needs to increase quality and efficiency and reduce Total Cost of Ownership. Hence, upgradable and robust manufacturing systems and plants are necessary for flexible, responsive and resilient manufacturing. Here, Artificial Intelligence, advanced robotics and other digital technologies will help.

Advanced materials are major enablers of high-performance and sustainability in many manufacturing sectors, reducing energy consumption and enabling circular economy. This brings about important challenges in terms of the competitive manufacturing of these products.

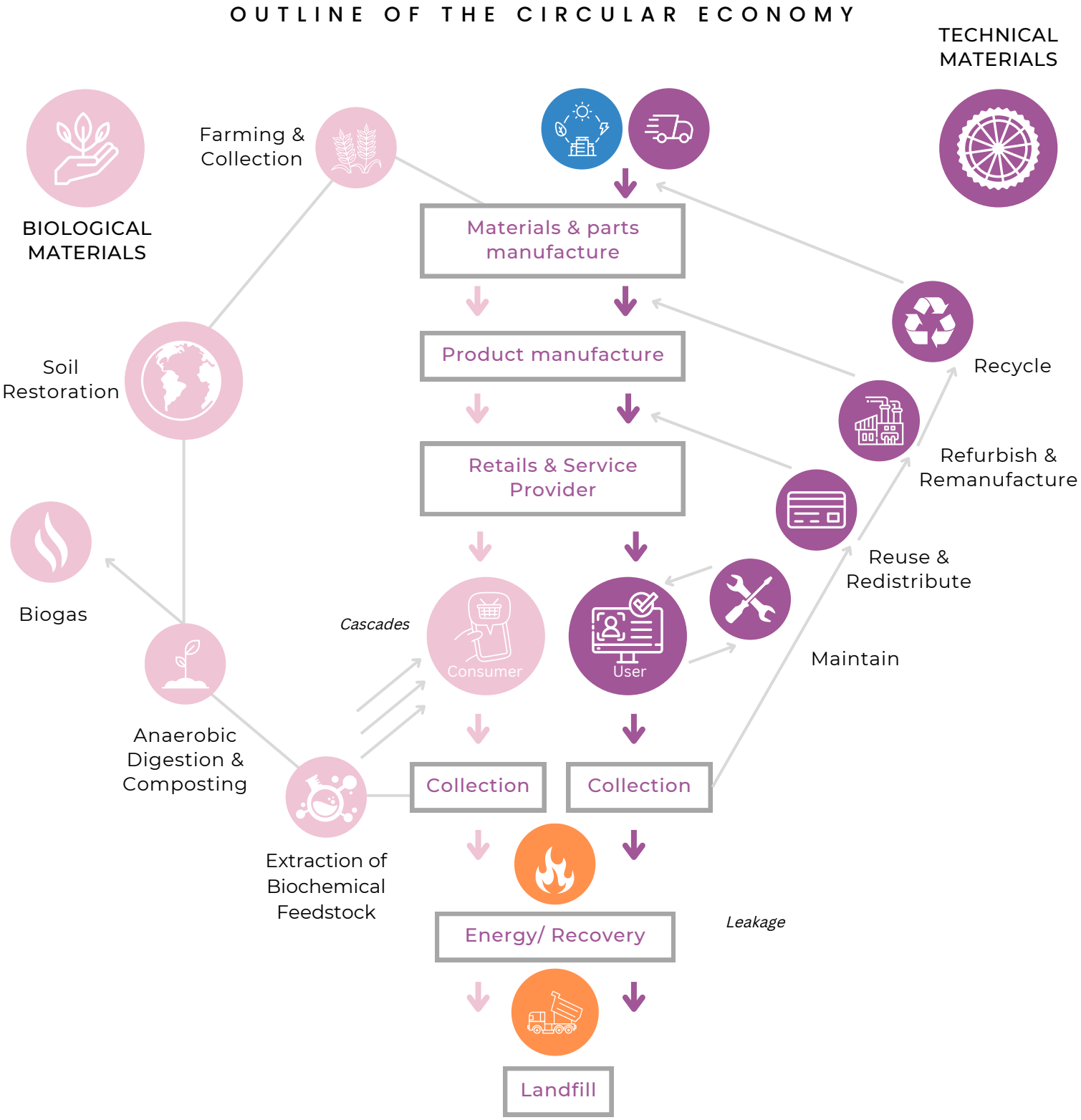


Product innovation

To reach the Green manufacturing it is important to apply advanced smart material and product processing technologies, and process chains (additive manufacturing, joining, shaping, structuring, surface tailoring, etc.) Advanced smart material and product processing technologies are at the centre of any manufacturing activity; they cover a broad range of manufacturing sectors and products. The combination of materials and process engineering with smart mechatronics is key.

Bio-inspired or bio-integrated manufacturing is an example of new developments, while also, the so-called ‘traditional material processing technologies’, that have been incrementally but significantly improved towards ‘high performance’ material processing technologies over the past decades, play an important role in manufacturing innovation. ‘Younger’ technologies such as photonics or other physical or chemical processes must be integrated in hybrid, flexible, and robust process chains.

Circular Economy models and next-generation sustainable materials and products induce profound changes in manufacturing systems and their supply chains. This requires life-cycle thinking from product design and production, via use, to recycling and remanufacturing.



Products are increasingly complex with an increasing amount of electronics or micro-features and advanced (multi-)materials. Products are also becoming smarter, stronger, lighter and more miniaturised and functionally integrated whilst remaining safe and secure. Completely new solutions will be introduced when designing future sustainable products enabling durability, energy-saving, the replacement of scarce or hazardous materials. Manufacturing system capabilities need to follow product and material roadmaps to enable the viable and sustainable manufacturing of these high-tech products.

Process Industry: Process industries will work more tightly with the value chains to ensure that the materials developed by the process industries will be suitable for the circular economy. Integration and data sharing is important along the supply chain and facilitation of innovative reuse, remanufacturing and recycling solutions.

De-manufacturing, recycling technologies, and **life-cycle analysis** approaches
These technologies, tools and knowledge-based methods should recover, re-use, and upgrade functions and materials from high-tech products (including capital goods). Product design and manufacturing engineering should anticipate end-of-life strategies.

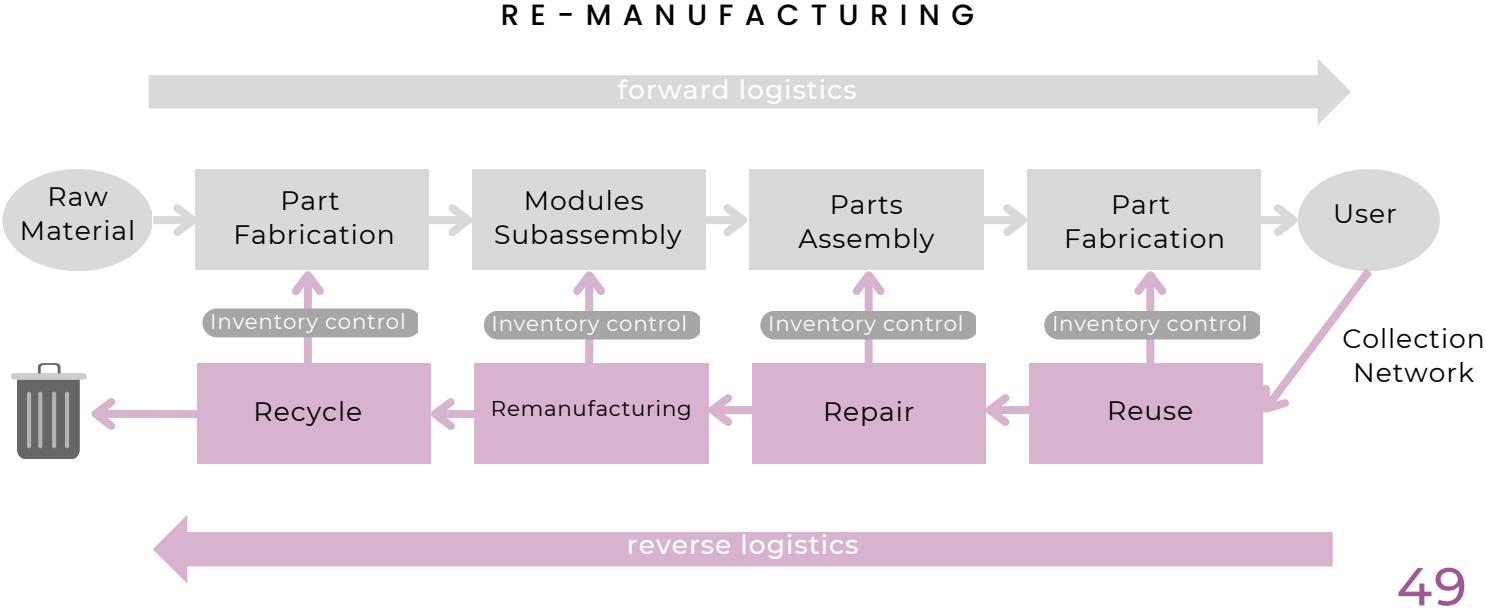
Developing complex new products - or second-generation commodity products - based on new sustainable materials and Nanotechnology will lead to new high value-added businesses boosting the EU economy and will also improve the competitiveness of our current EU manufacturing industry. It is also expected that sustainability itself will be an important source of differentiation and competitiveness for our manufacturing industry in the global market.

System innovation

GEMSTONE road map aims at ultra-efficient, low energy, circular and carbon-neutral manufacturing. Exploit the possibilities offered by advanced materials, digital technologies and manufacturing technologies to achieve a considerable reduction of the ecological impact and CO2-emissions.

On an ecosystem level, recycling and re-use of materials and components will be increased while still raising the performance of the manufactured products.

With higher expected CO2 prices and scarcity of key materials, the economics of manufacturing and materials use and re-use will change. This will have an impact on manufacturing technologies and will require new, different manufacturing equipment. That is why we need to study advanced de-manufacturing, re-manufacturing and recycling technologies for a circular economy involving manufacturing with new and substitute materials. In addition, new production systems and concepts will be needed when manufacturing increasingly uses recycled materials or when remanufacturing happens.



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GEMSTONE

Funded by the European Union

PROJECT INFO

Grant Agreement	Project 101074549 — GEMSTONE
Programme	Single Market Programme (SMP COSME)
Call	SMP-COSME-2021-CLUSTER
Topic	SMP-COSME-2021-CLUSTER-01
Type of action	SMP Grants for Financial Support
Project Title	Green Manufacturing supporting recovery and resilience of industrial SMEs
Project starting date	1st September 2022
Project end date	31st August 2025
Project duration	36 months

PROJECT CONSORTIUM

CIMES Creating Integrated MEchanical Systems

pootnet PORTUGUESE TOOLING & PLASTICS NETWORK

METAL PROCESSING CLUSTER

CLUST-ER MECH MECCATRONICA E MOTORISTICA

EMC2

PÔLE MECATECH

GREEN TECH CLUSTER

GEMSTONE

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