Circular Economy
SusChem Position Paper

SusChem, the European Technology Platform for Sustainable Chemistry has developed a strategic innovation and research agenda describing solutions to major European societal challenges. These solutions are based on enabling technologies developed by the chemical industry and its partners in academia, research and technology organisations and other industrial players from a variety of different value-chains.

Many of these technologies can contribute to the implementation of a sustainable circulareconomy. This position paper develops SusChem's vision for this topic and provides some concrete examples of the contributions that the platform can make in this area.

1. A sustainability based approach is needed

The integration of all aspects of sustainability is essential to the development of a circular economy in order to effectively ensure a positive impact on society while minimising environmental impact and maintaining economic growth. The evaluation of environmental impact should not be limited to resource efficiency criteria; other aspects such as energy and water should also be considered.

A coherent and pragmatic sustainability assessment methodology should be considered for the evaluation of the potential impact of circular economy initiatives.

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2. **Technology development is required for a sustainable circular economy**

A circular economy cannot be achieved only through implementation of new regulations, services and business models. Advanced technologies are essential to enable a better use of existing resources along the whole life cycle to develop new production and recycling paths.

The expertise of the chemical industry as a material supplier is highly valuable and important not only in the recycling of end-user products, but throughout all value chain processes. Therefore, enhanced collaboration between the chemical industry and all partners within the value chain is crucial to the design of the efficient and sustainable schemes that are essential for the success of the circular economy.

The chemical sector, as an industry that adds value to raw materials, can contribute to the development of a sustainable circular economy by making the best use of these raw materials in its own processes and in collaboration with other industrial players. In this context, we believe that the principle technology developments should take place in the following areas:

A. Utilisation of alternative feedstock

The aim is to integrate more sustainable alternative feedstock sources. For instance, secondary raw materials, ligno-cellulosic biomass, waste or CO_2 from industrial flue gases could be used as alternative carbon resources for the production of more sustainable materials, chemicals and fuels.

Support and decisions (e.g. labels or standards) in this field should not be driven only by the type of feedstock used, but by considering an overall sustainability assessment (including energy, water and land use) for the environmental indicators. A pragmatic sustainability assessment (limited to cradle-to-gate for the chemical production process) should then be applied in cases where the final product/material remains the same.

B. Design of materials enabling eco design of 'products'

New chemicals and materials have to be developed by the chemical industry to enable sustainable eco-design of products for consumers or other industry sectors to enable better recycling options.

In order to address very demanding requirements in terms of performance in downstream applications, including better recyclability, new technological development is often carried-out by the chemical industry in collaboration with its value chain partners to provide the improved characteristics and more recyclable end-use products.

The mobilisation of value chain partners is a clear condition for success and must involve companies of all sizes, including SMEs, who can bring very innovative ideas for improved recyclability; SusChem has been and will continue to be active in supporting innovative SMEs to participate in collaborative programmes with large companies in the chemical industry and other sectors.

C. An improved efficiency for production processes

The goal is to maximise the use of all resources entering the system including primary and secondary raw materials, water, and energy through:

- Improved reaction and process design (e.g. improved catalysts including biocatalysts, process intensification, ICT, and modelling)
- Close loop recycling of resources on production sites
- Increased resource and energy efficiency between different production sites / sectors via industrial symbiosis

These technologies are described in the SusChem's 2015 Strategic Innovation and Research Agenda (SIRA) and should be supported through the appropriate European funding instruments.

3. **Coherence and stability over time for the policy framework is critical for European leadership**

To contribute fully to a sustainable economy, the circular economy policy should be developed in coordination with other related policies such as the Energy Union Package. Policy coherence, as well as policy stability over time, is essential to establish a regulatory framework that enables investment in sustainable, resource efficient and innovative technologies in Europe and ensures European leadership in sustainable/clean technologies.

Uncertainty and extended timelines for policy decisions have negative consequences on the confidence of private investments in new cleaner technologies, and global competition has to be considered in the development of an appropriate policy framework

4. **Case studies**

A. Case study sustainable resource - Utilisation of CO2 as an alternative carbon resource

- Contribution to the circular economy:

The chemical valorisation of CO2 can contribute to the development of a circular economy through its use as a renewable resource for many process industries. CO2 represents an alternative to fossil resources in the production of more sustainable chemicals, materials, and energy carriers, while reducing pressure on biomass, land use, and other environmental stressors.

Supporting the development of technologies for CO2 conversion in Europe would contribute to the competitiveness of European industry and ensure leadership for Europe in sustainable technologies. Leadership in this field will bring business and export opportunities for clean technologies.

Technology development/deployment required

Advanced technologies for CO_2 conversion (new catalysts, efficient process technologies), integration of renewable energy, and access to cost-competitive CO_2, for lowering the energy requirements of CO_2 chemical conversion (including source and cost of co-reactants) need to be further developed. These advanced technologies would be used for the production of:

- chemicals and polymers
- advanced sustainable alternative fuels for transport and large scale renewable energy storage through:
  - Power to gas technologies to produce methane that can be stored in the existing gas transmission network
  - Power to liquid technologies to produce methanol and other energy carriers.

Development of processes to generate renewable hydrogen at lower cost will be the key for the deployment of some major CO_2 conversion routes.

- Non technology barriers/ policy framework:

The utilisation of CO_2 as a feedstock would be a major transition for the chemical industry, and will require significant investment. These new clean technologies have to compete against well-established processes that have achieved a high degree of efficiency and competitiveness. New sustainable materials with new properties will have to overcome the usual barriers of market penetration.

The deployment of CO_2 conversion technologies to produce chemicals, materials, fuels and store energy requires a stable policy framework with appropriate measures such as:

- A legislative system that accepts CO_2-based molecules produced using CO_2 from flue gases as renewable based products must be developed to attract future investors and enable positive environmental and social impacts. For the valorisation of CO_2, no distinction should be made between bio-based CO_2 (e.g. from bio-refineries) and CO_2 from fossil origin (e.g. from energy intensive industries). CO_2 based products should be recognised as renewable based products and benefit from appropriate regulatory frameworks and appropriate standardisation and labelling systems based on a consistent approach to LCA methodologies.

- The development of regulations that allow inter-sectorial use (between CO_2 emitters and CO_2 transformers) of CO_2 from flue gases also need to be put in place together with successful business models.

Competition with other global regions should be considered when developing appropriate measures.

B. Case study sustainable resource - Utilisation of CO2 as an alternative carbon resource

- Contribution to the circular economy

Composite materials (Fibre reinforced plastics) are part of the technologies that enable lighter weight structural parts in fields such as transport (cars, trains, airplanes etc.) and energy (wind turbines). The incorporation of lightweight materials leads directly to higher energy efficiency (e.g. better fuel efficiency in cars or planes). High performance Carbon Fibre Reinforced Plastics (CFRP) is widely used in the aerospace industry and its application in the car industry is growing, but there are limitations in the production capacity of current manufacturing processes and recycling is difficult.

New composites materials under development by the chemical industry and its partners will be more recyclable and will be produced on a larger scale.

- Technology development/deployment required
  - Most existing composite materials are based on thermoset resins which, once cured, cannot be recycled. The development of new composite materials based on thermoplastic resins needs to be encouraged due to their easier recyclability.
  - Research on thermoplastic resins used in new composite materials must be carried out to enable monomers to be recovered after recycling and used in other applications.
  - The developments required are not only related to the design and production of resins but also new techniques to manufacture the final composite material parts with appropriate production scale and costs.
  - New developments are also needed in the design phase (simulation of process and prediction of properties) for parts made from composite materials.

- Non technology barriers / Policy framework

A significant challenge is to improve the appropriate training and qualifications for engineers involved in Computer Aided Design (CAD) of parts containing composite materials, especially in the automotive industry.

C. Case study - New catalysts

- Contribution to the circular economy

About 90% of all chemical products are manufactured using catalysts to ensure that raw materials and energy are used highly efficiently in the production of industrial chemicals, high performing plastics, and fuels – catalysts are the key materials to increase the resource efficiency of such processes. Catalysts are indispensable to clean emissions from industrial processes and automotive combustion engines to limit environmental impact.
As a contributor to a circular economy, catalysts enable the use of alternative raw materials such as biomass, natural gas, carbon dioxide, and waste as feed stocks.

- Technology development/deployment required

Catalysts are often based on precious metals or rare elements and special efforts are dedicated by the chemical industry to the recycling of these elements and to develop catalysts with longer lifetime and performance. For example to produce hydrogen (required for CO2 conversion), a cost efficient electrochemical water splitting process promoted by new heterogeneous catalysts is a vital development. Today, Platinum and Iridium are the most popular catalysts for this type of application, but their relatively high cost and low natural abundance make them unsustainable for large-scale industrial applications. Alternative catalyst material development needs to be promoted continuously. Photo-catalytic water splitting represents a different approach but requires further technology development.

Advanced pyrolysis and/or depolymerisation technologies enabled by the introduction of novel catalysts to produce high-value chemicals out of polymer waste, e.g. used car tyres, plastics, textiles etc., needs to be developed further, turning such wastes into a resource and avoiding landfill or incineration wherever possible. This kind of chemical recycling is the goal of sustainability in polymer science.

D. Case study - Industrial symbiosis

- <u>Contribution to the circular economy</u>

Industrial symbiosis enables traditionally separate industries to foster new collective approaches involving physical exchange of water, energy, materials, by-products and/or waste that become feedstock in other processes and not losing them as waste. As such it contributes to a circular economy pattern between industrial players.

- Technology development/deployment required

The technologies to be developed for industrial symbiosis are generally related to separation or purification techniques when one partner wants to provide a stream of products (waste or other materials) from their production facility to another partner.

The technologies can also be related to the transfer of energy-containing streams and may include heat exchangers, heat pumps or thermoelectric devices, for example.

Many technologies are available 'off-the-shelf' but some still need development (e.g. industrial heat pumps, thermoelectric devices, and membranes for separation).

- Non technology barriers / Policy framework

As opportunities related to industrial symbiosis are cross sectorial, a framework for optimal and more efficient recycling strategies has to be developed; exchange between industry sectors and across value chains should be further fostered, including development of new business models.

To economically utilise waste, transportation of waste to existing conversion units needs to be made possible across borders through an appropriate legislation framework.
To consider waste as feedstock, further efforts have to be made to standardise processes, e.g., by separation of individual waste material groups during the collection process and making it available in large quantities allowing for cost efficient, large-scale recycling.

E. Case study - Bio-refineries

- Contribution to the circular economy

Bio-refineries are important for the transition towards a circular bio-economy. Increasingly they will play a vital role in developing and adding value to the principles of a 'zero waste' society. The concept of bio-refineries is analogous to that of petrochemical refinery processes but bio-refineries use renewable, rather than fossil-based feedstocks. Such feedstocks can include municipal solid waste, which would otherwise be sent to landfill, designated crops and agricultural and forestry waste, which might otherwise simply be burned or ploughed back into the land.

- Technology development/deployment required

The technologies to be developed for bio-refineries are related to Industrial Biotechnology. While industrial biotechnology is one of the Europe's strengths, further technology improvements will aim to make the processes more efficient and competitive. Also new feedstocks require tailored processes that make these resources available for the production of chemicals, materials, pharmaceuticals, cosmetics, plastics, food and feed ingredients, detergents, paper and pulp, textiles and bioenergy. Much effort is also required to scale-up innovative processes to commercial scale operation.

- Non technology barriers / Policy framework

Europe now needs strong policy signals and incentives consolidated through its circular economy strategy in order to engage industry in the creation of smarter products, processes and partnerships. We need to ensure the development of coherent, holistic, supportive policies for the circular economy and bio-based industries along the value chain and integrate bio-economy and circular economy policies into agriculture, regional, environmental, industry, climate, trade, energy and innovation policies.

About SusChem
In 2004, SusChem was launched as a European Commission supported initiative to revitalize and inspire European chemistry and industrial biotechnology research, development and innovation in a sustainable way.

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