Impact: Key Enabling Technologies in Horizon Europe

Call for strong support for EU Future Technology Competitiveness

Key Enabling Technologies[1] are technologies selected for their ability to: 1) address global challenges (e.g. low-carbon energy or resource efficiency), 2) support the development of new products, and 3) stimulate economic growth and provide jobs.

Sustainable chemistry is essential to the technological advance of Key Enabling Technologies (KETs) such as advanced materials, advanced manufacturing technologies, industrial biotechnology, micro and nanoelectronics, nanotechnology, and photonics.

SusChem *KETs in Horizon Europe* Key Messages:

1. SusChem asks that the next innovation framework programme (Horizon Europe) firmly embraces KETs as drivers of technology development, ensures its overall policy alignment and assigns appropriate levels of funding to maintain the EU's KETs leadership and keep industry jobs in Europe.
2. Advanced Materials, Advanced Process Technologies and Industrial Biotechnology KETs are essential to address societal challenges and accelerate the development of a low-carbon economy, circular economy, and the energy transition.
3. Considering the current digital evolution and the enormous benefits that it offers, SusChem recognises the need to integrate digital technologies into processes technologies, materials development, and business model creation. Synergies between the current KETs and potential new 'digital' KETs will accelerate the creation of new markets, growth, and jobs.

KETs address societal needs, but have low visibility in Society

KETs contribute to strengthening and modernising Europe's industrial base, and the development of entirely new markets, opportunities and industries. KETs reduce CO_2 emissions, make cars lighter and safer, enable storage of energy, and make a range of products from medicines to mobile devices more effective and sustainable. They "drive" innovation and value creation in a range of industrial value chains such as automotive, food, chemicals, electronics, energy, pharmaceuticals, construction, and telecommunications.

SusChem embraces KETs as the main technology building blocks for advancing Europe.
In preparation for the next Research and Innovation (R&I) Framework Programme, SusChem outlines what can be achieved by KETs and details the major technology developments and initiatives needed to:

- *create* **Advanced Materials** for use in energy efficiency (e.g., light weight), renewable electricity production and energy storage (e.g., battery components), or smart functionalities responding to stimuli (e.g., self-repair).
- *develop* **Advanced Process Technologies**, including Industrial Biotechnology, for more sustainable production including through utilisation of alternative carbon feedstock (waste, biomass, CO_2) and alternative energy sources.
- *leverage* **Digital Technologies** for use in advanced process control and materials modelling, to enable disruptive business models and to create new customer experiences.

[1] KETs are knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly-skilled employment. They enable process, goods and service innovation throughout the economy and are of systemic relevance. They are multidisciplinary, cutting across many technology areas with a trend towards convergence and integration. KETs can assist technology leaders in other fields to capitalise on their research efforts.
Ref: EC Document 30 September 2009: *Preparing for our future: Developing a common strategy for key enabling technologies in the EU*

Public funded KETs innovation success cases

3D-Printing polymer materials

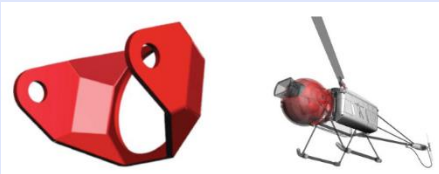
Technology breakthroughs enabled the creation of new business models, investments and jobs.

➔ *For Evonik DIRECTSPARE was an important project within a longer period of research, development and innovation concerning material for additive manufacturing. Without EU public funding, this project would not have taken place. This would have extended the time to market considerably, resulting in a high risk of being passed by competitors from outside the EU.*

Evonik has performed R&D on polymer materials for 3D-printing for about 20 years and is now commercially producing its first 3D-printing materials. A part of the R&D was done within the EU-Project **DIRECTSPARE**. A growing quantity of product types in every market and every sector of industry require large warehouses to keep stock for spare parts, with corresponding high costs and complex logistics. This emerging problem is caused by continuously decreasing product lifetime, decreasing time-to-market and increasing regulatory affairs. DIRECTSPARE aimed to find a solution using additive manufacturing (AM) technology, enabling economically viable, and on demand manufacturing of spare parts.

How was the breakthrough innovation achieved?

The project consortium consisted of technology providers, engineering companies, equipment producers, material producers, manufacturers, users, management consultants and academia. The DIRECTSPARE project has delivered several business models that allow SMEs to provide local services. Possibilities and challenges for obtaining cost reduction on stocks and warehousing have been identified. The project also learned that to obtain waste reduction and environmental benefits, a life cycle analysis approach needs to be used. One demonstrator part indeed proved that quality improvement, based on use information, can be achieved resulting in lower costs and better margins.



VESTOSINT Z2634 for gimbal applications, here shown for a flying camera

The objective of the DIRECTSPARE business model was for manufacturers to rapidly produce only those spare parts that are required, at a location close to the equipment that needs to be repaired. And also to improve the quality of the spare parts along the way.

The project analysed seven demonstrator parts. The functional and material requirements and the cost model of the original part were taken as the point of departure or baseline. The project team analysed the possibilities to manufacture similar parts using AM. The design, engineering aspects, material selection, production methods, quality issues and business economics of all of these parts were taken into consideration.

IMPACT

The project delivered several breakthrough innovations on materials, engineering, process management and quality management. Three viable business models were developed. DIRECTSPARE created a significant networking platform for further development of new 3-D printing powders at Evonik. In February 2018 a production plant for polyamide 12 (PA 12) high performance powders, mainly for the additive manufacturing market became operational in Marl, Germany. The PA 12 material is used in automotive and lightweight design as well as in oil and gas pipelines. In addition to current applications in the automotive sector, Evonik is also very well positioned for the future production of hybrid and electric vehicles. Furthermore, the material is used in the medical sector and in 3D printing.
The investment in a new polyamide production plant secured and created around 10 new jobs.

Directspare.eu
All about spare parts!

Reference information

EU-Project 'DIRECTSPARE - Strengthening the industries' competitive position by the development of a logistical and technological system for "high performance spare parts" that is based on on-demand production' (GA number: 213424)

Create Advanced Materials

Of essential importance to a wide range of EU economic sectors

IMPACT examples:

1. **Lightweight materials** are key for fuel efficiency and **reduce CO_2 emissions** in the **transport sector.**
2. Materials for **rechargeable batteries** with higher energy and power density, reduced cost, and higher cycle life will enable **700 km of electrical driving range by 2025.**
3. Eco-design of **composites materials** lead to potential **saving of 40,000 tonnes of deposits in EU landfill** annually.
4. Advanced **insulation foam materials** will help to enable **50-80% energy savings** in the building sector

The advanced materials KET creates tailored materials for many value chains, including construction, energy, mobility, food, health, and electronics. Once a process technology for producing a material has been applied, it can be further refined to obtain final smart properties defined for a specific application. This same material technology with new functionalities can often then be used in the development of other new applications.
The goals of the Circular Economy require disruptive innovation with respect to materials that it uses.

What can be achieved?

- Increased energy efficiency through:
  - Improved internal and external insulation of buildings, working on properties like insulation values, moisture absorption, thermal capacity, reflectance (for outdoor coatings), long life sealing, and pipe insulation
  - A holistic approach to the use of material systems in construction via Building Information Modelling (BIM)
  - Weight reduction of materials
  - Use of efficient light-absorbing and emitting chromophores
  - Cleaning clothes at lower temperatures using 30% less electricity by using washing products including enzymes
- Increased energy storage through:
  - Development of energy storage with higher energy and power density at reduced cost
  - Increased safety and cycle life for current and new battery systems for both stationary applications and electrical mobility
- Increased renewable energy production through:
  - Longer and lighter blades for wind turbines
  - Improved conversion, space efficiency, and cost base improvement of photovoltaic (PV) cells
  - Development of combined piezo- and thermo- electric properties and vibration for PV integration in roads or buildings
  - The efficient capture of solar energy to produce solar fuels
- Increased Fuel Efficiency through:
  - Reduced emissions and contaminants in fuels for transport
  - Reduced vehicle structural mass (that should also be recyclable)
  - New exhaust catalysts with lower temperature activity and/ or higher resistance to deactivation
  - CO_2 or renewables-based fuels

Carbon dioxide as a raw material for plastics

Innovative process technology reduces petroleum use

➔ *Availability of combined public funding appears crucial to mitigate the high risk of early research and complement own expertise with partnerships along the value chain.*

Covestro has been working for many years on the development of technologies to turn CO_2 into a valuable resource and for its implementation in making polymers. This "waste" gas is an alternative source of carbon and can substitute fossil raw materials and be used to make building blocks for polyols – a key starting material for polyurethanes. The first breakthrough came when Covestro's researchers discovered the right catalyst and process for an economically and ecologically efficient reaction. As a first product stemming from the newly developed technology, CO_2-based polyols for flexible foam found in mattresses and upholstered furniture are already on the market. Other kinds of products for further applications are under development – for example to obtain chemical building blocks and polymer intermediates for rigid foams and coatings to be applied in building insulation and coatings. The new technology, currently under investigation, is expected to reach TRL[2] level 6 by 2020. The next step, after 2022, might be building an industrial plant for the production of CO_2-based chemicals at large scale.

How was the breakthrough innovation achieved?

Partnerships between research-based companies and application-oriented research organisations along the value chain are the key to success. With a portfolio of collaboration projects, expertise can be built up starting from low TRL levels. At Covestro, first samples of CO_2-based polyols were produced on a mini-plant scale after only three years. Five years later, a demonstration plant with the capacity of 5,000 metric tons/year went on stream. To reach high impact, private investments have been complemented by public funding obtained from both German national sources and EU funds.

IMPACT

With the new technology, the use of petroleum can already be reduced by up to 20% in the case of CO_2-based foams and 25% in case of elastomers. Also, the carbon footprint is better than with conventional processes. In the latest project, substantial reduction of process energy consumption is also expected by as much as 70%. This is an important contribution to sustainability and achieving the circular economy and helps to close the CO_2 loop.

Reference information

Funding by Horizon2020 (SPIRE-08-2017):

- Carbon4PUR - Turning industrial waste gases (mixed CO/CO2 streams) into intermediates for polyurethane plastics for rigid foams/building insulation and coatings GA 768919

Funding by the German Federal Ministry of Education and Research:

- r+impuls Production Dreams, FKZ 033R150
- CO2Plus Dream Resource, FKZ 033RC002
- MatRessource Dream Polyols, FKZ 03XP0052

Funding by Climate-KIC / European Institute of Innovation and Technology

- enCO2re flagship project CroCO2PETs

[2] Technology Readiness Level. More information: https://ec.europa.eu/research/participants/portal/desktop/en/support/faqs/faq-2890.html

  - Blending of biobased fuels to achieve blends with 90% GHG reduction potential
  - Development of materials with resistance to high temperature for aerospace applications
  - More efficient processing of carbon fibres for cost reduction

- Reduced emissions, waste and footprints for industries through:
  - Moving to "zero waste/discharge" using new separation membranes for water and gaseous effluent treatment
  - Biological or chemical recycling of materials and recyclable materials by design

- Increased use of by-products from the food processing industries to create valuable products, better biocompatibility and tolerance in the human body for materials in medical devices and regeneration and integration of tissues (e.g. bones, tendons, joints) through:
  - Developing antibacterial devices and implants using nanostructures
  - Integrating biomimicry and functionalisation
  - Providing personalised devices produced by 3D printing of biocompatible materials

- Flexible sustainable, active and intelligent packaging for food through:
  - Enhancing the shelf life, quality and safety of fresh food
  - Developing recyclability and renewability of materials
  - Reducing moisture and oxygen impact

- Innovative cosmetic products through:
  - Balancing the skin's biotope, long hydration, and bioavailability
  - Use of animal free prediction of risk and functionality
  - Use of biomass as raw materials

- Innovative textiles through:
  - Integrated ability to measure pulse and breathing
  - Temperature control capability

The following are key examples of the technology developments required:

<u>New generation lightweighting technologies:</u>

- Development of high performance reinforcement fibres (glass, carbon, biobased etc.) for composite materials
- Re-design of polymer matrices such as thermoplastic resins for advanced mechanical properties and cost-effective manufacturing
- Cellular material developments including foamed nanostructures and aerogel polymer blends
- Development of recyclable new materials, like thermoplastic resins, biobased resins and polymers (for example, PLA and sustainable composites)
- Upcycling of (in)organic waste streams
- Development of durable coatings (erosion, resistance)
- Additives mixing

<u>Electrodes and electrolyte technologies and separators:</u>

- Electrodes development for next generation Li-ion batteries, flow batteries and solid-state energy storage
- Development of gel polymer and solid-state electrolyte ingredients and formulations for higher performance and safety
- Development of electrolytes, additives and solvents for high voltage and high capacity

Sustainable operation of flexible intensified processes

Digital technologies enable the migration from batch to flexible continuous intensified processes

➔ *Public funding facilitates the fruitful collaboration of seven companies from the chemical industry and eight excellent European partners from academia, research and technology*

The future competitiveness of the European chemical industry depends on its ability to deliver high quality and high value products at competitive prices in a sustainable fashion, and to adapt quickly to changing customer needs. The use of flexible intensified continuous processes is a promising strategy towards this goal, because they give access to new and difficult to produce chemical compounds, lead to better product uniformity and reduce the consumption of raw materials and energy drastically. Moreover, it facilitates flexible and mobile production in more efficient and smaller plants and enables companies to bring new products quickly to the market. As an analysis within the former SusChem flagship project F³ Factory[3] has shown, a fully automated process operation is a prerequisite to realise these benefits.

Therefore, the main goal of the **CONSENS** project was to advance the continuous production of high-value products that meet high quality demands in flexible intensified continuous plants by introducing novel digital technologies such as: new online sensors with capabilities that are not available on the market, novel closed-loop control methods for flexible operation and high-quality levels, as well as data-based and simulation-based methods to ensure optimal operation of the controlled system.

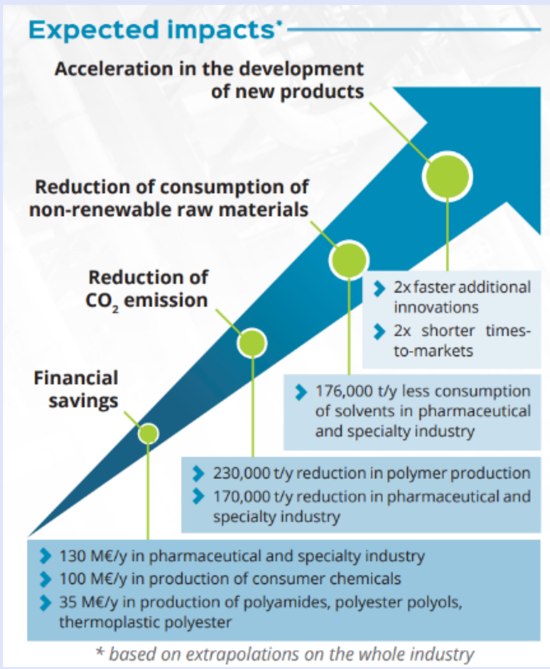
How was the breakthrough innovation achieved?

The development work was steered by the needs of the industrial partners. Three commercially relevant case studies were selected that reflect the requirements: an intensified pharmaceutical synthesis, a continuous polymerisation process, and the continuous formulation of complex liquids. The key success factor was to consider sensors, closed-loop control, monitoring solutions, soft-sensors, and process dynamics in an integrated approach. This led to holistic control solutions that were validated very successfully in the pilot plants.

IMPACT

From the results achieved in the three case studies, we can conclude financial savings of 265 M€/year, a reduction of CO_2 emissions by more than 490,000 t/year, and less consumption of non-renewable raw materials of 176,000 t/year in the related industries in Europe by enabling the migration from traditional batch processes to flexible intensified continuous processes.

It is expected that the market share of European chemical production plants on the global market will increase by ca. 3% due to better quality, innovative products and higher competitiveness.



CONSENS INTEGRATED CONTROL AND SENSING

Reference information

CONSENS – Integrated Control and Sensing for Sustainable Operation of Flexible Intensified Processes (GA number 636942).

Project website: http://www.consens-spire.eu/

---

[3] F³ Factory was a collaborative research project funded under the EU FP7 programme. http://www.f3factory.com/scripts/pages/en/home.php

Materials for ICT (see Digital Technologies):

- Embedded sensors for the Internet of Things
- New materials for future computing (memristors for neural networks, quantum computers)
- Stretchable electronics for interaction with the human body
- New man/machine interfaces

New Catalysts: (see advanced process technologies)

Stimuli responsive materials:

- Development of polymers responsive to parameters like pH, temperature, electromagnetic radiation at various wavelengths, mechanical force (e.g. self-healing properties or shape memory) and hydrophobic for self-cleaning
- Development of biologically responsive materials, such as enzyme responsive, biosensor applications or controlled drug delivery systems

Nanostructuring of crystalline materials, polymers and surfaces:

- Self-assembly of nanostructured building blocks
- Organic nanostructures, metal organic frameworks
- Chemical functionalisation of carbon nanotubes, graphene
- Metal halide perovskites, organic electronics for solar cells, LEDs, lasers, sensors, etc.
- Nanostructured photoelectrodes for production of solar fuels and CO2 valorisation

Formulation:

- Use of biobased compounds
- Smart, functional and engineered additives (for example, substitution of BPA, Phthalates, flame retardants etc.)
- Use of high throughput technologies and modelling (multiscale digital design) to maximise results (for example, complex mixtures)
- Sustainable liquid to powder processes and small particle control

Medical devices:

- Use of biocompatible materials
- 3D printable materials for tissue engineering

Combining stimuli responsive polymers with biological systems and nanomaterials can potentially give access to a wide variety of new functions and properties.

In addition, the following technologies support all advanced materials KETs and are essential for the success of research and innovation in this area:

- Characterisation
- Modelling
- Nanoengineering
- Eco-design

Pilot Line for Self-Assembly Copolymers Delivery

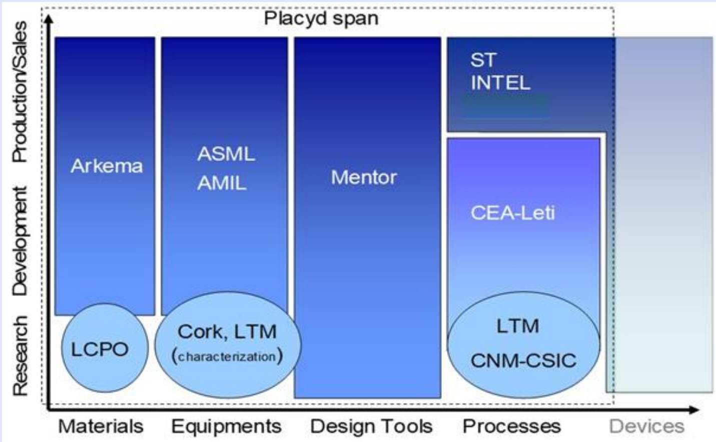
A disruptive technology breakthrough strengthened EU leadership in semiconductors.

➔ *Public funding aligned an eco-innovation system. Synergies enabled a breakthrough development.*

The semiconductor industry economy relies on geometrical scaling of transistors to insure performances improvement, power consumption reduction and cost per transistor reduction. Therefore, the well-known Moore's law, relating to the reduction of devices' critical dimensions by a factor of two every 18 months, has been driving the semiconductor roadmap. Up to now, devices scaling has been enabled by continuous improvements of optical lithography. Directed Self Assembly (DSA) lithography is a disruptive patterning technology that no longer relies on optics but on the polymer's characteristics (composition and molecular weight). In DSA technology, the pattern is included within the material as the molecular weight defines the critical dimensions and the pitch the composition of the pattern.

How was the breakthrough innovation achieved?

PLACYD project relied on a strong consortium gathering companies and academic laboratories that covered the full eco innovation system and all necessary skills from material to end-users including process and equipment manufacturers (see picture). The success of the project was established through synergies and complementarities of the partners along the value chain.



In DSA technology "the pitch is in the bottle", the polymer and resists quality and reproducibility were key to the success of the technology. Therefore, specific efforts in developing new processes as well as new metrology techniques have been carried out leading to excellent performance and the state of the art in this sector. The metallic contamination of the resist is bellow 10ppb for all metals, the organic purity of the polymer is greater than 99.9% thanks to a unique proprietary technique that allows to discriminate homopolymers from copolymers and the copolymer dispersity has been reduced to less than 1.05.
On the patterning quality aspect, CEA-Leti developed new integration schemes that allows a wide range of configurations while insuring optimum pattern performances.

IMPACT

Increasing European leadership in microelectronics and more specifically in lithography both in terms of academic recognition (more than 60 papers and conferences), Intellectual Property position (i.e. more than 25 patent families were applied for within the project, half of them are already public) and in terms of industrial leadership.

Commercial products have been launched based on PLACYD results. On the material side, ARKEMA launches its Nanostrength EO material suite that includes a full range of DSA resists for both lamellar and cylindrical pattern ranging from 20 nm to 50 nm pitches. On the design side, project partner MENTOR commercialises the DSA module within its EDA CALIBRE software suite.

In summary, PLACYD allowed the development of a full DSA solution that covers all key axes of the technology (material, process, metrology and design) strengthening European leadership in semiconductor technology and demonstrating the compatibility of DSA with manufacturing requirements. Moreover, commercial products have been derived from PLACYD developments: DSA material suite by ARKEMA, DSA software module by MENTOR.

.

PLACYD

Reference information

PLACYD has been funded through ECSEL JU and the following state members: France, Ireland, Israel and Spain. Netherland did support the project but did not funded it. The overall budget was €15 million and the grants covered €5.8 million (2.2 from ECSEL and 3.6 from the Member States).
Project Website: http://www.placyd.eu/

Impact – what else can be achieved?

Light weighting technologies

A better fuel efficiency and CO2 reduced emissions in transport using lightweight materials: Each 100 kg of mass reduction in a car reduces the CO2 emissions by 8 g/km.
Polymer composites for automotive sustainability

Ability to downsize batteries on electrical vehicles, using lightweight materials for EVs.

Higher wind energy efficiency using lightweight materials for longer blades: 13000 tonnes of composites / installed GW 30% production time reduction.
Wind in power: 2016 European statistics
windeurope.org

A better recyclability of Composites materials (potential saving of 40,000 tonnes of deposits in EU landfill per year).
Working paper SusChem Composites circularity

Insulation foams: 50-80% energy savings in buildings

With electricity costing some 10-25 cents per kWh and gas ranging from 3 to 12 cents per kWh a typical gas heated 100 m2 apartment would save 100 x 56 x €0,06 = €336 per year. In terms of energy this would be some 5600 kWh per apartment saved per year. If we can refurbish some 180,000 apartments per year under the Smart Cities programme and build also some 20,000 new ones using the proposed solutions then this would bring a total saving of 1.120 million kWh.

For commercial buildings, the possible target to refurbish some 10,000 office buildings of on average 5.000 m2 per building, which would deliver 40% energy reduction, could result in 3.9 billion kWh saved annually. This would provide an equivalent of 350 million euros of annual savings.
SusChem brochure:
Innovative Chemistry for energy efficiency in smart cities

Electrolyte / electrodes/separators technologies

Increased energy storage through higher energy and power density, reduced cost, cycle life increase through materials for rechargeable batteries: 600 GWh by 2025 mainly in electrification. 700 km of electrical driving range to be expected by 2025.
Fraunhofer Institute for System and Innovation Research ISI; BMW communication on new battery cell centre

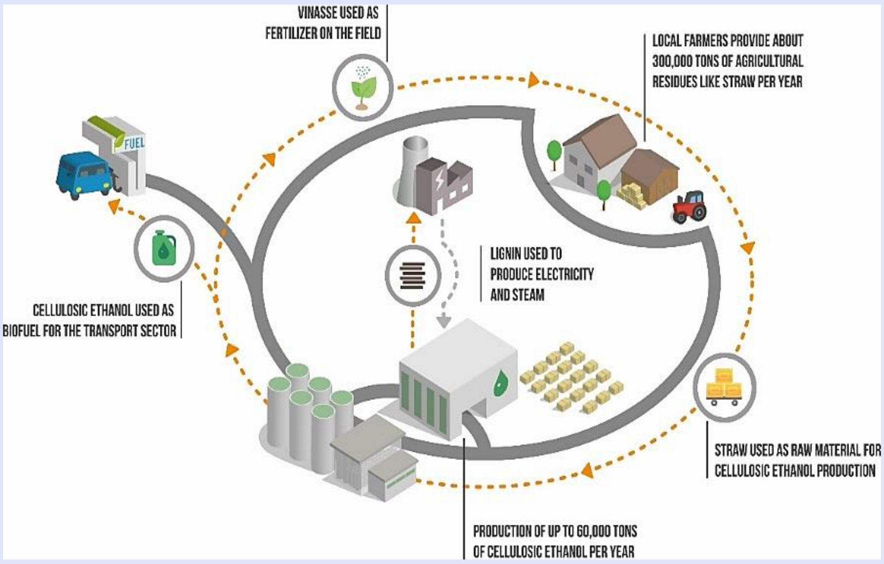
Agricultural residues into biobased chemicals

Innovative process technology reduces Green House Gas (GHG) emissions

➔ *The realisation of a first-of-its-kind flagship production plant using a new technology is always a high-risk project with significant higher costs compared to subsequent plants. The support through public-private funded projects helps to de-risk the investment in a production plant and leverages private capital in this important industry sector.*

Clariant's sunliquid® process converts lignocellulosic agricultural residues, such as cereal straw, into cellulosic ethanol or other biobased chemicals in a way that is highly efficient, economic, energy-neutral and sustainable. Sunliquid® contributes to the political objectives of reducing GHG emissions in the transport sector, to support the transformation from a fossil-based economy to a biobased, circular economy while creation of green jobs, especially in rural areas, mobilisation of currently underutilised agricultural residues, boosts to local economies and creation of additional business opportunities, and creation of a sustainable and competitive source of domestic renewable energy for the EU. Sunliquid® is a biotechnological process and hence contributes to the KET biotechnology.

How was the breakthrough innovation achieved?



The sunliquid® process was developed by Clariant for more than 10 years to overcome major technological hurdles like the need for high yields, low energy consumption, and a stable and economic process of cellulosic ethanol production. During this time the process was developed from TRL 4 to TRL 8. The maturity of the process was developed in pilot plant scale in Munich, Germany. As a subsequent step within the process development the technology was further up-scaled to demonstration scale with Clariant's pre-commercial plant in Straubing, Germany. This plant is operational since June 2012 and successfully demonstrated the process in an operational and integrated environment. Clariant's sunliquid® technology is now ready for a flagship production plant for lignocellulosic ethanol.

Various development steps and parts of the sunliquid® process received and still receive funding. The funded projects on Bavarian, National and European level as well the partnership with the region Straubing enabled Clariant to develop the technology and still supports the proof of techno-economic viability of the sunliquid® technology at commercial scale.

IMPACT

Clariant is investing in a new commercial-scale plant for the production of cellulosic ethanol made from agricultural residues, based on the sunliquid® technology, in the southwestern part of Romania. This undertaking will have the following impact:

- Reduction of greenhouse gas emissions of up to 95%
- Clariant investment in southwestern Romania of approx. €150 million
- Number of jobs: 80 direct and 300 indirect. 800–900 during construction phase in an underdeveloped region of the country with unemployment rates of 20%
- Additional income for farmers and local businesses: >€20 million
- Additional tax generated in the region: >€1 million annually for the next 20 years
- Regional Development: Industrial plant using agricultural residue as feedstock in a strong agricultural economy along with energy integration of actors along the whole value chain

Reference information

SUNLIQUID; large scale demonstration plant for the production of cellulosic ethanol
Funding Program: FP7 (EU) - GA number: 322386 Project Website: www.sunliquid-project-fp7.eu
LIGNOFLAG; Commercial flagship plant for bioethanol production
Funding Program: BBI JU/H2020 (EU) - GA number: 709606 Project website: www.lignoflag-project.eu

Develop Advanced Process Technologies

Our commitment to sustainable production

IMPACT examples:

5. Technical improvements in **catalyst** and related processes could further reduce **energy intensity** for chemical production processes by **20% to 40%** as a whole by 2050.
6. Process technologies enabling **recycling of carbon from CO_2** for more sustainable production of chemicals and polymers can effectively contribute to a more circular economy.
7. **Industrial Biotech** enables **2.5 billion tonnes of potential CO_2 savings** per year, which is equivalent to the **CO_2** emissions of 490 million cars.
8. **Process intensification** and **plant modularisation** considerably decreases energy consumption, CAPEX, and time-to-market of processes
9. Process technologies for the **production of major chemical building blocks** from CO_2 and H_2 from **renewable electricity** can enable high potential **CO_2 emission reduction**.
10. The use of **alternative energy sources** in chemical processes have the potential to **lower the global warming potential significantly** compared to conventional process pathways.

Process Technologies enable the transformation of raw materials into materials, which have a different chemical composition, structure, and properties than the input raw materials. Advanced process technologies are a specific type of KETs that enable the chemical industry to provide all industrial value chains (e.g. construction, automotive, medical, electronics, energy) with the materials (solid, gas and/or, liquid) and novel properties required to produce a vast range of end-user products.[4]

What can be achieved?

Further reduction of the footprint of the chemical industry and its wide portfolio of products can be achieved through:

- Better utilisation of alternative carbon sources as raw material:
  - Biomass including biogeneous waste streams
  - CO_2 (and CO) from industrial sources with and without H_2
  - Waste materials (mechanical and chemical recycling)
- Utilisation of renewable electricity, alternative energy sources, H_2 with low carbon footprint
- Improved energy management and higher conversion efficiency of chemical production processes
- Sustainable water management
- Materials created through advanced processes for high efficiency in value chain applications (higher quality, increased performance, advanced & lightweight materials)
- Retrofit of existing plants for fast technical adaption and higher quality target achievement with reduced risk (novel feedstocks or processes)

[4] Differs from 'Discrete Manufacturing Technologies' that enable the production of distinct units (systems and end-user products) by shaping materials provided by the Process industry, and assembling element, part of 'Advanced Manufacturing Systems' defined by the HLG KETs.

Water fit-for-purpose management

Economically and ecologically efficiency in the European Chemical Industry

➔ *Public funding brought an Innovation Ecosystem together to take on a significant challenge to develop and demonstrate eco-efficient industry water management.*

Water is a scarce resource and a key element for the development of our society and economy. The chemical industry, as a water user and solution provider of innovative products, technologies and services, offers significant potential for increasing eco-efficiency in industrial water management. To deal with critical challenges, such as the need to reduce water use, wastewater production and energy use, an EU FP7 funded project applied new research and development concepts to boost eco-efficiency and sustainability. E4Water has addressed a wide range of aspects relevant for an efficient integrated industrial water management in practice. Developments provided and demonstrated in the six case studies comprise: utilisation of alternative water sources; treatment of organic and inorganic wastewater streams and concentrates; recovery of valuables and energy from wastewater; linking process water and cooling water networks; combining different scales in water management (process – plant – site – local – regional); introducing tools to optimise water management; Life Cycle Assessment of selected measures; considering regulatory framework aspects. The success of the E4Water project has shown what is possible in the chemical and related process industry sectors in terms of 'fit for purpose' water management effectively decoupling industrial production from the use of fresh water, other natural resources and energy. The outcome of E4Water strengthens both, the leadership of the European Water Technology Industry and of position of the European Process Industries.

© Shutterstock mr.water

How was the breakthrough innovation achieved?

The E4Water project did create a complementing consortium with partners from nine EU countries: large chemical enterprises, leading European water sector companies, innovative research and technological development (RTD) centres and universities active in the area of water management. The European Technology Platform for Water (WssTP), the European Technology Platform for Sustainable Chemistry (SusChem), the Society for Chemical Engineering and Biotechnology (DECHEMA), the SPIRE Public-Private Partnership (PPP) and water authorities were also linked through their members in the project.

IMPACT

- *Economic impact:* Significant economic benefit can be gained, for example, operating expenditure (OPEX) was reduced by up to 30% for every m3 of saved freshwater/year (depending on local conditions); or eliminating the need for incineration (e.g. 5,000 tonnes/annum/plant) together with establishing a business case, leading to revenue generation.
- *Environmental impact:* 1) Reduced fresh water uptake of 40-80% resulting in freshwater savings of ~3 million m^3/year in one case. 2) Reduced wastewater production of 30-80%, with close to 100% (loop closure) in one case and resulting in reduction of waste water production by ~2.5 million m3/year in another case. 3) Resource recovery, efficiently extracting resources from water and returning these to the prime process or a local increase in resource efficiency by use of algae. 4) Reduced energy use of up to 20% by using low energy technology, heat recovery, or optimising the integrated process with the use of improved modelling;
- *Social impact:* Water is a key to resource efficiency, climate action and other major societal challenges: Efficient water management is also essential to enhancing resource efficiency, improving energy efficiency and thereby tackling climate change and ensuring the continuing supply of raw materials. The results are also key to implementing process intensification concepts that will form the basis of the chemical and process plants of the future. The E4Water resulted in strengthening the competitive position for Europe's process industry and water industry and keeping Europe an attractive location for industry.

E4WATER

Reference information

EU FP7 funded project E4Water (May 2012 to April 2016) project agreement 280756

Project website: http://www.e4water.eu/

Technology developments needed:

In order to achieve the above goals, a portfolio of advanced process technologies and their combination needs to be developed.

- **Process design** and realisation for sustainable process intensification, utilisation of alternative feedstock (e.g. waste/recycled materials, biomass, CO_2) and energy sources (supported by advanced sustainability-based process modelling, see Digital Technologies section). Advanced recycling technologies for physical and chemical recycling of materials.
- **Process and plant redesign** for retrofit of exiting assets with the optimal combination of process technologies (supported by sustainability-based advanced process modelling, see Digital Technologies).
- More **robust and tolerant production processes** enabling flexibility towards potential specification variations in feedstock (e.g. less purified CO_2 streams, integration of different/multiple sources of feedstock in biorefineries), energy and output.
- **Modular** concept for more sustainable continuous production systems for small and medium scale chemical processes, and a competitive approach in new and developing markets. Technical developments include design and realisation of "plug-and-produce" modules (including reaction, separation/workup, pumps and other utilities) equipped with advanced process control (see also Digital Technologies) to enable different plant set-ups and flexible adaptation of scale as well as stepwise modernisation or feedstock/process adaption of existing plants.
- New **catalyst** design and development (including materials development for asymmetric, organo catalysis, tandem-reactions, and support from Digital Technologies*)* for higher selectivity and reduced energy consumption (including for depolymerisation, CO_2 valorisation, H_2 production). Novel catalysts should be designed and produced to be less prone to poisoning and deactivation, be able to accommodate more complex and or variable feedstock quality, be less expensive to produce, and enable integration with separation technologies to reduce the number of process steps.
- **Biotech processes** including development of enzymes/catalysts, production strains, and processes enabling the efficient production of fuels, chemicals and polymers from new feedstock sources (e.g., biomass 1st and 2nd Generation). Development of improved fermentation protocols, improved bioreactors and improved downstream technologies (see separation technologies below) to improve cost competitiveness. Enable the use of modern molecular biology, biocatalysis and process options to make biotechnology more efficient, more versatile (feedstock) and more cost competitive. Enable the use of 2nd Generation sugars and CO_2/CO with biotechnological means.
- **Electrochemical** processes including development of new electrocatalysts electrodes (see Materials), compact electrolysis cells, and bioelectrocatalytic systems (incl. for CO_2 valorisation)
- Intensified processes with **alternative energy forms** such as plasma and microwave technologies, and pyrolysis technologies for better valorisation of current and alternative types of feedstock.
- Advanced **electro photocalatytic** systems for direct utilisation of sunlight in H_2 production and CO_2: valorisation.
- Advanced **separation technologies** including advanced and flexible thermal technologies, alternatives to thermal separations (e.g., membranes, adsorption including specific materials development), integrated and reactive separations technologies, separation technologies for recycling (of catalysts, polymers, composites), technologies for solvent management, technologies for water management including dilute solutions for bio-processes, and separation technologies for biomass pre-treatment (including lignocellulosic).
- **Advanced control technologies** for optimised production including advanced sensing technologies (see Digital Technologies).

Impact – what else can be achieved?

CO₂ as alternative feedstock and renewable electricity

Process technologies for the production of major chemical building blocks (e.g. methanol, olefins and BTX) from CO_2 and H_2 from renewable electricity can enable high potential CO_2 emission reduction in the chemical industry, as evaluated by DECHEMA in a recent study. As an example:

- -1.13tCO_2/t olefin for alternative CO_2-based route vs 0.76tCO_2/t olefin for the fossil-based route, i.e. 1.89t CO_2 avoided/t olefin, which in a theoretical maximum deployment scenario in 2050 would lead to 79.2 CO_2 mill. t per year CO_2 avoided vs the fossil route, for an electricity demand of 3,270 TWh, and significant investments.

The same process technologies can have an even higher absolute impact (evaluated on a well-to wheel basis) if used for the production synthetic fuels.

Low carbon energy and feedstock for the European chemical industry, Technology Study, DECHEMA, 2017

Alternative energy sources: Plasma

For the Nitrogen fixation process assisted by plasma technology and incorporating renewable energy: a reduction in the global warming potential of 19% as compared to the conventional production pathway has been reported from the Mapsyn project.

Life Cycle Assessment of the Nitrogen Fixation Process Assisted by Plasma Technology and Incorporating Renewable Energy
Ind. Eng. Chem. Res., 2016, 55 (29), pp 8141–8153

Process intensification and plant modularisation

Process intensification and plant modularisation will decrease energy consumption of processes up to -30%, CAPEX by -40%, and time-to-market by -50% have been reported from the F^3 Factory project (2013).

F^3 Factory Project:
http://www.f3factory.com/scripts/pages/en/home.php

Catalyst & Process

Technical improvements in catalyst and related process could reduce energy intensity for the top 18 energy intensive large volume chemicals by 20% to 40% as a whole by 2050 combining all scenarios. In absolute terms, improvements could save as much as 13 EJ (exajoules) and 1 Gt of carbon dioxide equivalent (CO_2-eq) per year by 2050 versus a “business-as-usual” scenario. Catalysis is thus crucial to reduce this environmental burden

European Cluster on Catalysis, October 2016
Science and Technology roadmap on catalysis for Europe, A path to create a sustainable future

IEA-ICCA-DECHEMA, 2013
Technology Roadmap, Energy and GHG Reduction in the Chemical Industry via Catalytic Processes

Industrial Biotechnology

- Industrial biotech (IB), one of the six technologies identified as a KET by the EU, is broadly accepted as one of the EU's core strengths, helping to enable a more competitive and sustainable bioeconomy. When considering direct, upstream, and downstream employment, IB alone is predicted to contribute up to 1.5 million jobs adding almost €100 billion to the EU economy by 2030[1]. Its potential to, quite literally, catalyse the transition towards a renewable future is being harnessed by an increasing number of sectors, creating new value chains. Therefore, IB is often considered the key to the development of the bioeconomy.
- Industrial biotech can also add value to industrial side streams such as CO_2, as well as biogenic waste streams, making valuable products from what might otherwise be considered either worthless or a cost burden. In this regard, IB can also make an important contribution to the Commission's objective to turn waste into a resource, a key pillar of the Commission's circular economy approach.
- Saving 31 million tonnes of CO_2 as a result of industrial biotechnology[2]. Using 30% less energy with biological washing powders enabling clothes to be cleaned at 30˚C rather than 40˚C[3]. This will result in 2.5 billion tonnes of potential CO_2 savings per year from Industrial Biotech[4], which is equivalent to the CO_2 emissions of 490 million cars.
- Improving crop production and preserving soil quality through the use of biodegradable agricultural mulch films. Reducing the use of water and chemicals by using enzymes for leather and textile production.
- Making lightweight and durable biobased plastics and tyres for the automotive industry. Improving the efficiency of pulp and paper production. Producing biobased molecules with new and novel functionalities such as durable and shatterproof smart phone and tablet screens.
- Making 100% recyclable and biobased plastics for consumer products and packaging. Enabling investment of €3.7 billion in biobased research and innovation in Europe over seven years (2014-2021).

EuropaBio - The European Association for Bioindustries

1. https://www.europabio.org/industrial-biotech/publications/jobs-and-growth-generated-industrial-biotechnology-europe
2. Annual global impact: WWF Denmark 2009
3. Life cycle assessment supporting cold wash enzymes: International Journal of Applied Sciences 2005
4. Annual global impact: WWF Denmark 2009

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

Real-time data and online decision support systems enable **IMPACT**

➔ *MORE has brought the computation, visualisation and use of resource efficiency indicators to a new level by evaluating them online in daily operations, visualising them for operators and managers in a transparent fashion and using them in decision support and optimisation.*

MORE was a STREP[5] project supported by the European Commission in the field of Nanosciences, Nanotechnologies, Materials and new Production Technologies (NMP) aiming at identifying resource efficiency indicators (REIs) that can support operational decisions in processing plants through the use of real-time data and the implementation of dedicated online decision support systems. MORE ran from November 2013 to February 2017.

How was the breakthrough innovation achieved?
Within MORE, the academic and research partners Technische Universität Dortmund, Germany, Universidad de Valladolid, Spain and VTT, Technical Research Centre of Finland, the solutions providers LeiKon GmbH and S•PACT GmbH, Germany, the industrial partners PETROLEOS DEL NORTE SA (Petronor), Spain, BASF Personal Care and Nutrition GmbH, INEOS Köln GmbH, Germany and LENZING AG, Austria as well as the coordinating consultant inno TSD, France collaborated impressively to develop theoretical results, implement them in practice, publish and standardise them.

IMPACT

As key results MORE defined principles for the definition of real-time Resource Efficiency Indicators (REIs) and proposed indicators for integrated chemical plants to be used in the daily operations of continuous and batch processes. They significantly extend available indicators as they cover resources overall and are based on the processing of real-time data that is available in the monitoring and control systems and from innovative analytical measurements. They form the basis for necessary steps from monitoring to improving resource efficiency through model-based real-time decision support provided to plant operators and plant managers.

Technical achievements were reported through the implementation in industrial cases. Two examples:

1. At Petronor the MORE partners optimised the distribution of hydrogen. Petronor estimates an economic gain of between € one million to € five million per annum equivalent to 3-5% of cost savings and a reduction of greenhouse gas emissions of 3.5%.
2. At Lenzing, the specific steam consumption together with the overall cycle cost of the evaporator system was optimised with an economic impact of € 575,000 to €825,000 per annum coupled with a significant reduction of direct CO_2 emissions from the site by about 0.3%.

Reference information
EU FP7 funded project MORE (November 2013 to February 2017) project agreement 604068
Project website: http://www.more-nmp.eu/

[5] Small or medium-scale focused research project

Leverage Digital Technologies

We recognise the need to fully integrate digital technologies into processes, materials development, and business models

IMPACT examples:

11. By applying **big data and supercomputer science** in catalyst research **time-to-market can be three times faster** than today.
12. **Real-time Monitoring** and optimisation of **resource efficiency** in chemical processes will make process lines **more energy efficient** translating into **reductions in CO_2 emissions.**
13. **Digitalisation** has the potential to reduce CO_2 emissions by **60-100 million tonnes** over the next decade. Digitally enabled business models could **generate up-to 225,000 jobs**.
14. Implementing **digital advanced technologies** into the chemical industry in Europe could likely **increase profit margins** thus improving competitiveness and **securing jobs.**

The chemical industries' contribution to the development of advanced materials is largely the enabler for other industries' continuous development of smarter and more sustainable electronic devices and equipment (see Materials Section).

However, at the same time, the chemical industry is itself being transformed and disrupted through digitalisation. From new forms of innovation and production - including modelling of processes and materials - to new business models the chemical industry is about to go through a revolution by taking full advantage of new innovative digital technologies. The fourth industrial revolution (Industry 4.0) is present in all aspects of the chemical industry, and will have impact throughout its value chains, from procurement, logistics, process- and materials design, planning, risk management, plant operations, process automation, manufacturing excellence, plant safety, monitoring and predictive maintenance of factory equipment to new roads to market.

Intensified continuous and batch processes using new types of real-time-sensors/process analytical technology (PAT) and model-predictive control are being further developed. Data science in a high-performance-computing (HPC) environment and artificial intelligence will enable the efficient management and optimisation of complex processes including the recognition of unusual situations, optimised recovery measures, equipment condition monitoring, monitoring of environmental targets, model maintenance, energy consumption and emissions, including aspects of retrofitting for 'brownfield' assets. Simulation capabilities (digital-twin) along the whole life cycle of a plant specifically in early design phases of processes and plants, and especially supporting flexible, modular, miniaturised and de-localisable plant and process intensification concepts.

Materials modelling including the use of high-performance-computing will revolutionise the development of new advanced materials and structures including, for example, *in-silico* development and testing of catalysts that allow more efficient processes (see Process Technologies).

Precision farming resulting from digitalisation is also adding value to farms, forests and food producers by enabling more sustainable primary production, harvesting, transportation and storage of biomass. This, in turn, will result in the development of even more sustainable biobased chemicals and other products.

What can be achieved?

Engagement in digital technologies is expected to have a particularly high impact in modernising Europe's production and R&D-capabilities and will support the European chemical industry's leading position for competitiveness, sustainability and safety.

Modularised solutions enabling solvent-free process

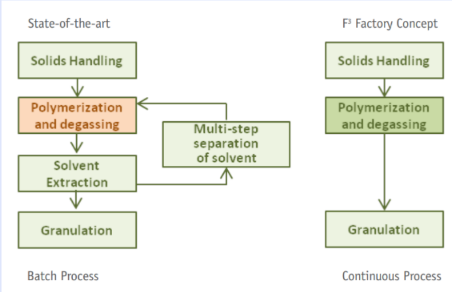
Improve the Competitiveness of the European Chemical Industry – F3 Factory

➔ *Public funding creates cross-sectorial collaboration, breakthrough technology advancement and fast-track-to-market of new products.*

BASF was part of the consortium behind the "**F3 Factory**" project. This consortium – consisting of 26 partners from academia and industry – aimed to develop an approach for radical modular process design. This concept enabled significant process intensification and at least 25% less energy consumption.

How was the breakthrough innovation achieved?

The concept of modularised solutions was investigated for different industrial processes. Results from academia were transferred in business case studies and were demonstrated at commercial scale in an open access backbone plant for modular continuous production (INVITE Research Centre). BASF together with Bayer Technology Services have collaborated to demonstrate the concept of multi-product, small-to-medium scale production for high viscous polymers in a solvent-free manufacturing process. This collaboration was supported by Technical University Eindhoven and the University of Paderborn.



IMPACT

- In addition to the technological advancement achieved in this project, the transfer from batch to continuous of a new solvent-free polymerisation process has demonstrated both cost (30% reduction of energy demand) and environmental (100% solvent reduction) impact for the production of highly viscous polymers.
- The modularisation concept investigated in the demonstration plant furthermore allows a reduction of investment cost (up to 40%) compared to conventional processes and reduced time-to-market (up to 50%).

Reference information

EU FP7 funded project F3 Factory (May 2009-2013) project agreement 228867
Project website: http://www.f3factory.com/scripts/pages/en/home.php

LIFEOMEGA Project

Solutex is an innovative SME continuously investing in research and innovation to offer high quality products for nutritional and pharmaceutical industries. Solutex is in the forefront of research in Omega-3 to improve the quality of life and nutrition of cancer patients. LIFEOMEGA-cancer, considered as one chemotherapy essential nutrient co-adjuvant, is one of the latest products. The scale up of technology to TRL 8, has been made possible with EU SME funding.

How was the breakthrough innovation achieved?

For an SME, partnerships with both RTOs and large companies is key to long-term success. Solutex has a partnership for a commercial agreement with one the most important pharmaceutical groups in Spain. Collaboration with hospitals and clinics has been essential for the success of the project and to carry out the clinical trials needed. After the preliminary research, carried out with company's own resources, Solutex successfully applied for a Phase-I SME Instrument, and for a Phase-II SME instrument. The funding received has been fundamental to develop the final product and the scale-up.

IMPACT

- The social impact for cancer patients' treatments is very important. With the new product, the quality of life of cancer patients is improved. Chemotherapy effects become tolerable and hospitalisation time is reduced.
- The new product is an essential nutrient adjuvant in chemotherapy. The medical benefits of the product are appreciated. Preliminary findings show that Omega-3 supplement increases chemotherapy effectiveness.

With the funding received, the time to the market was reduced by about three years, a parameter of paramount importance for an SME. Additionally, it brings the opportunity to open to new markets and new partnerships in the pharma and nutraceutical sectors.

Reference information

LIFEOMEGA: Innovative highly concentrated Omega-3 Specialised Nutrition Product (GA number 755889)

Digital technologies are a major enabler of higher plant availability, flexibility and throughput, better predictability of manufacturing, reduced lead times, remote operations, less quality issues, higher resource and energy efficiency, less costs for laboratory experimentation, switch to continuous manufacturing, reduced time to market for product and process developments, more efficient plant maintenance, more efficient allocation of staff, new and disruptive business models.

Larger and smaller companies including their innovation networks need to be fully supported to leverage new digital technologies in their operations and processes.

Technology developments needed:

Process Design Phase

- '**Digital Twins**' (virtual process and/or plant models) to predict the impact of (design) decisions and to anticipate bottlenecks as well allow efficient upfront operators training for new processes. Such **simulation capabilities** are specifically required in early design phases to systematically assess possible alternatives in terms of capital investment, quality levels, process sustainability, operational costs and flexibility, because in this phase fundamental decisions are taken that influence significantly the overall process efficiency
- Technologies to digitally **retrofit** existing plants

Production Phase

- New control strategies for **intensified** and **modular processes** and plants
- Safe **remote-control** of plants/processes
- New types of robust **online process sensors/PAT devices** with (wireless) communication abilities
- **Sensors** to measure online the **quality of water/wastewater**
- **Real-time architectures** – to provide accurate process information to operators in real-time
- **Feedback control** to detect deviations and automatically adjust process operations immediately
- More efficient **model-predictive control** methodologies
- Advanced **operator decision support** – new technologies like 'smart glasses' and augmented reality combined with smart hand-held devices and/or wearable-technologies to provide a hitherto unknown availability of information, visualisation and interaction possibilities
- Increase energy and raw material efficiency via **data-based optimisation**
- Asset performance management and **predictive maintenance** of equipment/plants
- Use of **autonomous systems** in production and logistics

Product Design Phase

- Advanced **materials modelling** (e.g., catalyst design)
- **Modelling of complex mixtures**, structure-property relationships to achieve prediction of formulation /final product properties

Supply Chain

- Marketing and **sales channel optimisation**
- Integration into 'digital platforms' to realise **new business models**
- Use of **blockchain technologies** for, for example, logistic solutions

Data Management

- Applied **'Big Data' science** for complete utilisation of information along the whole process, value chain and transfer between industrial and sectorial interfaces (planning assistance along the whole plant lifecycle, material flow management etc.)
- **Information integration** across operations and enterprise technology layers
- Strategies to employ **decision analytics**
- Standardised **communication platforms** for the Internet of Things (IoT)
- Broad accessibility of data to enable big data approaches and **artificial intelligence**

WALEVA Technology

Fostering a new value chain producing high value products from lignocellusic wastess

➔ *Synchronised combination of Member State and EU funding accelerates breakthrough technology to market*

The aim of Técnicas Reunidas' (TR) WALEVA technology is to transform a lignocellusic waste (rice straw) into levulinic acid, a high value-added product which is currently considered one of the 12 most promising chemical platforms according to the United States Department of Energy. Levulinic acid is a monomer subject to significant industrial demand since, after its chemical transformation, it can potentially be applied to several industrial sectors such as pharmaceuticals, fuels, polymers, food and chemistry in general.

WALEVA technology falls under biotechnology area, which is one the major Key Enabling Technologies defined by the European Commission. WALEVA has reached a TRL of 7 and first steps to commercialisation have been taken.

How was the breakthrough innovation achieved?

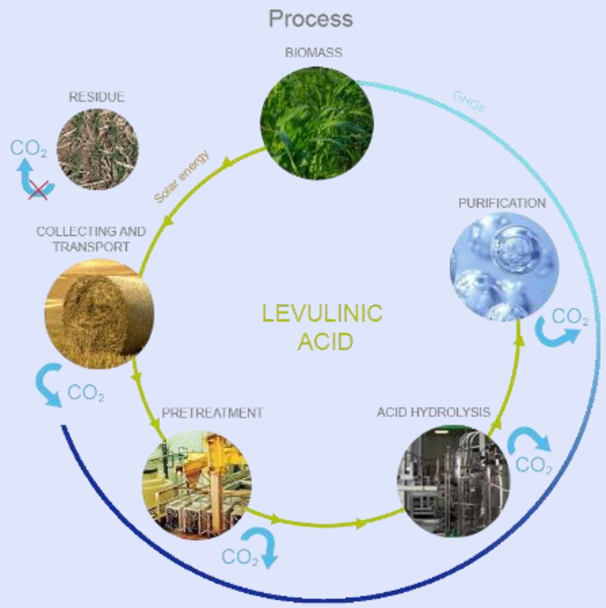
Public Private Partnerships are essential for TR's R&I activities including the development of WALEVA technology. During the initial stages of development TR received public funding from the Spanish Centre for the Development of Industrial Technology (CDTI) under the CENIT Programme (large, long term, applied research, collaborative projects). After these, TR decided to go a step further in the TRL and applied for a European LIFE+ project to scale-up and demonstrate the viability of the technology in collaboration with the Centre of Scientific and Technological Research of Extremadura (CICYTEX) and the Spanish Chemical Industry Federation (FEIQUE).

IMPACT

WALEVA technology will foster a new value chain that will produce high value products from residues ensuring the economic feasibly for each step in the chain: farmers, waste managers, biobased industries and end-users. This business model puts into practice the concept of Circular Economy and contributes to several UN Sustainable Development Goals (SDGs), such as, Climate Action.

Preliminary results demonstrate the economic feasibility of WALEVA technology for scales starting at the range of 10,000 t of levulinic acid per year. As for market deployment, levulinic acid is expected to play a key role in the Green Chemistry megatrend.

WALEVA will contribute significantly to improve rice sector sustainability, by reducing CO_2 emissions up to an 80% compared to current practice of burning of rice straw. Moreover, WALEVA will contribute to economic development and wealth creation in rural areas that heavily depend on this crop.



Reference information

Eu-Project 'LIFE WALEVA - From Whatever Residue into Levulinic Acid – an innovative way to turn waste into resource' (LIFE13 ENV/ES/001165)

CENIT BIOSOS: Sustainable Biorefinery (CEN-20091040)

Impact – what else can be achieved?

Advanced Digital Technologies:
As result of further developing and implementing digital advanced technologies, the chemical industry in Europe could likely increase profit margins by 10 - 15% thus improving competitiveness and securing industrial jobs in Europe.
Deloitte study 2017: *Digital Transformation: Are chemical companies ready?*

Catalyst & Process Simulation/Modelling:
"BASF applies 'big data' in catalyst research we reached a factor of 3 reduction in cycle times from customer request to the first promising product"
Public statement Frithjof Netzer, Senior Vice President BASF 4.0

Real-time Monitoring and Optimisation of Resource Efficiency:
Extrapolating from our results, we believe that visualising resource indicators in real-time will make process lines 2-3% more energy efficient. This improvement in efficiency translates directly into energy savings and reductions in CO_2 emissions.
FP7 project MORE,
interview Stefan Krämer of INEOS
http://ec.europa.eu/research/infocentre/article_en.cfm?&artid=42677&caller=SuccessStories

Social and Economic Benefits of Digitalisation within the Chemical Industry – Value-at-Stake:
Digitalisation has the potential to save 20 to 30 lives, to avoid 2,000 to 3,000 injuries and to reduce CO_2 emissions by 60-100 million tonnes over the next decade. Digitally enabled business models and offerings could generate 100,000 to 225,000 jobs. Across value migration and value addition to the chemical industry, the estimated cumulative economic value for the period 2016 to 2025 ranges from approximately €250 billion to €500 billion.
World Economic Forum, Digital Transformation Initiative, Chemistry and Advanced Materials Industry, 2017

"imPACts delivered": the Austrian platform for Process Analytical Chemistry

imPACts creates IMPACT through unique partnership

➔ Member State funding creates unique collaboration in a PAC platform of more than 20 partners

PAT – Process Analytical Technologies have an immense impact on the productivity, efficiency and safety of large volume chemical production. Investment in this expertise pays off in securing the position of the process industry.

In Austria, already in 2010, the research platform PAC – Process Analytical Chemistry was founded, based on a national funded research project.

The consortium placed a strong focus on further development of PAT in Spectroscopy and Micro-Electro-Mechanical Systems (MEMS) based on inline Rheology, on Process-Modelling and Process-Understanding, together leading to a closed-loop and tight real-time Process Control and Optimisation.

New measurement technologies were invented, application demonstrators implemented and evaluated in industry, high ranking journal papers were published, and patents were filed.

How was the breakthrough innovation achieved?

In the consortium more than 20 partners from industry and research institutions cooperate and perform application-oriented research as well as strategic research.

IMPACT

- Technology: more than 10 technology demonstrators evaluated, six patents filed
- Economic & Environmental: all process optimisation targeting efficiency issues
- Social: 28 PhD, 34 Master, 28 Bachelor Theses; internal training scheme established
- Scientific: 75 journal publications, > 200 conference contributions, five conferences
- European Link: The PAC-network was sustainably established in SusChem-AT

Reference information

The projects received funding from the Austrian Ministries BMVIT and BMWFW, the federal state of Upper Austria and the federal state of Lower Austria.

- imPACts: "Industrial Methods for Process Analytical Chemistry - From Measurement Technologies to Information Systems (imPACts)" – http://www.k-pac.at.
- imPACts (contract # 843546) and PAC (contract # 825340) are Austrian COMET K-projects, see http://www.ffg.at/comet for more information

For more information, please contact:
Henk Pool, Cefic Innovation Manager,
SusChem, +32 (0)2 676 72 19 or hpo@cefic.be