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European Commission

CORDIS Results Pack on

industrial demonstrators

A thematic collection of innovative EU-funded research results

March 2019

Securing Europe's industrial future through key enabling technologies and dedicated research partnerships

Research and Innovation

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Editorial

Securing Europe's industrial future through key enabling technologies and dedicated research partnerships

European industry is amongst the best and most advanced in the world, but even in the post-crisis age, new industrial champions continue to challenge Europe's leading position. As the second smallest continent with a declining population, Europe requires smart, innovative and efficient policies to help its industry flourish in the decades ahead. This CORDIS Results Pack showcases 10 EU-funded projects that demonstrate European prowess in some of the most innovative technological fields, from manufacturing and digital industry, to the circular economy and biotechnologies.

Technological change and the lingering after-effects of the 2008-09 Great Recession have caused many Europeans to wonder about the security of their livelihoods and living standards. To address these fears and ensure a prosperous, safe and secure future for European citizens, sustainable economic growth is essential. Whilst much of the European economy is now services-based, industrial production will continue to have an essential role in the future success of the continent and allow Europe to keep up and match its main international competitors, such as the United States and China.

Supporting industry through Key Enabling Technologies and Public Private Partnerships

The European Commission is determined to help high-tech firms meet their goals, advance their products and revolutionise their manufacturing processes to ensure Europe's competitive advantage. Therefore, the European Commission is pursuing its Key Enabling Technologies (KETs) policy, a crucial component of the EU's wider industrial strategy. KETs are a group of six technologies: micro- and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, photonics and advanced manufacturing processes. They have applications in multiple industries and help tackle many social challenges. The Commission's strategy aims to help KET firms translate their knowledge base into marketable goods and services, a particular weakness for European industry.

Alongside the KETs strategy, the European Commission is also boosting industry through eight research-focused contractual Public Private Partnerships (cPPPs) launched in 2013, leveraging more than EUR 6 billion of public investments to trigger additional investments for the development of new technologies, products and services. Some of the themes covered include 'factories of the future', energy-efficient buildings, robotics and sustainable process industries.

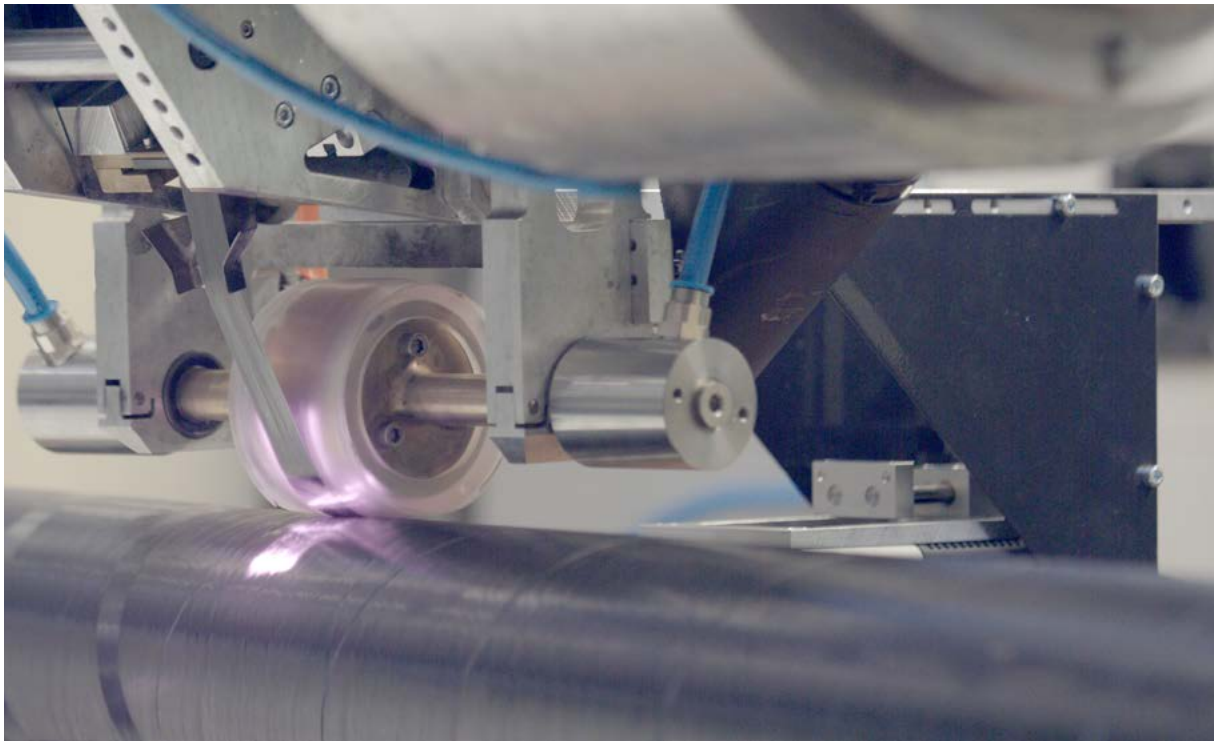
These two strategies have been a key part of Horizon 2020 and are expected to be continued and boosted through the proposed next Framework Programme, Horizon Europe.

Demonstrating industrial innovation

Whilst there are many positive examples to showcase from these strategies, this Results Pack has chosen 10 EU-funded projects that are fantastic demonstrators of Europe's industrial potential for the twenty-first century. Specifically, these projects are producing market-relevant outputs in the fields of manufacturing and digital industry, buildings and energy efficiency, the circular economy and biotechnologies.

Industrial potential of composite components unlocked

The EU-funded ambliFibre project has scaled up production of fibre-reinforced plastic (FRP) composite components. Tubular FRP parts are increasingly used in a range of industrial products, for example oil and gas pipelines and pressurised tanks for the automotive sector.



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The key success of the ambliFibre (adaptive model-based Control for laser-assisted Fibre-reinforced tape winding) project has been to demonstrate that automated and reliable mass production of thermoplastic composite parts is possible by laser-assisted tape winding. Prototype machines capable of delivering pressurised tanks for the automotive industry and pipes for the oil industry have been developed, and the system's modular technology is now available to industry.

"Customers can come to our facility in Aachen and see the process in action," explains ambliFibre project coordinator Dr Martin Schäkel from the Fraunhofer Institute for Production Technology (IPT) in Germany. "From the range of new solutions developed by the multinational consortium, they can select precisely which technologies might fit their specific needs, such as the data mining or laser optics applications. As a research institute, we are of course keen

to continue optimising and enhancing the technology with our partners."

Reinforced demand

There has been growing global demand for tubular thermoplastic composite parts from across a range of industries. This is because these materials are flexible, resilient and lightweight, and can be processed without the need for pressure chambers or autoclaves. This makes them potentially cheaper and faster to manufacture than thermoset composites. Access to the mass market however has historically been hampered by the perceived cost of scaling up production as well industry reluctance to switch to new materials.

We'd like to adapt the technology to new parts and applications, to see what the full potential is.

"The automotive sector has a lot of experience with using conventional materials like steel, and relationships with suppliers have been built up over the years," explains Dr Schäkel. "We therefore have to first overcome scepticism within the industry by really addressing their need for efficient mass production, and by demonstrating this in a transparent way."

Visible benefits

To do this, the ambliFibre project undertook a modular approach to build on and improve an FRP tubular part production technique called tape winding. Different technologies were selected and integrated into prototype processing machines, capable of manufacturing discontinuous products such as pressurised tanks for the automotive industry as well as continuous cylindrical products like oil risers.

For hardware, a quality monitoring device was built into the system along with a thermographic camera to measure the quality of the part as it is being processed. This means that an operator has access to direct feedback during the manufacture of an FRP pressurised tank for example, and can adjust or even stop the process immediately if needed. The project team also built new adaptive laser optics to optimise the heat input in the process zone, where subsequent tapes are melted and consolidated, layer by layer. A high-speed thermographic camera was developed to measure the resulting temperature distribution in real time.

On the software side, a data mining engine and a holistic process simulation model were devised to enable plants to optimise the process for their own specifications. Lifecycle modelling to assess the environmental impact of products and reliability modelling for the machine design complement the production system. This gives operators complete control and visibility over the automated process.

"Industry interest was encouraged through public workshops with industrial stakeholders as well as demonstrations of our prototype machinery here in Aachen," says Dr Schäkel. "We'd now like to adapt the technology to new parts and applications, to see what the full potential is."

Project partners still collaborate even though ambliFibre has been completed. "This has been one of the most positive aspects of the project," says Dr Schäkel. "It brought together a great package of different competences and capabilities. We are always looking for new projects to further adapt the technology to industry needs."

PROJECT
ambliFibre - adaptive model-based Control for laser-assisted Fibre-reinforced tape winding

COORDINATED BY
Fraunhofer in Germany

FUNDED UNDER
H2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/678875

PROJECT WEBSITE
amblifibre.eu

Combined technologies for hybrid composite car parts

A fully automated prototype production cell is up and running, manufacturing hybrid composite material parts. This success underlines the potential for automotive and other industrial sectors to replace existing metal parts with lightweight multi-material components.

The production cell is located at the site of an industrial partner in the EU-funded FlexHyJoin (Flexible production cell for Hybrid Joining) project and continues to efficiently produce composite roof stiffener parts for cars. Though the project was officially completed at the end of December 2018, the consortium envisions that the cell will operate for at least another three years, allowing potential customers of project partners – from the automotive sector and elsewhere – to come and visit and for other composite materials to be tested.

"The production cell is a demonstrator that shows the capability of the two joining technologies induction and laser joining in

combination with an online process control and non-destructive testing," explains FlexHyJoin project coordinator Ms Nora Feiden from the Institute for Composite Materials (IVW GmbH) in Germany. "Until now there has been keen demand, and one of our partners has already identified two potential customers."

New possibilities

Composite materials open the door to new possibilities across a range of industrial sectors by combining the best properties from each constituent ingredient. They surround us every day; plastic polymers mixed with natural, glass or carbon fibres for example are used to make the kind of strong lightweight material you might find in sports equipment, building surfaces and airplanes.

There has been keen demand and one of our partners has already identified two potential customers.

"Composites are well known in the areas of renewable energies, e.g. in the blades of wind power stations or sports and recreation such as in the manufacture of bicycles," notes Ms Feiden. "But in most applications a very strong and form-fit connection between the existing metal structure and plastic part is required. This is where FlexHyJoin comes in. We focused on the use of composite materials in the automotive sector though, because demand to reduce CO_2 emissions in transport is very high. One way of achieving this is by making vehicles lighter by substituting parts of them with hybrid composite materials."

Building up potential

The FlexHyJoin project built on a previous lab-scale project to create a pilot-scale flexible production cell capable of manufacturing composite car parts. "We developed the production technology with a car component as a spin-off product," says Ms Feiden. "The first challenge we faced was deciding what part we should use to demonstrate the technology. We wanted to focus on something applicable to everyday mass production passenger cars, and so we settled on a roof stiffener."

Roof stiffeners are usually made completely out of metal. The FlexHyJoin team substituted this with a lightweight glass fibre reinforced polymer composite with three metal brackets that then attach the stiffener to the car body.

This was achieved by using a laser to join two of the fasteners, and by applying induction joining to the middle fastener. "We combined these two joining technologies because laser joining is ideal for smaller parts with a complex geometry," Ms Feiden explains. "And induction is the fastest method for bigger parts that are not so complex."

All the individual process steps – from laser surface texturing through to laser joining, induction joining and an online process control – were integrated into a fully automated production cell. Material flow was then optimised in order to provide each step with an effective process time to achieve an optimal result. In addition to the project's specific material combination of glass fibre reinforced polymer and steel, an extensive range of other materials can also be handled by the cell after adaptation.

Representatives from the car industry have already been expressing an interest in the process. "The technologies themselves already existed," says Ms Feiden. "What we've done in this project is shown that producing hybrid composite parts is possible by combining these different techniques. One of the major advantages of this EU-funded project was that it brought together different competences from five different EU countries."

PROJECT
FlexHyJoin – Flexible production cell for Hybrid Joining

COORDINATED BY
Institute for Composite Materials (IVW) in Germany

FUNDED UNDER
H2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/677625

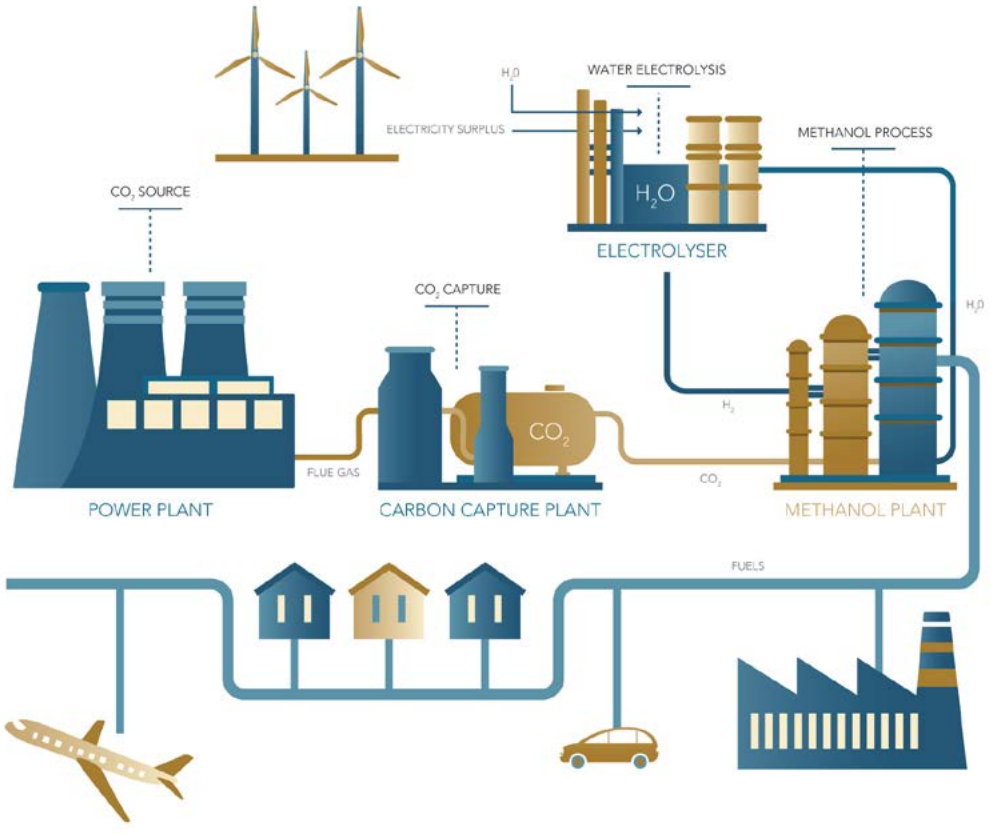
PROJECT WEBSITE
flexhyjoin.eu

Energy-intensive sectors can be part of low carbon transition

EU-funded researchers have demonstrated how carbon capture technology can be used by energy plants and other sectors to reduce emissions. What makes this innovation especially attractive is that the cost of installation can be offset through the creation of new revenue streams.

The MefCO2 (Synthesis of methanol from captured carbon dioxide using surplus electricity) project installed existing carbon capture and utilisation (CCU) technology at a coal-fired energy plant in Germany. This technology traps CO_2 emissions and combines these with hydrogen in a process powered by renewable energy.

This produces methanol, an industrial chemical that can be directly blended with gasoline or used as a building block for other chemical products like formaldehyde. Not only does this technique reduce the amount of CO_2 being released into the atmosphere; it also creates a potential new business opportunity.



"We've shown that CCU can be economically feasible," says project coordinator Mr Angel Sánchez-Díaz from I-Deals Innovation & Technology Venturing Services, Spain. "We were able to increase carbon capture viability from an economic perspective by using green hydrogen to produce a chemical of high industrial value."

CCU technology, says Mr Sánchez, can help other energy-intensive industries such as the steel sector to transition towards the low carbon economy. Facilitating additional revenue streams from industrial by-products like this one is also very much in keeping with the circular economy concept of turning waste into new value-added products.

Industrial challenges

While achieving Europe's climate goals will require significant industrial emissions reductions, access to cheap energy is important to guarantee competitiveness. The MefCO2 project demonstrated that European industry can be both greener and more competitive, and thus be part of the transition towards a low carbon economy.

"Showing that CCU technology can deliver results in highly industrialised and complex settings is hugely significant," says Mr Sánchez. "There is enormous pressure on the energy sector as well as other energy-intensive industrial sectors, such as steel, to reduce their carbon footprint."

We were able to increase carbon capture viability from an economic perspective.

While a project partner had previously demonstrated that CCU technology can function at a smaller scale in Iceland, transferring the concept to Germany was daunting. "Look at the challenges facing Germany," says Mr Sánchez. "The country is committed to getting rid of nuclear power, focusing on renewables and meeting climate objectives, while at the same time remaining industrially competitive. It also has to deal with the fact that coal-fired power plants are still needed."

Low carbon transition

As the project got underway, the technology first had to be adapted to meet the demands of the specific energy plant, and be integrated with the electricity grid. A catalyst to increase methanol synthesis efficiency was developed. "We really wanted to build a realistic case for CCU," says Mr Sánchez. "The challenge was demonstrating the technology in realistic working conditions."

With the pilot plant up and running, the consortium next put together a technology roadmap. "This is about how we can further scale up the technology and make possible the deployment of large-scale MefCO2-like plants," says Mr Sánchez. "We see the results of this project as just the first chapter of a story that has only begun, and MefCO2 partners will continue to work together in developing this technology."

Indeed, fostering cooperation has been a successful by-product of this project. "When you create the right working environment with different partners across Europe you are not only pursuing a common goal but creating a framework for future initiatives," notes Mr Sánchez. "Without European funding this would not have been possible, because businesses and industry need incentives. This project brought together the right ingredients and conditions to make this happen."

PROJECT
MefCO2 - Synthesis of methanol from captured carbon dioxide using surplus electricity

COORDINATED BY
I-Deals Innovation & Technology Venturing Services in Spain

FUNDED UNDER
H2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/637016

PROJECT WEBSITE
mefco2.eu

Flexible solutions for tapping sustainable forest biomass

EU-funded researchers have identified and sustainably exploited several under-utilised sources of biomass in northern Europe. This could bring additional revenue streams for producers and deliver new raw materials for industry.

Following studies on current forestry biomass usage, the MOBILE FLIP (Mobile and Flexible Industrial Processing of Biomass) project developed and trialled a range of mobile technologies designed to more fully exploit forestry raw materials such as bark. While the economic and environmental benefits of using forestry biomass are well recognised, accessing processing technology at the scale required can be challenging. As a result, a great deal of material is currently thrown away.

This EU-funded project showed however that efficient processing is possible. Several technical innovations such as an

improved pelletising system were successfully demonstrated, and will now move towards commercialisation.

"At least one participating company plans to start selling new equipment for producing biochar (charcoal produced from plant matter that can improve soil), while another is currently negotiating with a biogas company about installing pre-treatment technology on their production site," says MOBILE FLIP project coordinator Dr Tarja Tamminen from the VTT Technical Research Centre of Finland. "Particle boards were also successfully produced from waste biomass." Following project completion at the end of December 2018, partners are still working together to further refine ideas and identify even more opportunities.

Natural potential

Making better use of biomass – waste material sourced from vegetation not used for food or feed – could bring significant economic and environmental benefits. As a viable source of both renewable energy and industrial raw materials, biomass will undoubtedly play a critical role in Europe's transition to more sustainable models of production. There is also a growing understanding about how biomass can be exploited sustainably; from an ecological point of view, some biomass should be left on the ground, for example.

At least one participating company plans to start selling new equipment for producing biochar.

The availability of raw biomass varies according to geography, climate and season. "In Central Europe for example, straw from wheat, corn and other cereals dominates," explains Dr Tamminen. "The Nordic countries on the other hand are covered in forest."

Both bark and other forest residues, as well as agricultural residues, were therefore selected as the focus of the MOBILE FLIP project. These residues are often not collected at all, or are used as fuel when higher value applications are possible. Furthermore, biomass residues tend to be scattered and seasonally available. This makes it difficult for large-scale industries to economically exploit the residues, as high volumes of homogeneous raw material are typically required.

Mobile solutions

This is why the MOBILE FLIP project focused on mobile technologies for small-scale processing. Project partners developed containerised equipment capable of being transported between raw material sites. "We included several intermediate levels of mobility," explains Dr Tamminen. "In some cases, it might be feasible to transport raw materials to the production site. Using the electricity grid at a plant instead of a diesel generator in the field is beneficial from an environmental point of view."

A total of five technologies were identified as having real potential: pelletising (compressing biomass into a useable pellet); hydrothermal pre-treatment for saccharification (turning into soluble sugars); hydrothermal carbonisation and torrefaction for fuel; and slow pyrolysis (resulting in biochar). These technologies were then successfully demonstrated by industrial partners using selected raw materials. Environmental, economic and legislative evaluations were also carried out.

"Economic feasibility was a critical aspect given the limited capacity of end users," says Dr Tamminen. "These calculations will help businesses to better understand the conditions necessary to ensure that the processes are profitable. The wide range of competences available within the consortium also helped to make all relevant information about raw materials and processing available."

PROJECT
MOBILE FLIP - Mobile and Flexible Industrial Processing of Biomass

COORDINATED BY
VTT Technical Research Centre of Finland

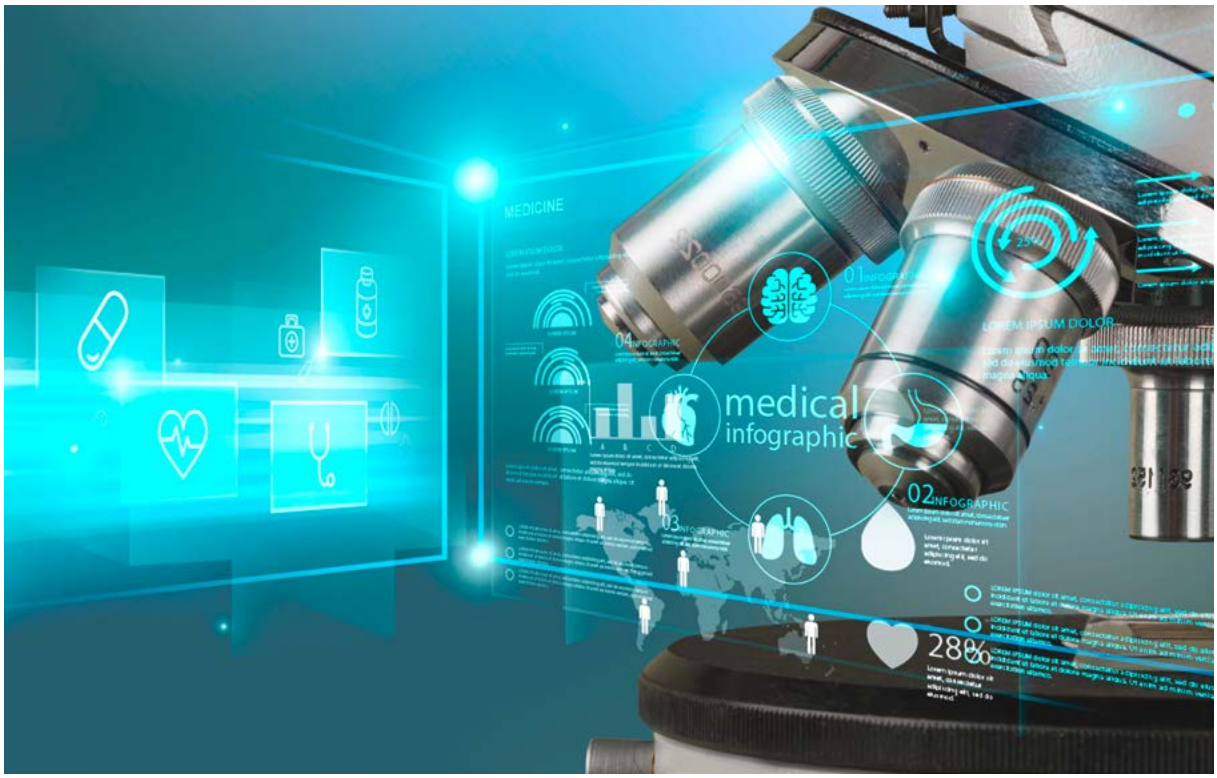
FUNDED UNDER
H2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/637020

PROJECT WEBSITE
mobileflip.eu

Continuous manufacturing means lower-cost biopharmaceutical products

To cut the costs of developing, making and buying biopharmaceutical drugs, the EU-funded nextBioPharmDSP project is implementing continuous manufacturing into the downstream process.



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Although biopharmaceuticals are effective drugs for treating a range of pathophysiological conditions, their high costs keep them out of reach for many patients. According to Dr Gorazd Hribar, coordinator of the EU-funded nextBioPharmDSP (Next-generation biopharmaceutical downstream process) project, their high cost is the result of the complexity of the drugs themselves and the complicated manufacturing procedures used to produce them.

"Biopharmaceuticals are made by biosynthesis in living cells, which is followed by a number of purification steps, each done

separately in so-called batch processing," explains Dr Hribar. "This is a very time consuming and costly procedure, where each and every step is followed by careful analytics and confirmation of quality."

Continuous manufacturing represents a disruptive alternative to this traditional step-by-step method. Unlike batch manufacturing, continuous manufacturing is composed of integrated (i.e., physically connected), continuous unit operations with zero or minimal hold volume between.

Dr Hribar and his team of researchers are helping to spearhead this transition towards continuous manufacturing. "Such a process has the potential to not only substantially reduce the costs of manufacturing biopharmaceuticals, but also expand patients' access to these highly efficient drugs," he says.

Advanced technologies and solutions

To lower the cost of biopharmaceutical development and manufacturing – and thus the end product – nextBioPharmDSP researchers focused their efforts on downstream processing (DSP). This is the purification process of biopharmaceuticals, where all impurities are removed and the desired quality achieved.

The most impressive outcome of this project is the establishment of a fully integrated continuous manufacturing platform for biologics.

In batch manufacturing, this is done via a series of individual chromatographic steps, filtrations, and final concentration and formulation. But with nextBioPharmDSP, these individual steps are replaced with continuous chromatography all the way to the final connected downstream process. This is possible thanks to single use continuous chromatography manufacturing-scale equipment developed by the project. "This continuous approach reduces the use of expensive protein A resin, allowing us to achieve a substantial reduction in costs," explains Dr Hribar.

Furthermore, the integration of continuous chromatography, together with the implementation of flow-through purification steps, results in the efficient removal of impurities and guarantees the quality of the final product. To ensure high product quality and efficient control of the process, advanced analytical tools for real-time monitoring of quality attributes are also incorporated.

Increased productivity and reduced costs

The benefits of implementing such connected and continuous downstream processes are many. For example, although the complete DSP only takes up 30 m^2, it is capable of processing material from a few thousand-litre bioreactors in just 24 hours. This in turn drastically reduces the required facility size compared to current standards.

With its single-use equipment, the entire process becomes flexible and mobile, meaning manufacturers can adapt production demands to market need. As a result, facility investments have decreased by at least 35 %, running costs by 30 %, and material costs by 50 %. But continuous manufacturing also brings environmental benefits, including a 25 % decrease in CO_2 emissions, reduced water consumption, and less energy use.

"The most impressive outcome of this project is the establishment of a fully integrated continuous manufacturing platform for biologics," says Dr Hribar. "This means faster times to market, more affordable drug prices, and a distinct competitive advantage for companies using this process."

PROJECT
nextBioPharmDSP - Next-generation biopharmaceutical downstream process

COORDINATED BY
Lek Pharmaceuticals d.d. in Slovenia

FUNDED UNDER
H2020-BIOTECH

CORDIS FACTSHEET
cordis.europa.eu/project/id/635557

PROJECT WEBSITE
nextbiopharmdsp.eu

Elevating Europe's old neighbourhoods into smart communities

The EU-funded REnnovates project uses an innovative prefabricated concept for renovating existing building stock into net-zero-energy homes.

For much of Europe, the post-war era was defined by a building boom. Although lots of new homes were constructed during this time, many were built fast, cheap and with little-to-no thought towards energy efficiency. The result is that Europe now has a plethora of technically sound old homes that, due to their poor energy performance, pose a significant challenge to the EU meeting its 2020 Climate Goals.

"With buildings being responsible for 30 % of all energy consumption, much of today's existing building stock is incapable of meeting the energy requirements of tomorrow," says Mr Dennis van Goch, project coordinator of the EU-funded REnnovates (Flexibility Activated Zero Energy Districts) project. "The good news is that these houses can be renovated to become more sustainable but doing so requires that the

renovation projects go beyond the simple bricks and mortar and towards facilitating an energy transition."

The REnnovates project seeks to position Europe's existing housing stock to better meet future challenges in terms of sustainability, comfort and costs. "Using a holistic approach that embraces the essential elements of energy savings, the project developed a sustainable yet flexible solution that brings value to all stakeholders," adds Mr van Goch.

A prefabricated approach to renovation

The REnnovates project elevates old neighbourhoods to smart communities, thus improving the quality of living, extending a building's lifespan, and reducing its impact on the local energy infrastructure. "We do this using a prefabricated concept for renovating existing houses towards net-zero-energy and by better managing the flow of energy at the neighbourhood level," explains Mr van Goch. "The end goal is to transform existing houses into smart homes in a commercially viable and scalable way."

With buildings being responsible for 30 % of all energy consumption, much of today's existing building stock is incapable of meeting the energy requirements of tomorrow.

The project's unique prefabrication system includes providing each house with a tailor-made insulating suit, an energy module, and connection to a local production source. "To avoid excessive demand on the energy grid, all the renovated houses in a given neighbourhood are networked together, thus optimising energy use while ensuring individualised comfort," says Mr van Goch. "This neighbourhood grid concept is essential to reducing the social cost of the energy transition while making large-scale renovation feasible."

Users can stay in their homes during the renovation, which takes less than a week. After renovation, they receive a dashboard to control and monitor their energy use. As a bonus, all post-renovation maintenance is provided by the project.

Energy saving potential

With over 250 demonstrator homes operating in the Netherlands and Spain, the REnnovates system has lowered energy consumption from over 15 MWh/year to an average of just 6 MWh/year – a reduction of 60 %. Thanks to the energy savings made possible by the REnnovates system, occupants saw their energy bills go down by an average EUR 1 600 per year. In total, the project is responsible for saving more than 1 m tonnes of CO_2 and generating 1.75 GWh of renewable energy – two numbers that are increasing every day.

"These numbers clearly demonstrate that REnnovates' radical concept and innovative business model has considerable energy saving potential," says Mr van Goch.

PROJECT
REnnovates – Flexibility Activated Zero Energy Districts

COORDINATED BY
BAM Construction and Engineering in the Netherlands

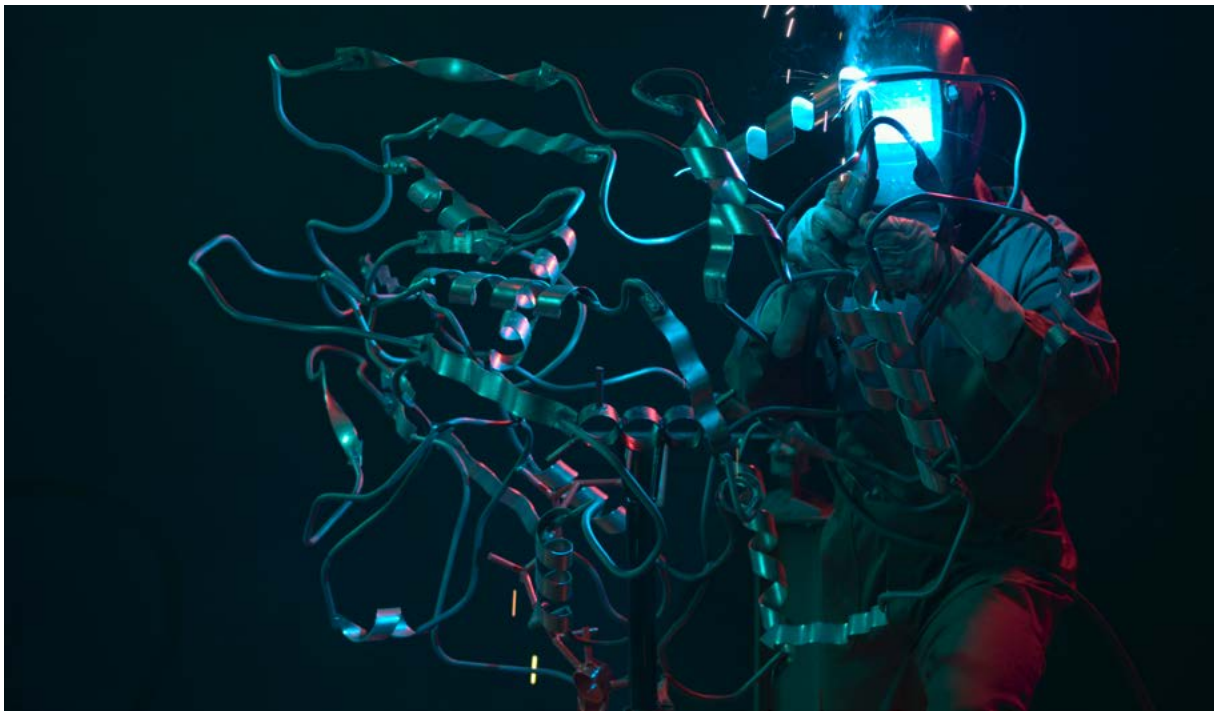
FUNDED UNDER
H2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/680603

PROJECT WEBSITE
rennovates.eu

Delivering a robust set of oxidative enzymes as biocatalytic tools for green chemistry

Towards a biobased economy, ROBOX has demonstrated the techno-economic viability of enzymatic bio-oxidation processes as a greener alternative to traditional chemical processes.



© ROBOX

Industrial chemical conversions are typically conducted under harsh conditions (high temperature and pressure), often requiring toxic chemicals and generating hazardous by-products. In the pursuit of greener alternatives, enzymes have been heralded as a replacement for chemical catalysts – a process referred to as biocatalysis.

Enzymes typically operate under mild reaction conditions, use cheap cosubstrates (e.g. oxygen) and display outstanding selectivity and good yields. Yet despite successes, full industrial-scale exploitation of biocatalysts is hampered by the instability of many enzymes.

The EU-supported ROBOX (Expanding the industrial use of Robust Oxidative Biocatalysts for the conversion and production of alcohols) project established a collection of stable enzymes, along with industrial conversion protocols. The project succeeded in: developing an enzyme capable of oxidizing glycerol, applying P450 enzymes to produce drug metabolites on a large scale, applying ADH and BVMO enzymes to produce novel fragrance molecules, as well as precursors for specialty and performance polymers.

Demonstrating target reactions of robust oxidative enzymes

The sustainability and economics of industrial processes can be greatly improved with biocatalytic oxidation routes using molecular oxygen (from air) under benign and mild (pH) conditions, such as ambient temperature and pressure. But this approach, with its high costs (> EUR 1 000/kg) associated with the enzyme-catalysed step, has been considered too expensive.

These biocatalyst types perform oxidations with high selectivity and specificity, often accompanied with a good yield. Results difficult to obtain in standard chemical oxidations.

To address this, ROBOX explored the biotransformation viability of four types of robust oxidative enzymes. "These biocatalyst types perform oxidations with high selectivity and specificity, often accompanied with a good yield. These results would be difficult to obtain in standard chemical oxidations", explains project coordinator Prof. Marco Fraaije.

Glycerol is a major by-product of biodiesel production and a promising building block chemical, as its oxidation generates valuable compounds, such as glyceraldehydes, of interest for the production of fine chemicals, pharmaceuticals or amino acids.

Monooxygenase (P450) enzymes in the human liver are responsible for detoxifying nearly all marketed drugs, and so biocatalytically producing drug metabolites at a large scale is of great importance for validating results in drug development and clinical trials.

ROBOX also developed and applied robust Alcohol DeHydrogenase (ADH), Alcohol OXidase (AOX) and Baeyer-Villiger MonoOxygenase (BVMO) enzymes, in the biocatalytic production of novel fragrance compounds and polymer precursors, illustrating the superiority of this group of oxidative enzymes over traditional chemistry.

ROBOX validated and optimised the target reactions for these enzymes at the lab-scale in pharma, nutrition, fine chemical and material applications. Where needed, the respective enzymes were improved by protein engineering or novel robust enzymes were identified through genome mining.

"This integrated approach involved the entire chain from enzyme discovery to application at a large scale", Prof. Fraaije says. "During the project, we dismissed some target reactions as not viable according to a rigorous techno-economic assessment. But this strategy worked successfully for most, enabling further exploitation of oxidative biocatalysis."

Expanding the toolkit of sustainable chemistry

The results of ROBOX contribute towards the production of green chemicals, as used in materials such as plastics, pharmaceuticals and inks – essential for the development of a biobased economy.

To start quantifying green credentials, the ROBOX team performed a comparative life cycle analysis for one of the BVMO target reactions. "The respective enzymatic oxidation had a lower environmental impact compared to its chemical equivalent, if recycling of solvents and enzymes is considered. Moreover, the climate change impact of the biocatalysed reaction can be decreased by 71 % when renewable electricity is used," says Prof. Fraaije.

To date, the project has generated patents for project partners, as well as a start-up biotech company through the University of Groningen.

PROJECT
ROBOX - Expanding the industrial use of Robust Oxidative Biocatalysts for the conversion and production of alcohols

COORDINATED BY
University of Groningen in the Netherlands

FUNDED UNDER
H2020-LEIT-BIOTECH

CORDIS FACTSHEET
cordis.europa.eu/project/id/635734

PROJECT WEBSITE
h2020robox.eu

Applying the principles of industrial symbiosis for more sustainable manufacturing

Borrowing from the elegant coordination within the human body, the EU-funded SYMBIOPTIMA project has introduced the concept of 'industrial symbiosis' to the design of production management tools for increased manufacturing sustainability.

Improving the sustainability of contemporary industrial processes requires a new paradigm whereby critical resources such as materials, energy, waste and by-products can be coordinated more efficiently between Production Units.

The paradigm, adopted by the EU-supported SYMBIOPTIMA (Human-mimetic approach to the integrated monitoring, management and optimization of a symbiotic cluster of smart production units) project, was 'human-mimetic symbiosis' which takes its inspiration from the functioning of the human body. This approach rethinks and reuses production resources across diverse industries, and even sectors, for increased efficiency with fewer adverse environmental impacts.

SYMBIOPTIMA developed an integrated Energy and Resource Management System (ERMS), which offers tools for production

scheduling and demand response management and for Life Cycle Sustainability Assessments (LCSAs). It also created hardware for modular 'plug and play' monitoring of production plants, as well as an integrated toolset for all thermal energy sources, flows and sinks. Additionally, to maximise the reuse of waste, it developed a unique de-polymerisation process for plastics (PET).

'Closing the loop' with eco-innovation

Modern industrial management involves monitoring, measuring, recording, analysing, controlling and redirecting energy and material flows within systems to ensure productivity and sustainability.

"Inspired by the human body, SYMBIOPTIMA's innovation was to view elements of an industrial cluster (such as companies), as functionally independent but simultaneously interconnected with other elements, in a unitary system," project coordinator Mr Andrea Ballarino says, adding that "each element pursues objectives for the good of the whole."

To operationalise their concept, SYMBIOPTIMA developed an ERMS as the integration point for all the environmental, energy and economic factors of each company, functioning as Production Units, in the cluster. With all the data aggregated, the platform uses evaluation tools to support decision making. For example, demand response software can exploit knowledge about energy use scheduling within the cluster, to communicate with the energy market and purchase energy more conveniently and at a lower cost for both individual companies and the cluster as a whole.

SYMBIOPTIMA re-evaluated what constitutes 'waste', allowing disruptive technologies to then find ways to exploit previously discarded materials. A prime example is the development of a new chemical treatment technology for recycling and reusing PET plastics, called Gr3n, recently the overall winner of the EU's Innovation Radar Award 2018.

The system is modular to facilitate integration and scalability, at both the hardware and software levels. Integration at the process monitoring level has been developed to complement, rather than replace, existing systems. Moreover, the adoption of interoperability standards and protocols, capable of building upon existing systems and features of the Internet, makes it easier to upgrade legacy systems.

Opportunities for growth

According to Mr Ballarino, based on Eurostat figures, the chemical, cement, ceramic, steel, petrochemical, minerals and ores, non-ferrous metals, and water industries collectively represent more than 450 000 enterprises, over 6.8 million employees and more than EUR 1.6 billion in revenue – constituting 20 % of all manufacturing in Europe. These statistics highlight the potential impact these industrial sectors have on the overall sustainability of the European economy.

"Sustainable processes cannot be achieved through competition but rather cooperative management, and integration of resources," says Mr Ballarino. "The incentives for this vary – from conventional business reasons, such as cost reduction or increased revenues, to long-term resource security or even regulatory compliance. We need to tap into these."

Inspired by the human body, SYMBIOPTIMA's innovation was to view elements of an industrial cluster (such as companies), as functionally independent but simultaneously interconnected with other elements, in a unitary system. Each element pursues objectives for the good of the whole.

Currently SYMBIOPTIMA is piloting the full solution with companies from across industry. Some technologies are already market-ready, such as the ERMS platform, as well as the integrated toolset for thermal energy sources and flows management, while others are shortly to enter the market.

PROJECT
SYMBIOPTIMA - Human-mimetic approach to the integrated monitoring, management and optimization of a symbiotic cluster of smart production units

COORDINATED BY
Spirax-Sarco Limited in the United Kingdom

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PROJECT WEBSITE
symbioptima.eu

Safer human-robot collaboration for workplaces of the future

The next generation of robots could be entering the workplace alongside humans, but this first needs some collaborative principles to be established. SYMBIO-TIC has developed a system for such a safe, dynamic, intuitive and cost-effective working environment.

Factories of the future will depend on the development of safe, cost-effective, hybrid assembly/packaging arrangements based on human-robot collaboration. However, the European manufacturing industry faces implementation challenges, which could be summarised as a lack of: adaptability, flexibility and vertical integration.

The EU-supported SYMBIO-TIC (Symbiotic Human-Robot Collaborative Assembly: Technologies, Innovations and Competitiveness) project created tools for robot-reluctant industries where current tasks and processes are typically considered too complex for automation. These included: a collision avoidance system, a planning and control tool to monitor and re-plan assembly tasks,

intuitive robot control commands and a real-time worker support system, tailored to workers' competence and skill levels, as well as changing assembly sequences.

A symbiotic multimodal solution

When it comes to human-robot collaboration, there is a high initial investment, often a programming skills-shortage, inflexibility of pre-programmed robots within dynamic environments, and safety concerns. There is also no common standard or associated regulations, leading to the current safety-driven prohibition, of humans working closely with robots in a shared environment.

The SYMBIO-TIC team came up with their modular solution after analysing the human-robot collaborative assembly line and identifying the critical missing elements. As project coordinator Prof. Lihui Wang from the KTH Royal Institute of Technology in Sweden says, "When a worker walks onto a robotic assembly line, the first priority is safety. The second is treating the robot as a teammate. Finally, at the system level, the human-robot interaction must be monitored and coordinated."

This approach enables an easy entry for industries that are reluctant to explore human-robot collaborative working.

SYMBIO-TIC's contribution provides a system that makes legacy industrial robots safe, smart and collaborative. "This approach enables an easy entry for industries that are reluctant to explore human-robot collaborative working," says Prof. Wang.

Part of the system's strength is the inclusion of 'function blocks', each containing multiple algorithms associated with data and event inputs, which can then be used as inputs for subsequent blocks. This gives rigid control codes more flexibility and adaptability, such as being able to modify a robot's trajectory if a human approaches.

The team have already recorded active collision avoidance for worker protection and are currently developing a demonstrator, to be ready by mid-March 2019, which integrates all the modules and sub-systems together to showcase the full solution. This demonstrator will be located at Volvo Cars in Sweden, where it will assemble a mass balancing system (MBS) within a car, but outside of the regular production environment.

After this, the team will seek out new partners to advance the technology to a market-ready state.

Smart agents

SYMBIO-TIC supports the increased competitiveness of European industries through these enabling technologies. More specifically, the integrated system will increase productivity by: shortening assembly lines, reducing the idle time of workers/robots and introducing rapid robot control by voice, vision and haptics, avoiding the need for programming skills.

This envisions a future where assembly operators will be 'smart agents' working with robots in a coherent, effective team, naturally communicating and controlling their robot colleagues through speech, sign language and/or touch.

"We are working towards better environmental and social sustainability through energy-efficient robotic control and ergonomic work environments. The latter improves workers' lives and encourages gender equality, as female workers can also perform heavy-duty tasks, with robotic support," says Prof. Wang. "Such smart agents, no matter their gender, height, age and physical strength, can do the same job efficiently."

The system will also maintain product quality, with humans remaining ultimately responsible for inspections and the necessary adjustments.

PROJECT
SYMBIO-TIC – Symbiotic Human-Robot Collaborative Assembly: Technologies, Innovations and Competitiveness

COORDINATED BY
KTH Royal Institute of Technology in Sweden

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CORDIS FACTSHEET
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PROJECT WEBSITE
symbio-tic.eu

Smart energy management platform maximises building efficiency

Increasing energy efficiency in buildings usually involves taking a performance snapshot, identifying causes of inefficiency and implementing a solution. But this can miss how buildings function in the real world, a situation TOPAs rectifies with continuous monitoring.

Buildings (including their construction) globally account for approximately 36 % of total energy consumption, which in turn contributes to 40 % of the world's total CO_2 emissions directly and indirectly (World Energy Outlook). An obvious response is to make buildings more energy efficient, but there is now extensive evidence that buildings do not typically perform as well as predicted, despite interventions.

One of the weaknesses of energy efficiency initiatives relates to the energy audit process which is typically performed for a fixed duration, at a specific point in time.

The EU-supported TOPAs (Tools for cOntinuous building Performance Auditing) project adopted the principle of continuous performance auditing, which offers a more detailed overview of building performance, taking into account how buildings are actually used and their climatic state. This provides a holistic audit which reduces the gap between predicted versus actual energy use.

TOPAs developed an Internet of Things (IoT)-driven platform to support facilities managers, building owners and energy service companies (ESCOs) in making informed decisions about building operations.

Reducing the performance gap

Gaps typically exist between estimates of building energy efficiency and actual efficiency – which can reach tens of percentage points – because occupants might start using the building in unpredicted ways. It may also be due to fluctuations, such as the activities, open hours or number of occupants in a building, or because the underlying estimation models were inaccurate.

The TOPAs platform can be viewed as a fitness tracker for buildings, providing continuous visibility of how energy-related interventions impact management, cost, air quality and comfort for occupants.

Traditionally, energy auditing is done annually and measured against key performance indicators (KPIs). This often misses opportunities to implement energy saving initiatives. The TOPAs continuous monitoring approach aligns KPIs with actual data, supporting the introduction of energy management standards such as ISO 50001.

"The TOPAs platform can be viewed as a fitness tracker for buildings, providing continuous visibility of how energy-related interventions impact management, cost, air quality and comfort for occupants," says Mr Boris Kantsepolsky.

The platform comes as two main components. TOPAs Core enables users to easily and quickly extract, process and analyse large amounts of data from buildings blocks. TOPAs Add-on services provide decision support tools, including a range of energy prediction models, building usage models, fault detection and diagnosis, air quality monitoring and predictive models to enable buildings to self-manage energy efficient operations.

During the validation of the solution, seven different Building Management Systems (BMS) in six different buildings, distributed across three sites, located in three different cities (Cork, Dublin and Paris) were integrated using the tools.

In excess of 177 000 000 messages generated by over 3 500 data points were processed within the platform. "The solution's energy prediction models (electrical and thermal) reduced the gap between predicted and actual energy usage in the range of 11-27 % and contributed to energy savings of 12-37 % across all sites," adds Mr Kantsepolsky.

Significant environmental and social benefits

By improving energy efficiency and reducing energy consumption, the TOPAs solution minimises environmental impacts, while increasing the productivity and health of building occupants. Additionally, contributing to energy sector innovation strengthens European competitiveness and creates jobs.

"Reducing costs and enhancing sustainability encourages businesses to invest in positive social change, making people's lives better. The ability to deploy the TOPAs solution across very different, demanding and complex environments demonstrates its real world benefit and replication potential," says Mr Kantsepolsky.

Some of the tools developed within TOPAs have already been introduced into the marketplace such as the CEA (spinoff business) created from a LINC software platform (a coordination middleware) which optimises industrial production systems. In terms of IoT technology, Fraunhofer developed an IoT-ready Energy Prediction Model called IoMod™, while IBM launched IoT building insights for facilities management. Additionally, Azimuth/Hager integrated TOPAs' results into their air quality solutions for smart homes.

PROJECT
TOPAs - Tools for cOntinuous building Performance Auditing

COORDINATED BY
Motorola Solutions Israel Ltd in Israel

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