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European Commission

CORDIS Results Pack on

frontier research for the Green Deal

A thematic collection of innovative EU-funded research results

November 2020

Driving forward Europe's climate ambitions through innovation and transformation

Research and Innovation

Contents

Editorial

Driving forward Europe's climate ambitions through innovation and transformation

With the European Green Deal, the European Commission aims for the EU to be completely carbon-neutral by 2050. This is an enormous ambition, and innovative frontier research supported by the European Research Council (ERC) will play a vital role in powering forward the cutting-edge research and technological development needed to achieve it. This CORDIS Results Pack highlights 15 ERC-funded projects that are playing their part in helping to achieve Europe's green and sustainable future.

Founded in 2007, the ERC's primary mission is to provide grants to Europe's most talented and dedicated researchers, without predefined themes and based on the sole criterion of scientific excellence. ERC grantees tend to be at the forefront of their fields and the funding offered to them gives them a chance to realise their most creative ideas and potentially produce results that will have a major impact on science, society and the economy. As a result, their research takes place at the frontiers of current human knowledge and indeed, are pushing them further outwards. Therefore, they are in a prime position to contribute to the broad discussion currently taking place on the European Green Deal.

The importance of frontier research

The Green Deal itself will span almost every policy area and research field, from enabling sustainable agriculture, industry and mobility, to clean energy, new methods to eliminate pollution and efforts to preserve biodiversity and increase urban sustainability. It aims to completely transform Europe's economy and societies to make them truly green.

Being such a large undertaking, frontier research will be a crucial ingredient in this transformative process. Advances in human understanding and knowledge driven by frontier research can help provide important context and comprehension of the issues at stake and can already begin laying the groundwork for real solutions to emerge. One recent example of this is COVID-19, where nearly 180 currently running ERC projects were immediately relevant to help address the pandemic. This is because they had already been engaged in research that could easily be recalibrated to help find viable answers to the many challenges and hardships that the virus has unleashed.

The projects paving the way

In the same vein, many of the ERC projects featured in this Results Pack are already engaged in pioneering research that may now be at a more theoretical or early technological development stage but could soon form the backbone of the drive to achieve the aims of the European Green Deal. Their research is broad, taking in many different fields but all of which have a key role to play.

These examples provide a snapshot of the full menu of 15 projects that are found within this Pack but these 15 projects themselves only scratch the surface on how innovation and excellence driven by frontier research will help turn Europe's Green Deal from mere ambition to a solid reality.

Cheaper, less invasive animal tracking takes off

The AIRSCAN project brings about an ultralight, low-cost aircraft for better animal tracking with no ground operations required. The aircraft has already provided unique data on predators and prey in northern Botswana.

The consequences of climate change are unfolding before our very eyes. Among these is what experts have come to call 'the sixth mass extinction', which threatens to wipe out over half of Earth's remaining species. Determining where and how this extinction takes place is key to taking appropriate countermeasures. And for that, we notably need animal tracking data.

"Studies on wild animals require the ability to find them and download data from their collars," says Alan Wilson, professor of Locomotor Biomechanics at the Royal Veterinary College, United Kingdom. "Usually, the animals are found using a radio beacon or GNSS receiver. Downloading the data, however, always requires observers to drive close to the animal and use a handheld radio receiver."

That was all before the ERC-funded AIRSCAN (A customised low-cost ultralight aircraft for survey, filming and animal tracking in wild environments) project came to fruition. In February 2020, Wilson and his team proposed a new generation of low-cost, ultralight aircraft to track animals in their natural environment. With this aircraft – which boasts a very low operating cost of approximately EUR 30 per hour – and its integrated onboard data collection technologies, the pilot can perform aerial surveys, film animal populations and download data directly from the air.

"Invading a wild animal's space and potentially putting the researcher at risk is just not necessary anymore. Our Trail ADAP (aerial data collection platform) aircraft can retrieve collar data by flying within 200-300 metres of the animal. This obviates the need to travel long distances overland and approach the animals on the ground," Wilson explains. Most importantly, the Trail ADAP is ultralight. It can take off from a dirt or grass airstrip and easily fits into a road trailer or shipping container.

Benefits for the animal tracking community are considerable. Areas where ground access would be impossible due to topography or vegetation density are now within reach. So are those areas where such access is risky or too time-consuming.

Unique data sets

The value of the retrieved information increases as well. Since the Trail ADAP is equipped with LIDAR and video cameras to conduct surveys of the ground and vegetation, it enables analysis of the tracking data in the context of the animal's environment.

Invading a wild animal's space and potentially putting the researcher at risk is just not necessary anymore.

"We have used our survey equipment to capture the hunting terrain of African wild dogs. The idea was to explore how they hunt in vegetation, flushing prey out of cover. In the same spirit, we used our equipment to explore how zebras navigate in their habitat, what trails they are following and whether they are loyal to particular routes," Wilson adds.

Besides wild dogs and zebras, the team studied the likes of cheetahs, leopards, lions and their prey in the vast savannah of northern Botswana. While other methods would have been impractical there, the Trail ADAP collected a uniquely detailed data set.

In a context of endangered biodiversity, there is little doubt that the Trail ADAP can help wildlife conservation and management. Although the project is completed, Wilson and his team have continued plans to use it in southern Africa – where they are seeking funding for new challenging projects on wildlife ecology – and in the United Kingdom where they want to study the aerodynamics of bird flight.

How about other applications? Several organisations usually using helicopters to conduct aerial surveys of infrastructure such as railways and pipelines have already shown interest in the aircraft and its much lower operating cost. "Trail ADAP will soon be available for purchase through aircraft manufacturer Groppo Ing. in Italy. It has great potential to transform aerial data collection in a wide range of disciplines and applications," Wilson concludes.

PROJECT
AIRSCAN – A customised low-cost ultralight aircraft for survey, filming and animal tracking in wild environments

HOSTED BY
Royal Veterinary College in the United Kingdom

FUNDED UNDER
H2020-ERC

CORDIS FACTSHEET
cordis.europa.eu/project/id/812904

Managed crowds for safer, greener and less congested cities

With the ALLEGRO project, Serge Hoogendoorn provides much-needed insight into pedestrian and cyclist behaviour in traffic. His findings could notably help cities manage crowds during major events and through the current COVID-19 crisis.

Congestion costs Europe EUR 100 billion each year. That's 1 % of the EU's GDP, for which car/road freight traffic has become – rightfully so – the scapegoat. Yet, whilst the growing number of citizens willing to ride a bike or e-bike, or even walk, provides a major source of hope – especially since the COVID-19 outbreak – we still don't know much about pedestrian and cyclist traffic. ALLEGRO (unrAvelLing sLow modE travelinG and tRaffic: with innOvative data to a new transportation and traffic theory for pedestrians and bicycles) addresses the problem of congestion from a completely new angle.

"We are facing a clear lack of data and it's difficult to collect," says Serge Hoogendoorn, Transportation and Planning chair at TU Delft and principal investigator of the ALLEGRO project. "Cyclist behaviour for instance has to be considered at three levels. The so-called operational level (split-second decision-making when interacting with another cyclist in the case of an overtaking manoeuvre, for example), the level of mid-term decision-making (which routes to choose), and that of long-term decision-making (which activities to partake in as a dedicated cyclist and in what order)."

Right now, most policy decisions related to pedestrian and cycling infrastructure are based on a rule of thumb. But ALLEGRO's work provides a more theoretical basis for decision makers.

From modelling to predictions

Since November 2015, Hoogendoorn and his team have been working on innovative data collection approaches. These include virtual reality (VR), field studies using GPS-equipped bicycles, controlled cycling experiments, social data for crowd characterisation, advanced data collection using Wi-Fi and 3D sensors, and extensive surveys.

"The innovation resides mostly in this mixed data collection approach and its consideration of all behavioural levels. We now have highly innovative models that can be used to test novel policies and design as and when they are proposed by policymakers. With our new current-state estimation techniques, we can provide crowd managers with a better insight into the likes of where crowds occur, the impact of specific measures (against congestion for example), etc. We have also developed traffic control strategies for smart bicycles that can be used to improve urban flow and ultimately make the bicycle a more attractive transport option for citizens," Hoogendoorn explains.

Beyond its microscopic and macroscopic models, the ERC-funded ALLEGRO project also provides game-theoretical models. These provide useful information on conditions under which traffic self-organises efficiently, as opposed to those where it collapses.

Several applications are already being considered. Hoogendoorn and his team are notably working together with Dutch company NS Stations – which manages over 400 railway stations in the Netherlands – on a proof of concept project that would deploy ALLEGRO's monitoring system for advanced crowd management in these stations. They are also working on smart bicycles and cooperative intersection control, to reduce the number of stops at intersections and guide cyclists accordingly.

"Our crowd management methods can be extended to larger areas. For example, we have a new platform that mimics the TU Delft campus and monitors changes in mobility patterns in a COVID-19 context. Do people behave according to the 1.5 metre guideline? Do they avoid areas that are too busy? The data we collected has been successfully used to test short-term and longer-term predictions using AI techniques," Hoogendoorn notes.

Soon enough, ALLEGRO's models could be used to monitor entire cities or be applied to the movement of people within individual buildings. The project team was already successful in its attempts to use VR for studying pedestrian behaviour in buildings, with potential applications including testing interventions for safe building evacuation.

We have also developed traffic control strategies for smart bicycles that can be used to improve urban flow and ultimately make the bicycle a more attractive transport option for citizens.

PROJECT
ALLEGRO – unrAvelLing sLow modE travelinG and tRaffic: with innOvative data to a new transportation and traffic theory for pedestrians and bicycles

HOSTED BY
TU Delft in the Netherlands

FUNDED UNDER
H2020-ERC

CORDIS FACTSHEET
cordis.europa.eu/project/id/669792

PROJECT WEBSITE
allegro-erc.nl

Plant-friendly microbes for more sustainable agriculture

With his research under the ERC-funded project BacBio, Diego Romero hopes to lead the way towards more sustainable agriculture, one relying more on beneficial microbes and less on pesticides and fungicides.

Bacterial disease is industrial agriculture's worst nightmare. It reduces yield, spreads like wildfire and cuts down profit margins. The answer so far has been nothing short of catastrophic either: Fungicides, bactericides and nematicides sprayed on crops not only contribute to the degradation of the environment, but can also become less efficient against microbes within fruits and vegetables.

According to Diego Romero, professor in the Department of Microbiology at the University of Malaga, it is now time for new approaches putting emphasis on sustainability. With the ERC-funded project BacBio (Mechanistic and functional studies of *Bacillus* biofilms assembly on plants, and their impact in sustainable agriculture and food safety), which was kick-started in 2015, he aims to answer one question: Is it possible to protect plants with beneficial microbes partly replacing pesticides, while avoiding contamination by human pathogens in the process?

"Maybe there is a conceptual problem in current agriculture. I think we should forget the idea of microbe-free products and try to find a balance between the microbial load in the product and the collateral damage we inflict on the environment," he explains. "I would personally put more effort into reducing damage to the environment, which over the long term would benefit agriculture."

Implicitly, this new approach calls for a diversification of strategies. Environmental conditions are not the same across regions, and greenhouse cultures add an extra layer of complexity. This means that microbial diseases will evolve differently in different environments, and that potential solutions will have to differ accordingly.

BacBio is showing the way forward by studying the extracellular matrix (ECM) of two microbe communities (also known as biofilms). "We specifically study *Bacillus subtilis* and *Bacillus cereus*, two related organisms with very different functions. The former is a biocontrol agent that protects plants, whilst the latter is pathogenic to humans. By studying these two soil-dwelling microbes living in association with plants, we can understand the chemical differences between their respective ECMs. The idea is to potentiate the benefits inflected by *B. subtilis* to plants while reducing or avoiding *B. cereus*," Romero adds.

The role of proteins

One of the most notable project findings so far is related to the way *Bacillus* adapts in order to live in more complex environments such as plants. "In *B. subtilis*, we have found that exopolysaccharide and a hydrophobic protein in the ECM form a shield that impedes access of foreign cells into the colony. If you remove these components, another microbe living on plants can penetrate the *Bacillus* colony," Romero notes.

The idea is to potentiate the benefits inflected by B. subtilis *to plants while reducing or avoiding* B. cereus.

The team also characterised an amyloid protein required to assemble the biofilm of *Bacillus*. Mainly known for their implication in human disorders, amyloids are widely distributed in nature and can contribute to define the physiological status of bacterial cells. They also have a double role: a lack of amyloid leads to an increase in antimicrobial production by the *Bacillus*, whilst cells within the phylloplane (the leaf's surface) become more sensitive to its presence. "We believe that *Bacillus* uses these two roles of the amyloid to complementarily permit the cells to adhere, colonise and persist in the aggressive phylloplane. It provides successful control of fungal diseases," Romero says.

By improving our understanding of the way bacteria transition from isolated entities to an organised community interacting with plants, the project could have a considerable impact in the field of agro-biotechnology. Romero hopes his findings will eventually enable the production of beneficial microbes for more sustainable and diversified agriculture.

PROJECT
BacBio – Mechanistic and functional studies of *Bacillus* biofilms assembly on plants, and their impact in sustainable agriculture and food safety

HOSTED BY
University of Malaga in Spain

FUNDED UNDER
H2020-ERC

CORDIS FACTSHEET
cordis.europa.eu/project/id/637971

BIOSEC questions security-inspired conservation strategies

The integration between security and conservation is growing stronger every year, but is it really a good thing? The ERC-funded BIOSEC project questions common beliefs, and its conclusions suggest more caution is needed in decision-making linking the two problems.

Elephants killed for their ivory tusks, endangered species sought as hunting trophies, or pangolins smuggled for their meat and alleged health virtues... The consequences of the illegal wildlife trade (IWT) are devastating in many respects. We've all been recently acquainted with its impact on humans. But this is just the tip of a much larger iceberg touching upon many aspects of our lives.

One of these aspects is none other than security. Did you know, for instance, that the IWT is often identified as a source of funding for organised crime and armed groups? Or that conservation organisations sometimes feel they have no choice but to partner with government armies or private military companies to protect endangered species? Or even that our own personal food security is at risk?

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The University of Sheffield-led BIOSEC (Biodiversity and Security: understanding environmental crime, illegal wildlife trade and threat finance) project sought to better understand and fact-check this growing integration between conservation and security, in the context of a recently renewed focus on the IWT. Over a span of 4 years, the project team built pioneering theoretical approaches and generated new empirical data on both issues, in a fully integrated manner.

The truth is that claims drawing a link between illegal wildlife trade and threat finance are made with little evidence, and that whatever evidence is offered sometimes stands beyond public scrutiny.

"Since 2008, the spikes in the poaching of elephants and rhinos have forged a renewed sense of urgency. The rates of poaching have kept rising every year and there have been clear concerns that, if left unchecked, these rates would soon drive elephants and rhinos to extinction. Billions of dollars have been funnelled into conservation by donors, philanthropists, the private sector and individual citizens, and the most common response has been much more security-oriented," says Rosaleen Duffy, coordinator of BIOSEC.

A real threat to security?

To study this trend, the project's team collected information on conservation in Europe, the Americas, Asia and Africa. As their findings soon highlighted, the 'security first' approach is not without risk. First, it tends to leave less visible or charismatic species behind, as two team members highlighted by focusing on 'plant blindness' in debates around the IWT. Then, the involvement of armies and the private military has been found to lead, in some regions, to reports of intimidation, exclusion, dispossession and human rights abuses by conservation authorities.

The project results also challenge some of the assumed facts surrounding the IWT. They notably disrupt the idea that there are distinct sites of production and consumption, point at racism in demand-reduction campaigns, and examine the mismatch between international conservation NGOs and grassroots organisations in Vietnam seeking to tackle the IWT.

"We've also examined the notion of the 'poacher as terrorist'," Duffy explains. "The truth is that claims drawing a link between illegal wildlife trade and threat finance are made with little evidence, and that whatever evidence is offered sometimes stands beyond public scrutiny."

"In our research, we highlight how an overfocus on the IWT as a form of threat finance could mean that ineffective strategies are developed to tackle both the IWT and terrorism," she continues. "We show that there is a need for a much more sophisticated and nuanced approach."

So, could the focus on threat finance become somewhat of a blind spot for policymakers? Duffy certainly believes so. The project even identified examples where these links allow governments to engage in conservation as part of counter-insurgency strategies against resistant populations. If such actions remain unchecked, conservation risks becoming less about saving species and more about pushing a particular political agenda.

"Meanwhile, using militarised responses may be storing up a range of problems for conservation and biodiversity protection in the future by alienating communities or unravelling trust between these communities and conservation agencies. There is also a lack of focus on the illegal trade in European species – eels, bears, songbirds and caviar are all sourced, traded and consumed within the EU. The attention and funding are focused on the IWT as a problem of Africa and Asia, but it is also a problem on our own doorstep," Duffy notes.

All in all, BIOSEC's work is about trying to develop ideas and policies that are both effective and socially just. The project could still provide other lessons for policymakers in the near future, as conservationists are now shifting their attention towards the COVID-19 pandemic – more specifically the relationship between security, the IWT and zoonotic disease.

PROJECT
BIOSEC – Biodiversity and Security: understanding environmental crime, illegal wildlife trade and threat finance

HOSTED BY
University of Sheffield in the United Kingdom

FUNDED UNDER
H2020-ERC

CORDIS FACTSHEET
cordis.europa.eu/project/id/694995

PROJECT WEBSITE
biosecproject.org

A ray of sunshine on renewable chemical fuel research

Are renewable chemical fuels produced from sunlight finally about to knock at our door? A new generation of organic photocatalysts by the name of covalent organic frameworks could contribute to realising efficient and highly tunable artificial photosynthesis.

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Plants are one of nature's greatest pieces of engineering. They capture vast amounts of CO_2 from the atmosphere, generate the oxygen we breathe and are capable of creating chemical energy out of sunlight. This last capacity even makes them a major source of inspiration for researchers aiming to develop green alternatives to chemical fuels. But many have hit a brick wall as they tried to mimic this process.

"Designing a platform that can harvest sunlight and convert it into the chemical energy of a fuel certainly is challenging," says Bettina Lotsch, director at the Max Planck Institute for Solid State Research and principal investigator of the ERC-funded project COFLeaf (Fuel from sunlight: Covalent organic frameworks as integrated platforms for photocatalytic water splitting and CO_2 reduction). "This is largely a materials challenge. We need to orchestrate a complex suite of physico-chemical processes, each with its own timescale and materials requirements, within an earth-abundant and stable materials platform."

With her ERC grant, Lotsch wanted to develop next-generation photocatalysts capable of doing just that. She decided to move away from inorganic photocatalysts, too: these are often toxic, expensive and difficult to fine-tune. Instead, she decided to focus on organic systems, which are tunable 'from the atom up'.

"Our materials are called covalent organic frameworks (COFs). They are a bit similar to the natural photosynthetic machinery of a plant: carbon-based, highly versatile, molecularly well-defined and amenable to the tools available in organic synthesis," Lotsch explains.

COFs can be seen as a bridge between organic molecules and solid-state materials. Simple organic compounds are linked with each other to form COFs, making the resulting materials compositionally tunable using simple chemistry. Unlike most other organic polymeric materials, COFs also benefit from a structure that can easily be studied: As crystals, they are indeed accessible to a range of diffraction and microscopic probes providing unique insights into their solid-state structures.

"COFs have many advantages," Lotsch notes. "They have an exceptionally high degree of both compositional and structural tunability, which sets them apart from classic polymers. In addition, their structural porosity gives them an advantage over other photocatalysts in terms of surface area. The rule of thumb is, the larger the surface area, the better the catalytic activity."

A new and promising research field

After 5 years of research, Lotsch and her team could successfully demonstrate that COFs show great potential as earth-abundant and highly tunable energy converting systems. A potential so enormous that it opened up a new field of research called 'soft photocatalysis'.

Perhaps the project's most important outcome is its demonstration that COFs can harvest light efficiently and convert it into chemical energy such as hydrogen. The new photocatalytic systems are earth-abundant and functional in aqueous conditions. Thanks to innovative chemical strategies, they could even be made chemically robust under harsh photocatalytic conditions.

"We have also demonstrated what so far has been – and still is – one of the holy grails of photocatalysis. We can precisely tune the activity-determining parameters with atomic-level precision. Finally, we have developed 'all-single-site' heterogenous photocatalytic platforms with molecular-level precision. These can not only reduce the usage of expensive and noble metals during photocatalysis, but also serve as platforms for a better understanding of the photocatalytic reaction mechanism."

Our materials are called covalent organic frameworks (COFs). They are a bit similar to the natural photosynthetic machinery of a plant: carbon-based, highly versatile, molecularly well-defined and amenable to the tools available in organic synthesis.

Eventually, Lotsch's efforts could contribute to realising efficient and highly tunable artificial photosynthetic platforms using organic polymers. Whilst commercial applications are still far away, the project's development of solar batteries for a class of polymers called carbon nitrides, along with concepts such as time-delayed 'dark photocatalysis', already point towards promising research avenues. Other possible applications include nitrogen fixation and the valorisation of biomass or microplastics.

PROJECT
COFLeaf – Fuel from sunlight: Covalent organic frameworks as integrated platforms for photocatalytic water splitting and CO_2 reduction

HOSTED BY
Max Planck Society in Germany

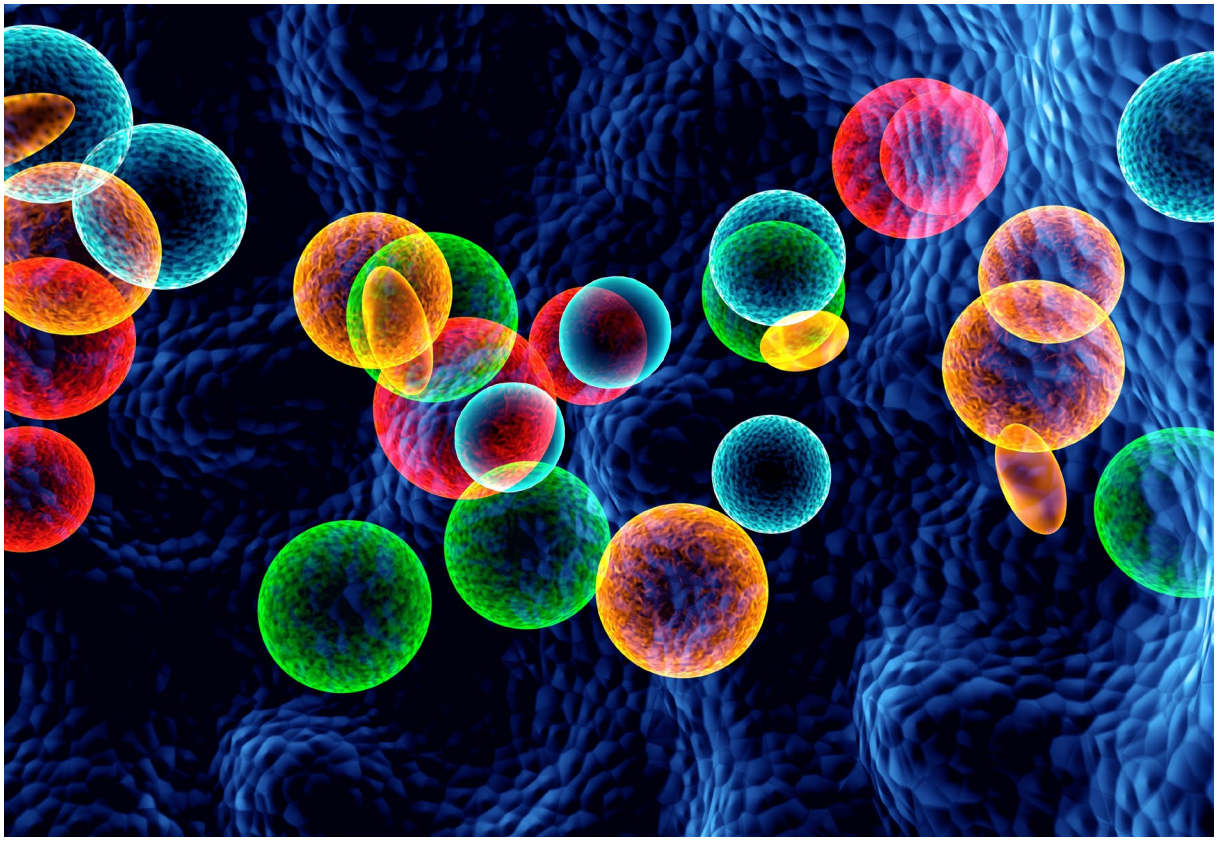
FUNDED UNDER
H2020-ERC

CORDIS FACTSHEET
cordis.europa.eu/project/id/639233

Microbial cell factories for more sustainable production processes

Microorganisms producing valuable chemicals could one day replace fossil fuels as sources of industrial compounds. To make this possible, the CUSTOM-SENSE project has created biosensors that ease the identification of the microorganisms with the most potential.

Humanity has made a habit of producing the chemical compounds it needs from fossil fuels, with the consequences we know in terms of high energy consumption, CO_2 emissions and toxic waste products being released into nature. But what if we could produce our amino acids, food colourings or plastic monomers with microorganisms? After all, don't fossil fuels have microbial origins too?



For years now, industrial biotechnology has been aiming to use microorganisms or their enzymes to convert sugars into the many compounds the chemical industry provides, only through a more sustainable process. But to make this possible, researchers first need to identify which microorganisms produce which compound and to what extent.

We can look at up to 80 000 cells per second. With so much 'screening power', the idea of producing thousands – or even millions – of cell variants and seeing how each change affects product formation is no longer a dream.

"The idea is to engineer microorganisms and 'force' them to channel their energy into the production of chemicals instead of focusing on growth and replication. But we often do not know how to maximise product formation in the given microorganism. To circumvent that problem, we have to create hundreds or thousands of variants of the same microorganism and characterise them individually. This calls for big investments in terms of money, workforce and time," says Jan Marienhagen, head of department: Synthetic Cell Factories, at the Jülich Research Centre in Germany.

To overcome these problems, Marienhagen began the CUSTOM-SENSE (Custom-made biosensors – Accelerating the transition to a bio-based economy) project in May 2015, which is funded by the European Research Council (ERC). "We have two core objectives," he explains. "The first is to find out whether we can design and construct biosensors to look into a single cell to get an idea of how much it produces. The second is to deliver a solution capable of evaluating the production capacity of millions of cells very swiftly without the need to culture them."

Biosensors and trackers

Concretely, CUSTOM-SENSE is working on a range of biosensors that can detect interesting chemicals directly in single cells. Each sensor scans for a defined compound and, once it finds it, forces the microorganism to emit fluorescence as it produces this compound. The more compound a microorganism produces, the more fluorescent it gets.

Of course, analysing one cell at a time would be impossible, so Marienhagen and his team combine their biosensor approach with machines called fluorescence-activated cell sorters (FACS). "We can look at up to 80 000 cells per second. With so much 'screening power', the idea of producing thousands – or even millions – of cell variants and seeing how each change affects product formation is no longer a dream. It can be realised. This means not only powerful production strains, but also more insights into the microbial metabolism," he notes.

The project team has already developed several biosensors for amino acids and aromatic compounds of biotechnological interest and combined them with the FACS device to conduct large screening campaigns. Even though the project won't end until April 2021, some findings are already turning heads. "We were notably able to 'sharpen' the specificity of a biosensor, which means that we could remove one specificity of the biosensor without altering the response to another metabolite of interest. This had never been done before and was recently published in the prestigious journal Nature Communications. Meanwhile, we created a whole 'biosensor family' for very different aromatic compounds. All of these biosensors can be combined with FACS and directly put to use," Marienhagen adds.

Over the next few months, the team intends to keep working on computer-based algorithms to investigate the changes in 100 different strain variants improved with the project's biosensors. Such study is expected to contribute to an improved understanding of the microbial metabolism, and eventually lead to more industrial applications for microorganisms, which in turn would lead to a greener European industrial sector.

PROJECT
CUSTOM-SENSE – Custom-made biosensors – Accelerating the transition to a bio-based economy

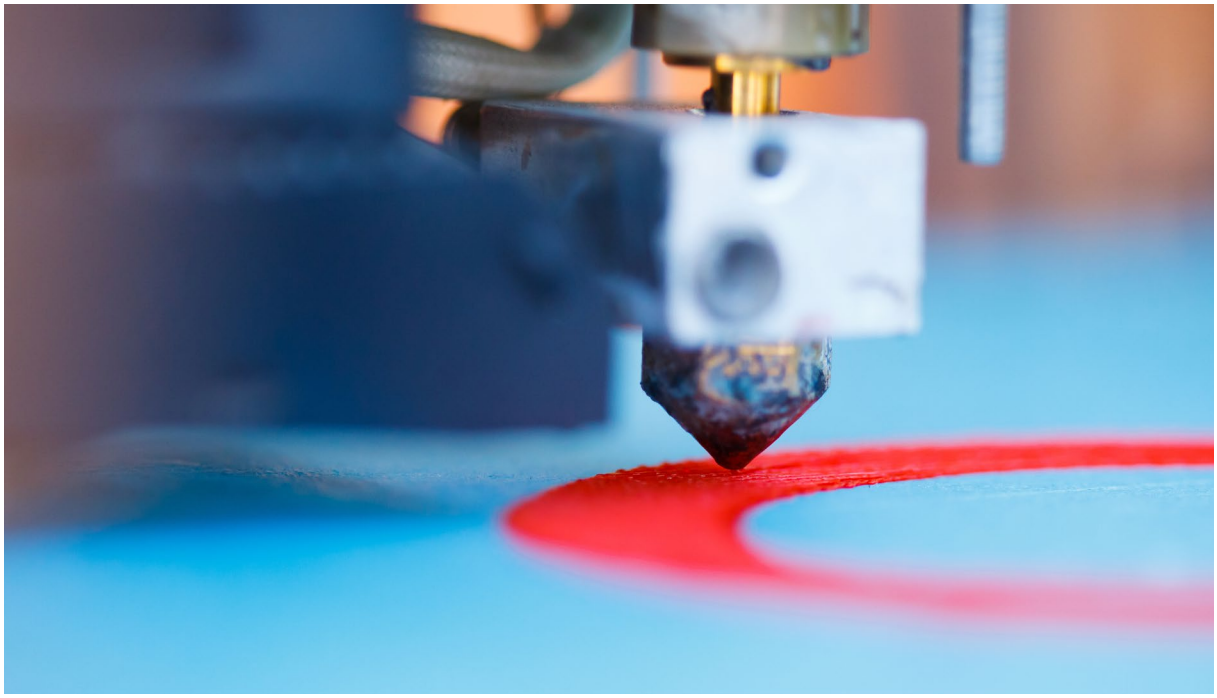
HOSTED BY
Jülich Research Centre in Germany

FUNDED UNDER
H2020-ERC

CORDIS FACTSHEET
cordis.europa.eu/project/id/638718

Sustainable polymers for 3D-printed batteries

The race for environment-friendly alternatives to lithium-ion batteries is on. For start-up company POLYKEY, the belief is that sustainable polymers could one day outperform current batteries – at least for some applications.



Start-up company POLYKEY was created in 2020 as a spin-out of the University of the Basque Country. Besides specialising in plastic recycling through depolymerisation, it also proposes a new generation of solid-state batteries built from sustainable polymers. The promise is tantalising: the new batteries are lighter, perform better at high temperatures and are not flammable.

The venture initially started in 2012 with the ERC Starting Grant iPES project, followed 2 years ago by ERC Proof of Concept (PoC) project iPES-3DBat (Innovative Polymeric Batteries by 3D Printing). Concerned with the limitation of current batteries with regards to shape, rigidity and cost, the project team led by David Mecerreyes first developed a range of new polymeric materials. Then, with iPES-3DBat, they set out to produce polymer batteries from a fast and cheap 3D printing process.

"All-polymer batteries offer several advantages over conventional lithium-ion batteries," says Mecerreyes, vice-director at Polymat – the Basque Centre for Macromolecular Design and Engineering, University of the Basque Country. "First, they don't require toxic and scarce inorganic materials such as lithium, cobalt, nickel or manganese. Then, all-polymer batteries offer other advantages such as the use of renewable bio-based materials, flexibility, recyclability and the possibility of using additive manufacturing methods such as 3D printing for their fabrication. Our dream with iPES-3DBat was to develop materials that allow people to print their own battery at home."

From biopolymers to low-energy applications

While battery cells traditionally have a planar structure, 3D printable inks would allow for the creation of different shapes. It would also provide higher power and energy density due to the increased surface area of electrodes. To create these inks, the iPES-3DBat project used novel redox polymers previously developed under iPES. These include biopolymers abundant in nature such as lignin, which also implies a much easier recycling process.

Besides their optimisation for 3D printing, the biopolymers have three main things in common. They are environmentally safe, free of toxic chemicals and made of renewable resources. "The 3D printing part wasn't easy. We had to print between three and five different layers (conducting layer, anode, cathode and electrolyte) and ensure that they all worked together smoothly," Mecerreyes notes.

The project successfully demonstrated several 3D polymeric batteries, although these cannot yet compete with lithium-ion batteries in high-energy applications such as electric vehicles or mobile phones. But they are still useful, as Mecerreyes points out: "We could foresee niche applications for thin or 3D batteries in (micro)electronics, health, the internet of things or toys, for instance."

The prototype batteries do quite a good job with tunable voltages between 0.5 and 1.5 V and energy/power density in the order of 80.6 Wh kg^{-1} / 348 kW kg^{-1}, which may be enough for such applications. The batteries are quite robust and can live through more than 1 000 cycles.

"With POLYKEY, we now intend to provide the market with polymers for batteries as well as sustainable polymer solutions for plastic recycling and bio-based industry. Since the end of the project, we have been working on scaling up our materials portfolio and looking for partners and investors interested in this technology," Mecerreyes concludes.

All-polymer batteries offer several advantages over conventional lithium-ion batteries.

PROJECT
iPES-3DBat – Innovative Polymeric Batteries by 3D Printing

HOSTED BY
University of the Basque Country in Spain

FUNDED UNDER
H2020-ERC

CORDIS FACTSHEET
cordis.europa.eu/project/id/789875

How 'little tools' shape the success or failure of the bioeconomy

The success of the bioeconomy depends on a wide range of elements, from political guidelines to market strategies and technological advances. By analysing as many of these elements as possible over the span of 5 years, the LITTLE TOOLS project could help avoid any mishaps.

Great oaks from little acorns grow. In bioeconomy-related research, some refer to such little acorns as 'little tools'. They include the likes of strategy documents, budgets, expert reports, research protocols and algorithms. Of course, these little tools taken individually wouldn't, say, enable societal shift towards a bioeconomy. But together, they certainly pack a punch.

"When you study the bioeconomy closely, it becomes clear that it is made possible by a large number of little tools in use across government, markets and science. Documents are especially important across these three fields," says Kristin Asdal from the Norwegian Centre for Technology, Innovation and Culture.

Atlantic cod makes for a pretty good illustration, which is why it was selected by Asdal for her research under her ERC-funded LITTLE TOOLS (Enacting the Good Economy: Biocapitalization and the little tools of valuation) project. From the perspective of this niche market, the bioeconomy implies a switch from cod caught in the wild to domesticated cod fit for aquaculture. It's not an easy task: domesticated cod reproduction is difficult to control. It keeps escaping through nets and easily catches disease. Making it market-ready calls for a reconfiguration of biological and economic aspects.

"Zooming in on one species allows us to work on how nature – the cod itself so to speak – and markets must be studied simultaneously. We have proposed the notion 'co-modification' to capture how both sides are worked upon and modified simultaneously. Concretely, we look into the little tools used by government, markets and science at the same time," Asdal explains.

A complex net

Due for completion at the end of the year, LITTLE TOOLS essentially focused on gathering valuable data (the little tools of the bioeconomy) and analysing it. The list of tools considered ranges from consumer surveys and innovation documents to lighting technologies in fish cages. The idea is simple: Without grasping how these tools work and how they connect in larger assemblages, it is hard to comprehend how large transitions such as the bioeconomy happen – or fail to happen – in practice.

The project has already contributed to major insights into how the bioeconomy and its predecessors have developed historically. A rich history that had never been told, as Asdal underlines.

"We have conducted a deep case study that follows the marketisation of the wild Atlantic cod, along with the efforts to produce a viable domesticated cod. Other case studies have shown how the 'blue bioeconomy' is built upon calculations of future value production. Such an approach is highly problematic in terms of environmental concerns. The forecasts assume that all current environmental challenges will have been solved without even considering the environmental costs of achieving the expected growth. All in all, we face the serious risk of building a bioeconomy that is in fact a threat to nature and the environment," she adds.

So how do we prevent this from happening? "Our recommendation is to be more cautious in the planning stage and prevent the 'precautionary principle' (the notion that something is dangerous unless proven otherwise) from being sidelined by optimistic calculations of potential future growth," Asdal notes. But there is more. She also urges politicians and governmental agencies to adopt a 'holistic' approach to aquaculture planning, in which all relevant considerations are actively taken into account and effectively balanced.

We face the serious risk of building a bioeconomy that is in fact a threat to nature and the environment.

"This is to avoid that nature and the environment are defined merely as externalities to value creation. What we need is to give serious attention to the massive pressure put by aquaculture projects upon our oceans, fjords, rivers and wild stocks of cod, salmon, trout and shrimp."

Eventually, Asdal hopes the project will help policymakers make more informed choices and be critical of optimistic growth scenarios.

PROJECT
LITTLE TOOLS – Enacting the Good Economy: Biocapitalization and the little tools of valuation

HOSTED BY
University of Oslo in Norway

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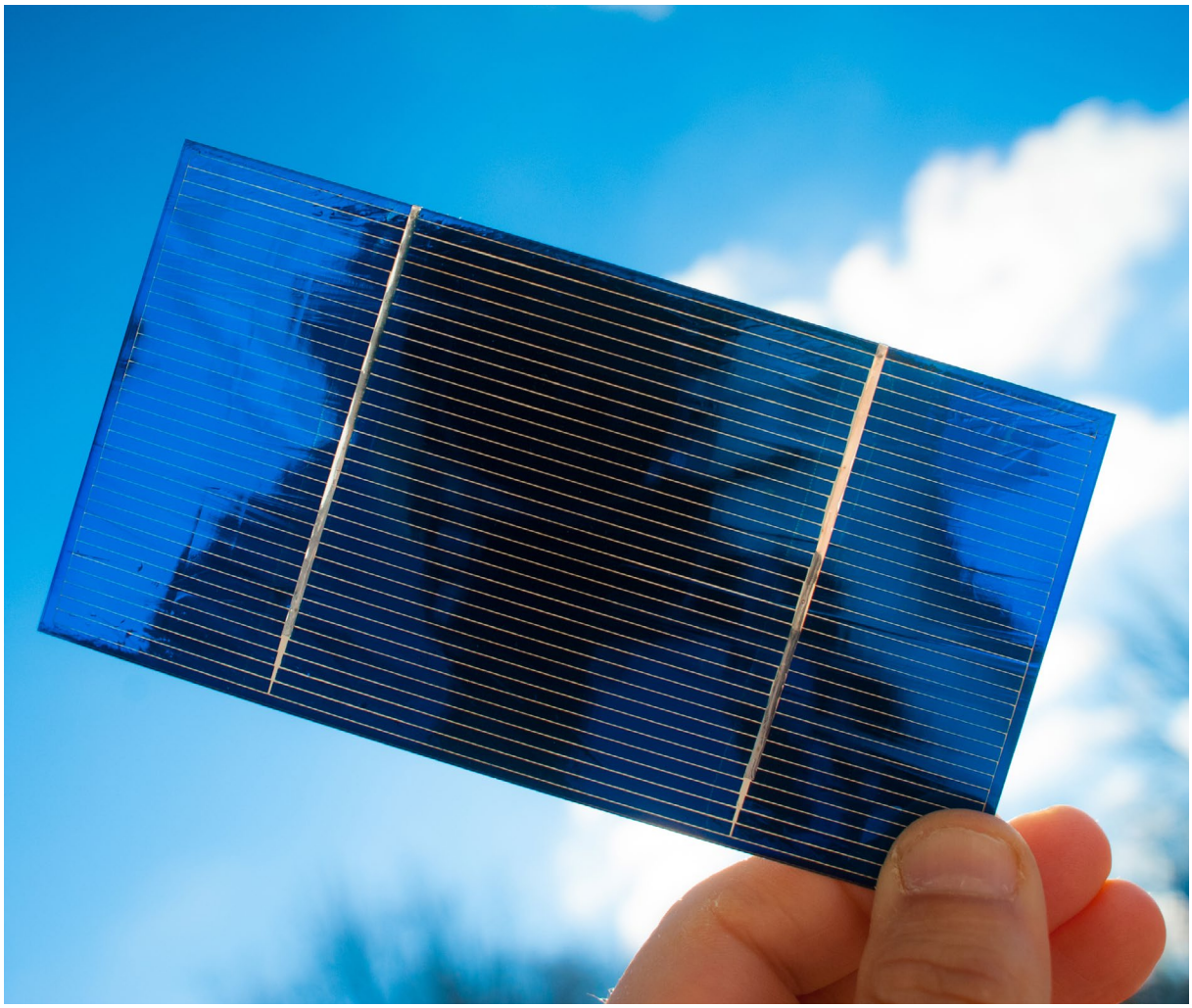
CORDIS FACTSHEET
cordis.europa.eu/project/id/637760

Towards a brighter future through third-generation solar cells

Third-generation solar cells promise fast and cheap industrial scaling. But that's only if we can control their processing conditions and ensure that the proper nanostructure is formed within their photoactive layers.



The third generation of solar cells is at our doors. Whether it's organic photovoltaics (OPVs), quantum dot or perovskite solar cells, all third-generation technologies promise smaller cells with higher power efficiency – at a lower price tag. But there is a serious obstacle on the path to commercialisation: Third-generation cells are so tiny and complex that by the time they are fully manufactured, we're not so sure how they are structured any more.

"The optimisation of third-generation solar cells, organic or inorganic, is very much a process of trial and error," says Jens Andreasen, specialist in researching synchrotron-based 3D imaging of energy materials at DTU Energy and principal investigator of the ERC-funded project SEEWHI (Solar Energy Enabled for the World by High-resolution Imaging). "This has a double effect. First, it seriously delays the search for optimal material combinations, since testing has to be done on completed devices for every process parameter. But more importantly, better performing systems may be completely overlooked."

Andreasen has a plan to tackle this issue. In May 2016, he began developing novel 3D imaging techniques based on X-ray ptychographic tomography and 3D X-ray diffraction. If successful, his efforts would enable discrimination between materials showing very subtle differences at high spatial resolution.

Nanostructures revealed

Take organic solar cells for instance. They consist of light elements with small variations in density. Studying the nanostructure of these elements calls for a technique providing some contrast between different microstructural irregularities at the nanoscale. Although this is key to correlating photovoltaic performance with processing conditions, it was almost impossible to achieve before SEEWHI.

"We are close to identifying differences at a resolution higher than 10 nm in 3D. Before this project, the nanostructure of organic solar cells was not known from direct observation but rather inferred from modelling. We just didn't know for a fact what structure the best-performing solar cells had," Andreasen explains.

Before this project, the nanostructure of organic solar cells was not known from direct observation but rather inferred from modelling. We just didn't know for a fact what structure the best-performing solar cells had.

Once the actual nanostructure is established thanks to X-ray imaging, Andreasen can correlate these structures with models of photovoltaic performance and molecular dynamics. This allows him to determine the relation between processing parameters and the resulting structure. "We can then establish a feedback loop that allows us to manufacture solar cells with an optimally performing nanostructure," he notes.

SEEWHI is a year away from completion, yet early results have been quite encouraging. The team notably devised new algorithms for the 3D reconstruction of ptychographic tomography data. These are hoped to allow the imaging of complete solar cells in 3D at 10 nm resolution, at least as soon as they can be combined with a fourth-generation synchrotron.

"There is more," Andreasen adds. "We have achieved unprecedented characterisation of a kesterite (CZTS) solar cell. We are also very close to having a scheme that allows us to model the optimal structure of any organic solar cell materials system. We will also soon be able to determine the processing parameters required to realise such structure in a large-scale solar cell."

By the time the project comes to an end, the team hopes to demonstrate a photovoltaic modelling of the 3D nanostructures they measured and modelled. Should fourth-generation synchrotron sources become capable of carrying out the appropriate 3D imaging experiments soon, they could also show the 3D nanostructure of an organic solar cell with sufficient resolution to distinguish its donor and acceptor domains.

"My hope is that we will succeed in providing a roadmap allowing experimenters to bypass years of trial and error and find out about overlooked opportunities. Eventually, this may lead to a major breakthrough, not only for organic solar cells, but for many technologies relying on self-organisation of structure from the atomic to the mesoscale," Andreasen concludes.

PROJECT
SEEWHI – Solar Energy Enabled for the World by High-resolution Imaging

HOSTED BY
Technical University of Denmark (DTU) in Denmark

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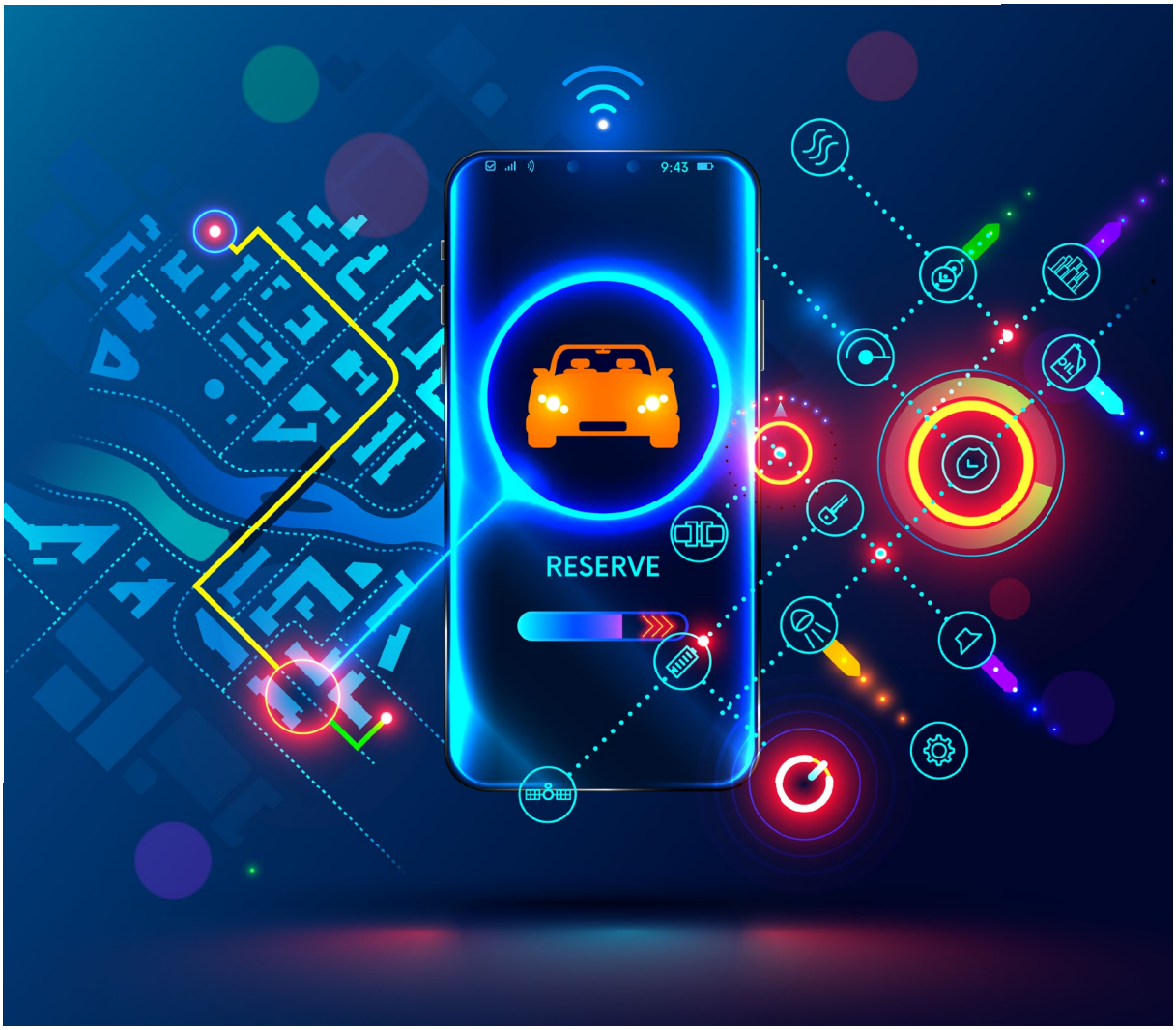
H2020-ERC

CORDIS FACTSHEET
cordis.europa.eu/project/id/681881

PROJECT WEBSITE
seewhi.eu

How word of mouth can contribute to limiting global warming

Social influence plays a big part in many of our decisions. But is it also true when it comes to climate change? The SILCI project investigated and its findings are clear. Word of mouth indeed has a strong influence on people's decision to adopt a range of different behaviours and habits to reduce carbon emissions.



"All of us have a part to play." In September 2020, the 108 United Kingdom citizens who formed the country's first Climate Assembly released the conclusions of their 6-month deliberations on how to reduce greenhouse gas emissions to net zero by 2050. Beyond the proposals they made, one aspect stands out. Whilst clear government leadership is required, consumer-led change is equally important.

One of the phenomena driving such change is called social influence. "We've known that social influence is important for spreading new ideas since the 1950s," says Charlie Wilson, professor at the Tyndall Centre for Climate Change Research. "It has been confirmed by thousands of studies and synthesised in a book called 'Diffusion of Innovations' by Everett Rogers. The book sets out the four key ingredients to understanding how and why new ideas spread: adopter heterogeneity (differences between people's motivations), information transmission (how the word spreads), social networks, and innovation attributes (inherent qualities of the product)."

What is still unknown, however, is whether these mechanisms apply to the spread of potentially disruptive, low-carbon innovations in many different contexts. What role does social influence play then?

To find out, Wilson kick-started the ERC-supported SILCI (Social Influence and Disruptive Low Carbon Innovations) project in 2016. "I wanted to focus on the potential contributions we could all make as consumers of goods and services. Over three quarters of global carbon emissions can be attributed to how we live, how we move around, how we eat, and how we interact with energy systems," he explains.

Applying social influence to climate change

SILCI's approach can be broken down into three steps. First, the team investigate potentially disruptive innovations in mobility, food, homes and energy. Then, they supplement this analysis with deep-dive case studies on specific innovations in each of these fields. Finally, they incorporate some of their new empirical insights into complex simulation models of the global energy and land-use systems to work out climate impacts.

"The objective is to explore what the near- and longer-term climate impacts of consumer innovations might be. This was particularly exciting. We were able to show that – under certain assumptions – rapid uptake of digital consumer innovations could help the world limit warming to 1.5 °C, without having to rely on extremely costly and risky negative emission technologies," Wilson adds.

We were able to show that – under certain assumptions – rapid uptake of digital consumer innovations could help the world limit warming to 1.5 °C, without having to rely on extremely costly and risky negative emission technologies.

The SILCI team have also confirmed the importance of word of mouth and social norms to spread awareness and experiences of low-carbon innovations (information transmission). Furthermore, SILCI analysis has identified the characteristics of successful low-carbon innovations, such as bicycle sharing. These include convenience, flexibility of choice, customisation, and pay-per-use cost structures (innovation attributes).

On adopter heterogeneity, the team found that early adopters can be separated into three groups: novelty-seekers, technophiles and environmentally minded adopters. Social networks are also important: "We have found that people with less cliquey and more varied social networks, with larger numbers of both strong and weak social connections, are more likely to adopt low-carbon innovations," Wilson notes.

The team have already surveyed 3 000 people in the United Kingdom and 3 000 people in Canada to differentiate adopters and non-adopters of 16 different low-carbon innovations related to mobility, food, homes and energy. A repeat survey is due to launch soon, tracking change over 2020. Efforts will then be focused on translating scientific insights into a comprehensive set of recommendations for policymakers, service providers and other stakeholders.

"Social influence is a potentially self-reinforcing mechanism: the more we hear about a low-carbon innovation, the more likely we are to try it out. The more we try it out, the more we're likely to tell others about it. Then, the more we tell others about it, the more likely they are to try it," Wilson concludes.

Thanks to SILCI, we now understand much more clearly how to successfully trigger these snowball effects for low-carbon innovations.

PROJECT
SILCI – Social Influence and Disruptive Low Carbon Innovations

HOSTED BY
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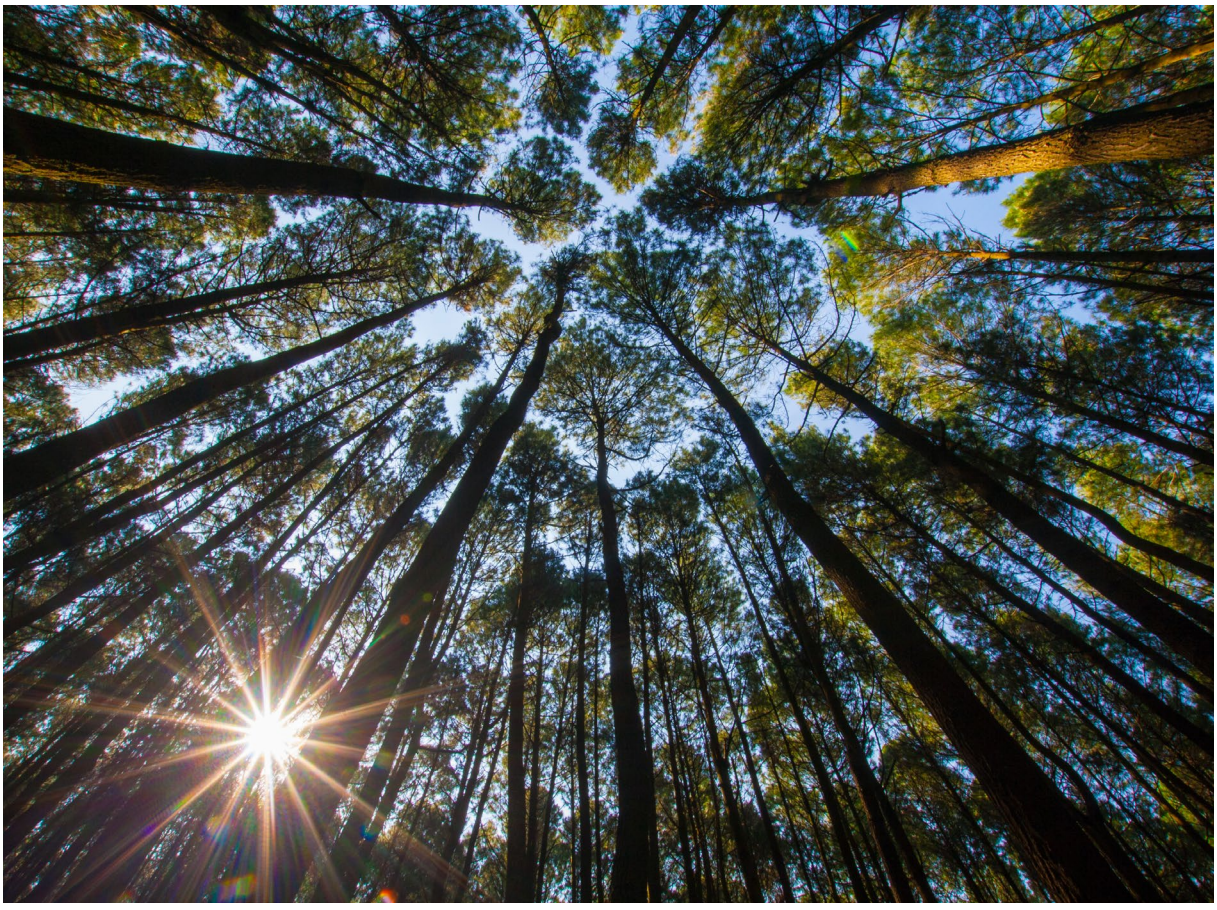
CORDIS FACTSHEET
cordis.europa.eu/project/id/678799

PROJECT WEBSITE
silci.org

Settling the controversy on biofuels with data

A new methodology for establishing the climate and biodiversity footprints of bioenergy highlights the benefits of early and selective deployment. By quantifying the long-term ecological footprint of biofuels, the ERC-funded SIZE project provides a clear assessment of potential risks and benefits – and a roadmap for steering production accordingly.



The debate over biofuels has been raging for years. "Groups are extremely divided, with one side claiming that biofuels with carbon capture and storage are the only way to combat climate change, while the other categorically rejects biofuels because of their impact on biodiversity. As usual, the truth is somewhere in the middle," says Mark Huijbregts, professor of Integrated Environmental Assessment at Radboud University and principal investigator of SIZE (Size matters: scaling principles for the prediction of the ecological footprint of biofuels).

SIZE evaluated the large-scale implementation of second-generation biofuels produced from bioenergy with carbon capture and storage (BECCS). BECCS refers to the process of removing the greenhouse gases produced when burning biomass from the atmosphere and permanently storing the carbon, often underground.

The project team came up with a methodology that measures the impact of this process and translates this data into concrete recommendations on when and how to deploy it for best results.

Large-scale trade-offs

"SIZE looked into the potential benefits of biofuels for climate mitigation, but also the related biodiversity loss due to land use change," Huijbregts explains. "Our new framework is able to quantify the trade-offs in terms of biodiversity and climate mitigation at the global scale by combining integrated assessment modelling, biodiversity indicators and life cycle assessment data in a way that has not been done before."

Huijbregts' team has been able to provide clear evidence on what can be physically expected from this major energy source. "Our results show that over a period of 30 years, BECCS can only play a modest role. Over the full century, however, we could theoretically reach up to 40 Gt of CO_2 sequestered per year – more than the current total annual emissions."

On the other hand, full global implementation of BECCS could lead to competition with other land uses: "Think about fast-growing wood plantations all around the world, including Brazil and Indonesia," adds Huijbregts. "Biofuel production requires vast amounts of land which could take a toll on food production and substantially threaten biodiversity."

Our new framework is able to quantify the trade-offs in terms of biodiversity and climate mitigation at the global scale.

In the most extreme scenario, up to 2.4 billion hectares of land would be required by 2100 to grow lignocellulosic crops for BECCS, which equals 16 % of the total land surface area on Earth.

A roadmap for the future

Factoring the interplay between these different environmental challenges into their analysis, the scientists conclude that early and limited deployment is the most promising strategy.

While launching large-scale production as early as possible will help to achieve the required level of mitigation over a longer time horizon, natural land conversion should be kept to a minimum to protect species and food production.

Instead, the team recommends using abandoned agricultural lands as well as residue and waste biomass, which have little effect on land use. They also highlight the need for combining BECCS with other renewables and additional technologies to reduce emissions and remove CO_2, calling on policymakers to promote these in parallel.

To take the results achieved in the context of the SIZE project further, Huijbregts and his team have now started to work on global-scale modelling of other renewable energy sources, including wind, solar and hydropower.

PROJECT
SIZE – Size matters: scaling principles for the prediction of the ecological footprint of biofuels

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cordis.europa.eu/project/id/647224

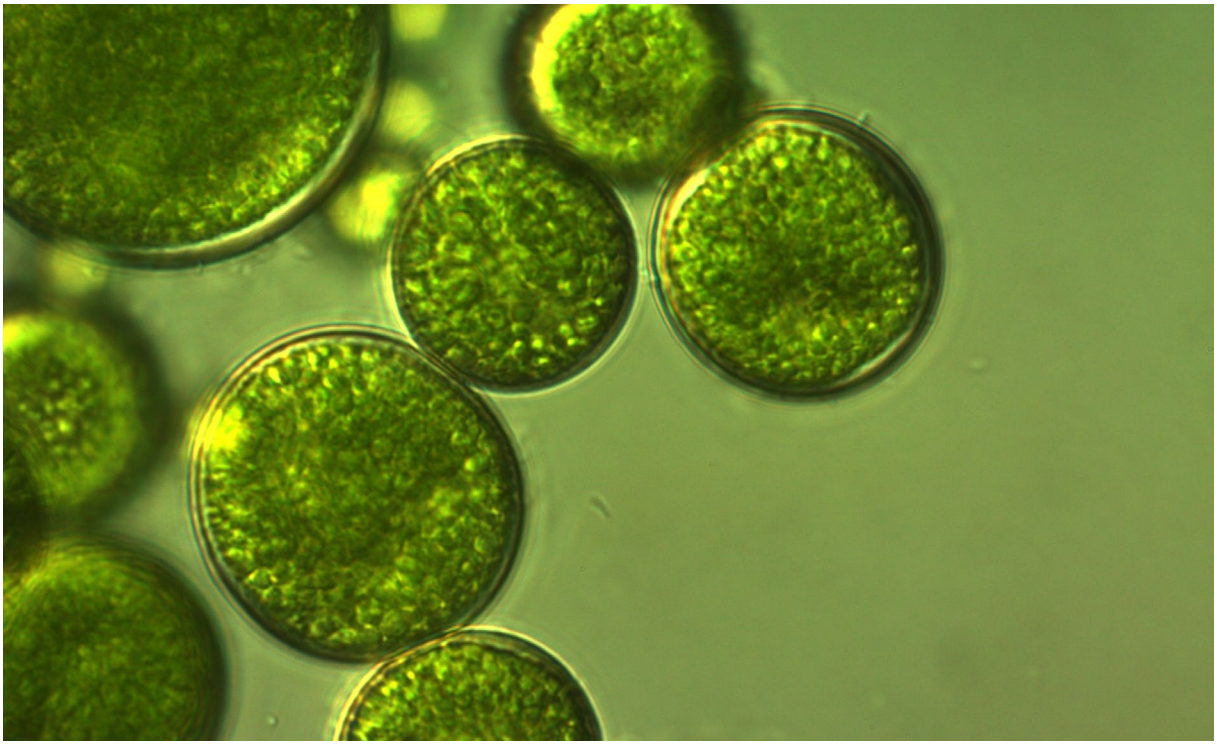
Algae biomass: unlocking new uses as food, feed and fuel

Microalgae could become a valuable source of biomass thanks to new processes improving photosynthesis, enabling novel food, feed and health products while also driving progress towards sustainable biofuels.

SOLENALGAE (Improving photosynthetic solar energy conversion in microalgal cultures for the production of biofuels and high value products), a project funded by the European Research Council (ERC), investigated how biomass production in microalgae could be improved by making the process of light energy conversion to biomass more efficient.

"As photosynthetic organisms, microalgae hold great potential for producing sustainable biomass: unlike other sources of biomass, they do not compete with food crops for arable soils. Moreover, they absorb CO_2, thereby reducing carbon emissions, as well as nutrients from wastewater," explains Matteo Ballottari, associate professor of Plant Physiology at the University of Verona and SOLENALGAE principal investigator.

To make full use of this potential, however, the productivity of the algae's photosynthetic process needs a boost. The microalgae's light-to-biomass conversion mechanism, naturally evolved to enable them to survive, does not yield enough biomass to enable industrial applications.



The SOLENALGAE team set out to analyse the molecular basis of the photosynthetic process and tested different strategies to overcome its limitations. They successfully engineered microalgae strains with improved photosynthetic efficiency, triggering a 30% increase in biomass productivity.

Benefits for human health

The researchers also discovered how to produce one of the strongest antioxidant molecules found in nature. They developed a novel process (which was the focus of the earlier ERC-funded Proof of Concept (PoC) ASTAOMEGA project) that is currently being patented, for the production of astaxanthin and omega-3 in marine algae.

"Astaxanthin is a molecule in high demand on the market, especially for animal feed or as a nutraceutical for humans, with an estimated price of thousands of euros per kilogram," says Ballottari. "This means that microalgae could be used at industrial scale using sustainable processes to produce novel foods and high-value products for human health, such as antioxidants, omega-3 or even drugs and vaccines."

Microalgae could be used at industrial scale using sustainable processes to produce novel foods and high-value products for human health.

Further steps required to make this happen will involve the development of industrial procedures for the cultivation of these organisms where expenditure is high. There is sufficient incentive to get there, Ballottari notes: "Increased biomass and lipid productivity and the development of high-value products like astaxanthin, obtained during this project, will contribute to reducing the imbalance between costs and market value of microalgae applications."

New hope for 'green' biofuels

Potential applications for the production of biofuels are another important aspect of SOLENALGAE. In addition to improved biomass productivity, the project team was able to develop strains of marine algae with an increase of up to 80% in lipids, a macromolecule which is key to biofuel production. They also proposed a novel process for reducing the cost of microalgae cultivation by recycling nutrients in waste waters, further increasing lipid productivity.

Ballottari cautions, however, that biofuels production remains the most challenging application for microalgae: "It is worth noting that the sustainability of microalgae-based biofuels production still requires further work, combining novel biotechnological applications and smart engineering process design."

Looking ahead, Ballottari says the team is now close to bringing their technology to the market. Negotiations between the University of Verona and several private companies are currently underway with a view to launching a dedicated start-up.

To fully explore the potential of microalgae as biomass and biofuel, he is also looking to further develop international cooperation on this topic: "The ERC funds allowed me to establish a solid scientific network with other labs in Europe, the United States and Asia. My plan is to reinforce these collaborations to conduct high-level scientific research, focusing in particular on the development of microalgae as novel foods for sustainable and healthy human nutrition."

PROJECT
SOLENALGAE – Improving photosynthetic solar energy conversion in microalgal cultures for the production of biofuels and high value products

HOSTED BY
University of Verona in Italy

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H2020-ERC

CORDIS FACTSHEET
cordis.europa.eu/project/id/679814

Creating balanced, and sustainable, ocean policies

New legal tools aim to help decision makers balance competing interests at sea and create a more sustainable ocean policy.

Maritime economic activity is increasing – and increasing fast. Not only are such traditional sectors as oil and gas and fisheries expanding, new economic activities are also coming onto the scene. From wind farms to deep-sea mining, these emerging sectors create both new opportunities and new challenges.

"When planning maritime activity, policymakers have to not only balance the often competing interests of these sectors, but also protect the marine environment, mitigate the effects of climate change, guarantee energy efficiency and ensure the rights of local coastal communities," says Seline Trevisanut, a researcher at Utrecht University and principal investigator of the ERC-funded SUSTAINABLEOCEAN (Accommodating New Interests at Sea: Legal Tools for Sustainable Ocean Governance) project.

When planning maritime activity, policymakers have to not only balance the often competing interests of these sectors, but also protect the marine environment, mitigate the effects of climate change, guarantee energy efficiency and ensure the rights of local coastal communities.

According to Trevisanut, it is crucial that all these interests go hand-in-hand with the relevant fields of international law. "Even if legal regulation is fragmented, these maritime interests are not – which means various legal regimes must work together," she explains. "The question, however, is how the law can strike a balance between competing interests at sea and contribute to the sustainable use of our oceans – this is what the SUSTAINABLEOCEAN project aimed to find out."

Initiating important debates

To answer this question, project researchers had two main objectives. First, they set out to develop a new line of research based on a theory of interest and regime interaction in ocean governance. "This helps us better understand how relevant legal frameworks interact, how we can resolve tensions between different frameworks, and how energy and climate change law are reshaping ocean governance," adds Trevisanut.

Based on this initial research, the project then developed reports and a database to help governments, industry, NGOs, local communities and other stakeholders sustainably govern ocean use.

These tools have already contributed to several important academic debates on how to enhance the protection of the marine environment and how the law can contribute to fostering the sustainable transition of many maritime activities.

Challenging traditional thinking

In addition to the scientific and societal benefits of the project, Trevisanut says the research benefited her on a personal level. "It has been a very enriching experience for me to supervise my research team of three for the past 5 years," she remarks.

Trevisanut notes that a highlight was her earning a position as professor of international law and sustainability, an accomplishment she attributes to the success of the project.

"Maritime activities and the law of the sea are often seen as highly technical and specialised and thus are seldom included in broader theoretical legal debates or discussed in their broader context," concludes Trevisanut. "Our work challenged this traditional thinking, showing the added value of taking a holistic approach to maritime activities to ensure their sustainable transition."

The research team is currently working to publish the papers presented at the project's final conference, along with developing further legal tools.

PROJECT
SUSTAINABLEOCEAN – Accommodating New Interests at Sea: Legal Tools for Sustainable Ocean Governance

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PROJECT WEBSITE
uu.nl/en/research/sustainable-ocean

How lianas help tropical forests adapt to climate change

Researchers head deep into the jungle to study why lianas are growing at an increasing rate and what this might mean for climate change.

Tropical forests play an essential role in the global carbon cycle. Through photosynthesis, trees absorb carbon dioxide. They then store the carbon in their biomass, which reduces the amount of this greenhouse gas in the atmosphere. In fact, according to the Global Forest Atlas, tropical forests contain about 25% of the world's carbon. As such, they play an important role in the fight against climate change.

The effects of climate change also impact these same tropical forests. For example, over the past few decades, researchers have noted a substantial increase in lianas, the vines that grow into trees.

The ERC-funded TREECLIMBERS (Modelling lianas as key drivers of tropical forest responses to climate change) project aimed to shed new light on why lianas are growing at an increasing rate and what the impact of this growth might be.

"Although nobody knows for sure, we suspect this increase might be a way for tropical forests to adapt to the realities of climate change," says Hans Verbeeck, a principal investigator and researcher at the Ghent University CAVElab. "If this is the case, it could have a significant impact on the long-term carbon balance of tropical forests."

Deep into the jungle

The team sent researchers deep into the jungles of Costa Rica, Democratic Republic of the Congo, Ecuador, French Guiana, Panama and Rwanda. Armed with terrestrial LIDAR technology, stable water isotopes, and measuring tapes, they carefully inventoried all lianas in large areas of forests and studied their water use and the way they impact forest structure. Their goal: to build the very first mechanistic representation of lianas in vegetation models.

From this work we hoped to gain important insights into how lianas influence the carbon uptake of tropical forests.

"From this work we hoped to gain important insights into how lianas influence the carbon uptake of tropical forests," explains Verbeeck. "We also wanted to unravel the extent to which lianas contribute to the canopy's vertical structure."

According to Verbeeck, researchers succeeded in developing a liana plant functional type and integrating it into two vegetation models. "These models enable us to represent the role of lianas in mature and young tropical forests in terms of carbon stocks and fluxes," he adds. "This will serve as a blueprint for other modelling groups aiming to build liana models."

Researchers also gained important new insights on both the below- and above-ground competition happening between lianas and the trees themselves. "Our findings from French Guiana challenge the long-standing liana deep-rooting hypothesis," notes Verbeeck. "We've already started planning multiple follow-up studies on this topic."

A significant contribution

In addition to these scientific discoveries, the project team, which included postdocs, PhDs, and master students, made a significant contribution to existing scientific literature. "For example, we found substantial variation in liana functional traits – a finding that challenged our initial plan of clustering all liana species into one plant functional type," adds Verbeeck. "We also contributed to the scientific community's understanding of lianas' behaviour, particularly in terms of their efficient use of water and their abundance in different successional stages of the forest."

Verbeeck says that the TREECLIMBERS team has multiple follow-up projects in the works. They are also working to organise an international liana modelling workshop with other research teams that started to follow the example set by the TREECLIMBERS project.

PROJECT
TREECLIMBERS – Modelling lianas as key drivers of tropical forest responses to climate change

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Ghent University in Belgium

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CORDIS FACTSHEET
cordis.europa.eu/project/id/637643

PROJECT WEBSITE
bit.ly/TREECLIMBERS

Keeping wind turbines healthy using low-cost sensors

A new monitoring system uses low-cost sensors to efficiently inspect and monitor a wind turbine's structure and performance. The result could be an extended lifespan for this important source of renewable energy.

As part of its comprehensive efforts to reduce carbon emissions and stop climate change, the EU is looking for alternatives to fossil fuel-based energy production. Renewable energy, especially wind energy, is one of the sustainable solutions of choice.

Wind energy production accounts for almost half the world's generating capacity of renewable energy sources. It is both clean and sustainable but one of wind turbines' shortcomings is their relatively short lifespan and their high operation and maintenance costs.

"With a number of wind turbines reaching the end of their lifespan, stakeholders and policymakers are seeing the need for reliable life cycle assessment methods," says Eleni Chatzi, chair of Structural Mechanics and Monitoring at ETH Zürich. "Unfortunately, because existing tools have not yet caught up with the maturity of wind turbine technology, visual inspection and offline evaluations remain the norm."

This is where the ERC-funded WINDMIL (Smart Monitoring, Inspection and Life-Cycle Assessment of Wind Turbines) project comes in. Led by Chatzi, the project is developing a more efficient and cost-effective method for monitoring wind turbines. The result is the WINDMIL Suite: a long-term monitoring solution that uses low-cost sensors to provide real-time cradle-to-grave feedback on the structure's condition.

How to diagnose a windmill

According to Chatzi, most of today's wind turbines feature so-called Supervisory Control and Data Acquisition (SCADA) systems. "While these systems monitor a number of quantities, including revolutions per minute (RPM), power produced and wind characteristics, they fail to provide important structural information such as damage, fatigue and deterioration," she explains.

With a number of wind turbines reaching the end of their lifespan, stakeholders and policymakers are seeing the need for reliable life cycle assessment methods.

To fill this gap, the WINDMIL project has added structural information into the wind turbine structure assessment loop. "By measuring the structural response and overall performance of the turbine, we can diagnose its condition," adds Chatzi. "This allows us to optimally plan for its operation and maintenance and, as a result, possibly predict – if not extend – its lifespan."

The WINDMIL diagnostic and predictive module was validated via diverse data sets. These included data sets produced via large numerical simulations, laboratory data from a small-scale wind turbine mock-up, SCADA data generated from wind farms across Europe, and structural monitoring data coming from sensors installed on windmills.

New data, new results, and new opportunities ahead

As a result of a recent acquisition, Chatzi's lab now owns a small-scale wind turbine that serves as an operational lab. "Using direct measurements of response extracted from structural components, such as the blades, tower and foundation, we are demonstrating WINDMIL's potential for reducing operating and maintenance costs and preventing damage," remarks Chatzi.

The project remains ongoing and continues to produce new data and results. It has also spurred several follow-up and collaborative projects. For example, ETH Zürich is currently collaborating with the University of Applied Sciences of Eastern Switzerland to deliver a first-ever micro-electro-mechanical system-based surface pressure and acoustic smart measurement system for monitoring wind turbine blades.

"WINDMIL has created a flourishing research direction with numerous opportunities to transfer our results into current practice," concludes Chatzi.

PROJECT
WINDMIL – Smart Monitoring, Inspection and Life-Cycle Assessment of Wind Turbines

HOSTED BY
Swiss Federal Institute of Technology, Zurich in Switzerland

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SOIL AND SUSTAINABILITY: RAISING THE GAME FOR EUROPEAN AGRICULTURE

This issue of Research*eu focuses on the issue of soil quality, particularly with regards to innovative new methods for sustainable agriculture, as well as how researchers are implementing innovative solutions to restore previously degraded soil.

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